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

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

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

LOGIC PROBE Kit £13.48
COMPUTER MOVEMENT DETECTOR £8.98
SPECTRUM SPEECH SYNTH. & 8-BIT LO PORT £25.19
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Extra: Transistor £9.98, Case £2.95, BBC board (c) £1.99.
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Small unit - type MG £3.20/boxed
Large unit - type MGL £2.20/boxed

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 onboard monitor program. The system is programmed and run via an RS232 link from either a standard terminal or a BBC computer to act as a terminal (we can supply the interface) to suit your order.

PHONE OR WRITE FOR FULL DETAILS REF P66

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68000 P8 £21.20
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6116 (256k) £9.99
C64/128 (256k) £9.99
27128 EPROM M148 £3.88
M148 £3.88

MAGENTA

EDUCATIONAL SETS

FOR USE WITH ELECTRONICS

Enables recreation to electronics, full of new ideas, full of class, full of other pictures and easy to follow text. Ideal for all ages - mothers and adults. Only basic tools needed. 64 full colour pages cover all aspects - simple - hand building - component identification and how they work.
Also full details of how to build 2 projects - Integral alarm, radio, games etc. Requires soldering - 4 pages clearly show how to do it.
COMPONENTS SUPPLIED ALLOWS ALL PROJECTS TO BE CONSTRUCTED.
Supplied less batteries 8-9 times.
FUND WITH ELECTRONICS
COMPONENT PACK £16.98
MODE EXTRA £1.76
Book available separately.

LOGIC TUTOR
A specifically designed test bed for the practical side of the 8-bit educational series. Introduction to Digital Electronics. Practical Experiments (Oct-May '84). Full kit incudes screen printed PCB, power supplies, connector strips and terminal pin sockets (desk case).
£34.98
REFRESH EXTRA THE YEAR

ADVENTURES WITH ELECTRONICS

An easy-to-follow book suitable for all ages, ideal for beginners. No soldering, uses 5-15 Dec Board. Gives clear instructions with colour pictures for 6 projects - including three radios, sirens, metronome, orgon, inter-com, timer, etc. Helps you learn about electronic components and how circuits work.
Component pack includes 5-15 Dec breadboard and all the components for the projects.

HIGH PERFORMANCE STEPPING MOTOR DRIVER

As featured in a December issue. Kit including PCB, I.C. & All Parts £20.98
Transformer 300V 16VA £5.98 extra
Case for PCB extra £2.99
Used & Constructor for BBC Computer £1.98
Motor - £68.99 £14.92
TEA1012 also available separately £6.98. Data £1.00

BBC TO 1035 STEPPER MOTOR INTERFACE KIT £13.98 PCB, driver IC, components, connectors and kits included. Demonstration software, listings, circuit diagram, pin hand and construction details. Requires unregulated 52VDC power supply.
INTERFACE KIT only £4.95 extra
OPTIONAL POWER SUPPLY PARTS £4.67
DCS STEPPER MOTOR 48 steps 12v £14.90

BBC HEART RATE

Bbc Heart Rate Monitors - Ready Built £35.99
Practice 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.

CATELOGUE

Brief details of each kit, look costs, and illustrations and descriptions of our range of tools and components are included:
Robotics and Computing section included. Our adverstment shows just a selection of our products.
Up to date price list enclosed. Official orders welcome.
Catalogue & Price List - Send 1 £1 in stamps etc or £1 to your order.
Price list only 9x4 SAE. Catalogue free to schools/colleges requested an official letterhead.

HOW TO ORDER

MAGENTA ELECTRONICS LTD.
PER, 139 HUNTER ST.,
SILVERHILL A.V.
STAFFS, DE25 2ST.
MAIL ORDER ONLY.
0239 355426. Mon-Fri 9-6.
DEALER ACCOUNTS.
PRICES INCLUDE VAT.
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OFFICIAL ORDERS WELCOME.

OUR PRICES INCLUDE VAT

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Any enquiries for credit card orders.
OVERSEAS Payment must be made in £ sterling for 1st class post. WEILS £350.00 for 1ST CLASS EIRLLENEIRE - write for price.
CONSTRUCTIONAL PROJECTS

DF BEACON TIMER by R. A. Penfold
Offshore navigation aid with crystal controlled accuracy

NOTCHER EFFECTS UNIT by John Simon
Audio add-on to produce some very unusual effects

PE HOBBY BOARD by Richard Barron
A universal interface and peripheral controller for all home micros

NEWS AND REVIEWS

NEWS AND MARKET PLACE
What's new, what's happening and what's coming in the electronics world

BOOK REVIEWS
A selection of the latest releases

REGULAR FEATURES

THE LEADING EDGE by Barry Fox
The technology behind the technology

ROBOTICS REVIEW by Nigel Clark
The latest from the world of industrial and educational robots

SPECIAL FEATURES

SOLAR ENERGY by Professor R. Hill
Science feature—modern solar technology

USING SOLAR CELLS by Nick Hampshire
Amorphous silicon plates and silicon wafers—which?

PE SERVICES

SUBSCRIPTIONS AND BACK NUMBERS
Regular order form

PCB SERVICE
P.c.b. list and prices for PE projects

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

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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 x 207mm x 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; Tr-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.

WHAT'S NEW...

Challenge to CRT technology

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

The display measures 280 x 116 x 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 l.c.d. which simplifies the interface between CPU, l.c.d. and video RAM. In character display mode it can control 80 characters x 25 lines and handle cursor, 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

degrees celsius, 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, lightweight 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.

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 230V, 50Hz is either 2 x 0-21mA or 2 x 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.

Further 256 available from an external ROM facility.

Details from: Epson (UK) Limited, Dorland House, 388 High Road, Wembley.
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 developed and produced in just 18 months, a 32-bit microprocessor more powerful than a 68020. Running Basic, it is a 32-bit processor. Acorn 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 commercial standard colour LCD displays. The Epson device is the larger of the two with a 5-13 inch diagonal screen with a resolution of 480 x 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 LCD. The Matsushita display is slightly smaller (4.25 inch diagonal) with a 300 x 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

Ericsson 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 x 40mm slice of lithium niobate at the most complex part of such a 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 optical 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.

## 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 3000 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 re-emitted 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.

## COUNTDOWN

Events, diary dates and forthcoming attractions

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**WHAT'S TO COME...**

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**Printed Software**

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DISC DRIVES
These are fully cased and wired drives with slim line high quality mechanisms. Drives supplied with cables manuals and formatting disc suitable for the BBC computer. All 80 track drives are supplied with 40/80 track switching as standard. All drives can operate in single or dual density format.

PO600P (2 x 40K/2 x 60K/40/80T)

3.5" DRIVE

2 x 40K/2 x 60K 40/80T

3.5" DISC

PS400 with psu 1 x 40K/1 x 640K

BIG DISC

£129 (b)

£109 (a)

£119 (b)

£199 (b)

£129 (b)

£209 (b)

3M FLOPPY DISCS

High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

5¼ DISCS

40 SS DD £12 (d)

40 SS DD £16 (d)

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3½ DISCS

80 SS DD £30 (d)

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All 14" monitors now available in plastic or metal cases, please specify your requirement on order.

14" RGB

Full RGB with PAL & Audio

£149 (a)

£133 (a)

£129 (a)

£139 (a)

£129 (a)

MONOCROME MONITORS:

SANYO DMH112CX Hi Res 12" Green Screen

£179 (c)

£174 (c)

KAGA KX2110 Hi Res 12" Elged Screen Monitor

£179 (a)

£174 (a)

£179 (a)

£179 (a)

£179 (a)

£179 (a)

20" RGB with PAL & Audio

£380 (a)

£395 (a)

£405 (a)

£415 (a)

£425 (a)

£435 (a)

SUPERVISION III with amber/green option ....... £249 (a)

MITSUBISHI XCH404 12" Monochrome Res IBM & BBC Compatible .... £249 (a)

All prices in this double page advertisement are subject to change without notice.

HOSTS EXCLUDE VAT

Please add carriage 50p unless indicated as follows:

(a) £8.20 (b) £5.70 (c) £1.50 (d) £1.00

ATTENTION

Serious Test Monitors RS232 and CTY24

Transmissions, nonsubs. status with dual colour LEDs on 7 or more significant figs.

£33 (a)

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£54 (c)

£30 (d)

£54 (c)

All connections must be secure and of good quality. Jumper cables can be used and re-used.

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<thead>
<tr>
<th>Kit</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>MK6</td>
<td>Transmitter for above</td>
<td>£4.95</td>
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<tr>
<td>TD300K</td>
<td>Touch Dimmer</td>
<td>£7.75</td>
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<td>TS300K</td>
<td>Touch Dimmer</td>
<td>£7.75</td>
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<tr>
<td>TEDK</td>
<td>Extension for 2-way switching for TD300K</td>
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This kit comprises a transmitter with a drilled box and two receivers.

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<tr>
<th>Kit</th>
<th>Description</th>
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<tr>
<td>MK4</td>
<td>Proportional Temperature Controller</td>
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<th>Description</th>
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<tr>
<td>Electronic lock kit</td>
<td>With hundreds of uses in doors, garages, car anti-theft devises, electronic equipment, etc. Only the correct coded sliding four digit code will open all</td>
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**HOME LIGHTING KITS**

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<td>13 BOSTON RD</td>
<td>£2.95</td>
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<tr>
<td>Send 9&quot;x6&quot; S.A.E. or Call at shop for further information</td>
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<th>VA</th>
<th>SERIES NO.</th>
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<td>120</td>
<td>4 12.71</td>
<td>625 9 25.96</td>
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ALL ABOVE PRICES INCLUDE VAT AND CARRIAGE. QUANTITY DISCOUNTS AVAILABLE FOR 5 OR MORE OF ANY ONE TYPE.
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 over-

![Block diagram](image)

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
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 I.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 i.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...
devices to the manual reset circuit, and together with D1 in the divider circuit it enures 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 millamps. The standby 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. Piers 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
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.

As the unit will be used in a fairly hostile environment it 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 emersed 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 aligned 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 Mitsubi-shi 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-every-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 a 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 suitase 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 broadcasters, 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.
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 making the development oriented 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.


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 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 third 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.
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](image)

A typical single crystal silicon solar cell (Fig. 1) consists of a wafer of silicon about 1 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 possible 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 0.4 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 1%/°C 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 1 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...
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 applica-

Further in the future, the conversion efficiency 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 net 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 the shunt resistance \( R_s \) is given by \( V_m = I_m R_s \). If the power of the light falling on the solar cell is \( P_{in} \), the efficiency of the cell is \( P_{out}/P_{in} = V_m I_m / P_{in} = V_{oc} I_{sc} FF/P_{in} \), 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 13-20% 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 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.

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 1990s, although the retail cost could be higher.
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 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 sources ranging in size from milliwatts to megawatts, in applic-
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" x 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.

Solar cells of either form are usually used in conjunction with a battery or other power storage device in order to evenly 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 performance.
efficiency. Peak efficiency requires that the light reaching the solar cell has an energy equivalent of at least 1 kilowatt/square 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 semiconductor 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-n structure, the i layer being a silicon carbide to ensure a wide spectral activity range, the n layer is hydrogenated amorphous silicon and a further layer of amorphous silicon creates the p 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 550nm. Fig. 2 shows the I/V curve for a foot square panel, the curve has the same shape for panels of different sizes.
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 efficiency in power utilisation. The product should have wide appeal in the UK and overseas, thereby 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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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.

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

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**CONSTRUCTIONAL PROJECT**

**NOTCHER EFFECTS UNIT**

**BY JOHN SIMON**

An unusual musical effects unit producing harmonic waveforms
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.

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

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 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.
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**
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**

<table>
<thead>
<tr>
<th>RESISTORS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2</td>
<td>4k7 (2 off)</td>
</tr>
<tr>
<td>R3, R4, R10</td>
<td>47k (3 off)</td>
</tr>
<tr>
<td>R5, R6, R20</td>
<td>100k (3 off)</td>
</tr>
<tr>
<td>R7, R8, R9</td>
<td>10k (3 off)</td>
</tr>
<tr>
<td>R11, R12,</td>
<td>27k (4 off)</td>
</tr>
<tr>
<td>R15, R16</td>
<td></td>
</tr>
<tr>
<td>R13</td>
<td>2M2</td>
</tr>
<tr>
<td>R14</td>
<td>22k</td>
</tr>
<tr>
<td>R17</td>
<td>390k</td>
</tr>
<tr>
<td>R18</td>
<td>220k</td>
</tr>
<tr>
<td>R19</td>
<td>15k</td>
</tr>
</tbody>
</table>

**POTENTIOMETER**

VR1  1M hor. sub-min preset

**CAPACITORS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>C1, C9</td>
<td>470µ 10V radial elect (2 off)</td>
</tr>
<tr>
<td>C2</td>
<td>100µ 10V radial elect</td>
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<tr>
<td>C3</td>
<td>390p ceramic plate</td>
</tr>
<tr>
<td>C4, C10</td>
<td>1µ 63V radial elect (2 off)</td>
</tr>
<tr>
<td>C5</td>
<td>2n2 carbonate</td>
</tr>
<tr>
<td>C6</td>
<td>4n7 carbonate</td>
</tr>
<tr>
<td>C7</td>
<td>330p ceramic plate</td>
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<tr>
<td>C8</td>
<td>10µ 25V radial elect</td>
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<tr>
<td>C11</td>
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<td>C12</td>
<td>470p ceramic plate</td>
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<tr>
<td>C13</td>
<td>220p ceramic plate</td>
</tr>
<tr>
<td>C14</td>
<td>330n carbonate</td>
</tr>
</tbody>
</table>

**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 (FP3 size) |
|              | Case about 205 x 140 x 40mm; printed circuit board, PE107; battery holder; 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.

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.

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Photo 5. Constructional details

PHONOSONICS, DEPT PE56, 8 FINUCANE DRIVE, ORPINGTON, KENT BR5 4ED.
TEL: ORPINGTON 37821 (STD 0689, LONDON 66).

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EFFECTS, DISPLAY AND TEST KITS

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- **BASS BOOST**
  - Variable depth & range. Set 128 (£3.82)
- **BLOW BOX**
  - Tone & delay & amplifier for 이것이 있는 효과에 창조적 허용. Set 138 (£2.32)
- **CHORUS-FLANGER (PE JAN 84)**
  - More Stereo. Supports dual media sound enhancement. Set 225 (£1.09)
- **COMPANDER**
  - Auto & manual, compression, expansion, switchable. Set 238 (£2.99)
- **CYPHERBOX (EE APR 85)**
  - Variable depth & range, with ring modulator & reverb. Set 228 (£4.86)
- **DISCO LIGHT CONTROL (PE NOV 85)**
  - 1-2 channels to light, with other, plus level & computer interface (BBC). Set 208 (£2.68)
  - 2 Chs bassed to light only. Set 205 (£3.88)
  - Both works to light only. Set 206 (£4.88)
- **ECHO-REVERB (PE SEP 84)**
  - More Stereo. (EE Apr) echo unbalanced. 100ms, switchable & computer interface. Set 218 (£2.88)
- **ENVELOPE SHAPER**
  - More stereo, ADF, with BBC, Set 174 (£5.79)
- **EQUILISER**
  - Includes: Variable low pass, high pass, band pass and notch/Wahs. Set 253 (£3.23)
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  - Up to 4 channel, automatic fade in, Variable and sensitivity control. Set 260 (£5.62)
- **FLANGER**
  - Variable depth & range equal phase shifting. Set 163 (£3.15)
- **FREQUENCY DOUBLER**
  - Variable phase & frequency change. Set 168 (£3.15)
- **FUZZ**
  - Variable phase & frequency change. Set 209 (£3.15)
- **GUITAR EFFECTS**
  - Variable phase & frequency change. Set 162 (£3.26)
  - Variable phase & frequency change. Set 232 (£3.26)
  - Variable phase & frequency change. Set 207 (£3.26)
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  - Auto & manual, compression to light only. Set 141 (£1.75)
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  - Voice controlled, on/off sequencer. Set 223 (£3.47)
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  - Variable level & gain, switchable tone & treble filter. Set 144 (£4.60)
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  - Variable level & range. Set 200 (£3.56)
- **REVVER - MONO (EE OCT 85)**
  - Variable level & range. Set 232 (£2.72)
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  - 3 instruments controlled for pre-programmed L/2 basic rhythm, superposable with 400th switch combinations. Set 240 (£2.99)

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- Frequency generator, with ALC & monophonic VCO. Set 245 (£3.45)

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VOCADOX

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VODALEX

- Variable depth & range modulation, Set 175 (£1.75)

VOICE-OP-SWITCH

- Voice level controls 1 amp VDTN inca, Variable sensitivity & pace control. Set 193 (£2.24)

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Published by: PE Practical Electronics, EE Everyday Electronics. Designed by John M. Becker.

- Stores 120 samples - 15 inch metal rack mounting, with 8 LEDs - Katak designed. Store with black box & manual. All kits include FCUs, parts, manuals and secret code.

- Further details are in catalogue of over 70 exis - Send 1st class air mail for free samples & catalogue of over 1000 (£5.00)

- MAIL ORDER: Freescale CMS, plc, Access, Visa insurance cover 50p per item. Details correct at press time.

- Add 15% VAT. Add P&P (£1.50 each kit) (Dues rates in catalogue).
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, micro 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 i.e.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 onto-board 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.

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.

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 Armandroid 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 Armroid I while adding the Colvis vision system and a CNC lathe.

Attempts were made during the last year to upgrade the Armroid 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 assault 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 Petset, looking like a furry cat, costs about £50 and responds to handclaps and also has a roam mode. Petset 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.
**CONSTRUCTIONAL PROJECT**

**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 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 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 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 PEBH, 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 8255 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 (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 (PAO—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
Fig. 1.1. The complete circuit diagram of the PE Hobby Bus
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/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 SCNT 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
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 W line will be used to generate a R/W line via IC6c. The 6502 only has a single R/W line so there are no such problems with machines such as the BBC.

**Fig. 1.3. Simple output port**

**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.
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.

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 Rf 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.
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.

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.

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

<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>REM</td>
</tr>
<tr>
<td>20</td>
<td>REM</td>
</tr>
<tr>
<td>30</td>
<td>REM</td>
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<tr>
<td>40</td>
<td>REM</td>
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<td>50</td>
<td>REM</td>
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<tr>
<td>60</td>
<td>REM</td>
</tr>
<tr>
<td>70</td>
<td>REM</td>
</tr>
<tr>
<td>80</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>PROC_initialise_port</td>
</tr>
<tr>
<td>100</td>
<td>REPEAT</td>
</tr>
<tr>
<td>110</td>
<td>REPEAT</td>
</tr>
<tr>
<td>120</td>
<td>CLS:INPUTTAB(8,5)&quot;OUTPUT VOLTAGE = &quot;VOLTS</td>
</tr>
<tr>
<td>130</td>
<td>UNTIL VOLTS&gt;-0.001 AND VOLTS&lt;2.56</td>
</tr>
<tr>
<td>140</td>
<td>PROC_analogue_out</td>
</tr>
<tr>
<td>150</td>
<td>PRINNTAB(5,10)&quot;Press &lt; SPACE &gt; to continue&quot;</td>
</tr>
<tr>
<td>160</td>
<td>A$=GET$</td>
</tr>
<tr>
<td>170</td>
<td>UNTIL FALSE</td>
</tr>
<tr>
<td>180</td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>DEF PROC_initialise_port</td>
</tr>
<tr>
<td>200</td>
<td>DDR=&amp;FE62;DBR=&amp;FE60:?DDR=&amp;FF:?DRB=&amp;00</td>
</tr>
<tr>
<td>210</td>
<td>ENDFPROC</td>
</tr>
<tr>
<td>220</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>DEF PROC_analogue_out</td>
</tr>
<tr>
<td>240</td>
<td>OUT%=(VOLTS*1000) DIV 10</td>
</tr>
<tr>
<td>250</td>
<td>?DRB=OUT%</td>
</tr>
<tr>
<td>260</td>
<td>ENDFPROC</td>
</tr>
</tbody>
</table>
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 volts at up to 2 amperes.

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 micro-computer 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 CLS;INPUTTAB(8,5)"OUTPUT VOLTAGE = "VOLTS  
120 UNTIL VOLTS>-0.001 AND VOLTS<25.6  
140 PROC_analogue_out  
150 PRINTTAB(5,10)"Press < SPACE > to continue"  
160 AS=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 similar 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 thermometer controller or to generate various waveforms not easily achieved using conventional analogue techniques.
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 am 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:

R. P. Gabriel, Chobham.

Dear Editor,

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 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. Yeareley, 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. Grpvenor or someone will come up with the answer. We will, of course, publish the best solution in a forthcoming issue.

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Dear Sir,

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I am no at full 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 untrained 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

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J. W. Hill, S. Yorks.
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 plenty 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
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 plate 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.

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)

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**STE-BUS POWER SUPPLY**

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

**Fig. 2.2. System constructional details**

**Fig. 2.2. PSU mechanical details**

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PRACTICAL ELECTRONICS MAY 1986

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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.
Space Watch

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 programme 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 approach, the audience was told that the spacecraft had lost contact with the Earth, and Voyager 2 had, apparently, failed to communicate. It is a sad fact that such disasters have happened before, and it is easy to be pessimistic. But we must be patient, for the Voyager 2 mission is by no means over. The programme is to continue to 1990, when the spacecraft should be at a distance of 2.76 astronomical units from the Earth, and will be able to communicate directly with Earth Station.

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 zenithal 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 Aquarids 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 Castor, Pollux and Pleiades 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 Bootes (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.
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.e. 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.e. 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 i.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 would 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.e. test clip via a 16-way selector circuit. In order to use the unit the i.e. 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.
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 inter-changeable, 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.e.d. 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 i.e.d. indicators show whether each pin is in the high state or the low one. The decoder provides buffering so that the i.e.d.s do not load the test point.

**CONDITIONS**

Sometimes both i.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 i.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 i.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 i.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 i.e.d. indicator which it switches on for about half a second when an input pulse is detected. The i.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.

**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 i.e.d.s respectively, and these have R5 and R6 as their current limiting resistors. Although you might expect D1 to be the "low" i.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

### Table 1. Possible indicator conditions

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<th>LOW LED</th>
<th>PULSING LED</th>
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<tr>
<td>FLOATING</td>
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</tr>
</tbody>
</table>

**COMPONENTS...**

**RESISTORS**

- R1-R4 1k (4 off)
- R5,R6,R8 390 (3 off)
- R7 22k
- All ½ watt 5% carbon

**CAPACITORS**

- C1 6μF 6V tantalum bead
- C2 100n ceramic

**SEMI-CONDUCTORS**

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

**MISCELLANEOUS**

- SK1,SK3 1mm sockets (2 off)
- SK2 16-pin d.i.l. i.e. test clip
- S1 horizontal hex switch (Cirkit 53-01163)
- Case about 133 x 70 x 38mm;
- printed circuit board, PE108, 16-way ribbon cable; wire, solder, etc.

---

**Fig. 1. Block diagram**

**Fig. 2. Switch details**
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.

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

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**Fig. 3. Complete circuit diagram**

---

**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 i.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 i.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.e.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 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.

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' i.e.d. to switch off and the 'low' i.e.d. to turn on. The 'pulsing' i.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.d. 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 +5V 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 difficult, 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.d devices, but with such inputs left unused it is then essential to exercise more care to avoid confusion over which pin S1 is set to select.
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.

**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 (ROM) version in a plastic package. The erasable EPROM versions are more expensive but are ideal for developing a project which can then be transferred 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

---

**Fig. 1. Block diagram of HD63701V**
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. Intermittent 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**

---

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

---

**FEATURES OF HD63701X**

- 4K Bytes of EPROM (compatible with 2732A type)
- 192 Bytes of RAM
- 53 Parallel I/O Pins
- 21/0 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 x 1
- Free Running Counter x 1
- Output Compare Register x 2
- 8-bit Reloadable Timer
- External Event Count
- Spare Wave Occurrence
- Serial Communication Interface
- Asynchronous Mode/Clock
- Synchronous Mode
- 3 Transfer Formats (Asynchronous Mode)
- 8 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)
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.
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 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.
internal heatsource, though it is unreasonably high. There may be some preciously quoted figure of 40 to be 10 per cent, much less than the of Uranus are dark, narrow and thin. Observations were made as though 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 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 in Earth in 1977, it reached its closest point to Uranus 1 minute early!
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PRACTICAL ELECTRONICS MAY 1986

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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 they 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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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.
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