Get moving with these new developments in UK Robotics — advanced electrohydraulic designs for education, industry and now available to the home constructor.

HEBOT II

Up to the nano-second hard, firm and software developments embodied in a complete system. 12 Mega Hertz 16 bit CPU, 64K upwardly compatible DRAM, separate 16K video DRAM and 24K T.I. Power Basic with overwrite. Supports up to four Disc drives of mixed type with 16 serial I/O ports. Programmable Baud rate and comprehensive E Bus interface designed to support real world applications.

Highly resolved graphics gives 3D simulation in 16 colours on 36 prioritised planes of user definable characters. Software FORTH coming includes this trendy language along with NOS C/PM.

Hardware components available separately with details in Nov., Dec. and Jan. issues of ETI. Software features include: Real time clock, full renumber command, buffered I/O to free machine whilst printing, call to machine code routines, hexadecimal support and user-friendly textual error trapping messages.

If computers interest you then the Cortex will expand your understanding infinitely more than off the shelf machines. Use it in business, education, research or just play with the incredible graphics capability. At Powertran we are using these machines in conventional roles, in product control and R & D. We shall coordinate the Cortex user group and distribute software for the TMS 9995 CPU. Complete 16 bit 64K computer kit £295.00 + VAT. Complete 16 bit 64K computer ready built £395.00 + VAT.

---

Example prices and specifications

- **Genesis S101**
  - Base: 19.5" x 11" x 7.5"
  - Lifting capacity: 1500gm
  - Arm length: 14.0"
  - Weight: 29Kg
  - 4 axis model in kit form: £425
  - 5 axis model in kit form: £475

- **Genesis P101**
  - Base: 19.5" x 11" x 7.5"
  - Lifting capacity: 2000gm
  - Arm lengths between axles: 14.0"
  - Weight: 34Kg
  - 6 axis model in kit form: £675

- **Complete Systems as shown in Photograph on right**
  - Genesis S101: £691.50
  - Genesis P101: £995.00

- **All prices exclude of VAT**

---

With prices starting below £1,000 the Genesis range of general purpose robots provide a first rate introduction to robotics for both education and industry. Each has a self-contained hydraulic power source which enables loads of several pounds to be smoothly handled. The system operated from a single phase 240 or 120V AC supply or a 12V DC supply. The machines can be supplied with up to 5 axes each of which is fully independent but capable of simultaneous operation. Position control is achieved by means of a closed-loop feedback system based around a dedicated microprocessor. Movement sequences can be entered, stored and replayed by use of a hand held controller. Alternatively the systems can also be interfaced to an external computer via a standard RS 232C link.

---

**HEBOT KIT**

- £85.00

**INTERFACE BOARD KIT**

- £10.00

---

**HEBOT II**

- **Genesis 5101**
  - 4 axis system in kit form: £681.50
  - 5 axis system in kit form: £737.50
  - 5 axis system Ready Built £1450

---

**GENESIS S101 AND GENESIS P101 WITH PROCESSOR BOXES AND HAND-HELD CONTROLLERS**

---

**HEBON KIT**

- **HEBON II**
  - £1950.00

---

**C0r4TF**

- **Cortex II**
  - £295.00

---

**OB1**

- **RASCU**
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  - £48.50
  - £2.50
  - £3.00

---

**MINI KIT**

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  - £48.50
  - £2.50
  - £3.00

---

**GENESIS P102 PROCESSOR BOX, HAND HELD CONTROLLER AND CORTEX COMPUTER**

---

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OUR APRIL ISSUE WILL BE ON SALE FRIDAY, MARCH 11th, 1983
(for details of contents see page 5/6 of Micro-file)

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<tr>
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<th>Module Number</th>
<th>Output Power</th>
<th>Load Impedance</th>
<th>Distortion</th>
<th>I.M.D.</th>
<th>Supply Voltage</th>
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Bipolar Modules

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<td>240</td>
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Hi-Fi Separates

Unicases

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<thead>
<tr>
<th>HiFi Separates</th>
<th>Price incl. VAT</th>
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<tr>
<td>UC1</td>
<td>Preamplifier</td>
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<tr>
<td>UP1X</td>
<td>30W/4Ω stereo</td>
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<tr>
<td>UP2X</td>
<td>60W/4Ω stereo</td>
</tr>
<tr>
<td>UP3X</td>
<td>60W/8Ω bipolar</td>
</tr>
<tr>
<td>UP4X</td>
<td>120W/8Ω bipolar</td>
</tr>
<tr>
<td>UP5X</td>
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<td>UP7X</td>
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Power Slaves

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<th>Power Slaves</th>
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<td>US1X</td>
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<td>US2X</td>
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<td>US3X</td>
<td>60W/8Ω MOS</td>
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<tr>
<td>US4X</td>
<td>120W/8Ω MOS</td>
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</table>

Please note X in part number denotes mains voltage. Please insert 0 in place of X for 110V ~ 1 in place of X for 220V (Europe), and 2 in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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Dimensions: 105 x 130 x 40mm.

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- No photographic experience needed.
- Simple etching process.
- Economic aid simple to use.
- No expensive equipment required e.g. darkroom, cameras etc.
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- No expensive equipment required e.g. darkroom, cameras etc.
- No photographic experience needed.
- Simple etching process.
- Economic aid simple to use.
- No expensive equipment required e.g. darkroom, cameras etc.
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Now there’s the ZX Spectrum! With up to 48K of RAM. A full-size moving-key keyboard. Vivid colour and sound. High-resolution graphics. And a low price that’s unrivalled.

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The ZX Spectrum incorporates all the proven features of the ZX81. But its new 16K BASIC ROM dramatically increases your computing power.

You have access to a range of 8 colours for foreground, background and border, together with a sound generator and high-resolution graphics.

You have the facility to support separate data files.

You have a choice of storage capacities (governed by the amount of RAM). 16K of RAM (which you can uprate later to 48K of RAM) or a massive 48K of RAM.

Yet the price of the Spectrum 16K is an amazing £125! Even the popular 48K version costs only £175!

You may decide to begin with the 16K version. If so, you can still return it later for an upgrade. The cost? Around £60.

Ready to use today, easy to expand tomorrow

Your ZX Spectrum comes with a mains adaptor and all the necessary leads to connect to most cassette recorders and TVs (colour or black and white).

Employing Sinclair BASIC (now used in over 500,000 computers worldwide) the ZX Spectrum comes complete with two manuals which together represent a detailed course in BASIC programming. Whether you’re a beginner or a competent programmer, you’ll find them both of immense help. Depending on your computer experience, you’ll quickly be moving into the colourful world of ZX Spectrum professional-level computing.

There’s no need to stop there. The ZX Printer – available now – is fully compatible with the ZX Spectrum. And later this year there will be Microdrives for massive amounts of extra on-line storage, plus an RS232/network interface board.

Key features of the Sinclair ZX Spectrum

- Full colour – 8 colours each for foreground, background and border, plus flashing and brightness-intensity control.
- Sound – BEEP command with variable pitch and duration.
- Massive RAM – 16K or 48K.
- Full-size moving-key keyboard – all keys at normal typewriter pitch, with repeat facility on each key.
- High-resolution – 256 dots horizontally x 192 vertically, each individually addressable for true high-resolution graphics.
- ASCII character set – with upper- and lower-case characters.
- Teletext-compatible – user software can generate 40 characters per line or other settings.
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- Sinclair 16K extended BASIC – incorporating unique ‘one-touch’ keyword entry, syntax check, and report codes.
ZX Spectrum software on cassettes — available now

The Spectrum software library is growing every day. Subjects include games, education, and business/household management. Flight Simulation...Chess...Planetoids...History...Inventions...VU-CALC...VU-3D...Club Record Controller...there is something for everyone. And they all make full use of the Spectrum's colour, sound, and graphics capabilities. You'll receive a detailed catalogue with your Spectrum.

ZX Expansion Module

This module incorporates the three functions of Microdrive controller, local area network, and RS232 interface. Connect it to your Spectrum and you can control up to eight Microdrives, communicate with other computers, and drive a wide range of printers. The potential is enormous, and the module will be available in the early part of 1983 for around £30.

The ZX Printer — available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set — including lower-case characters and high-resolution graphics.

A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.

How to order your ZX Spectrum

BY PHONE — Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day. BY FREEPOST — use the no-stamp needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt — and we have no doubt that you will be.

To: Sinclair Research, FREEPOST, Camberley, Surrey, GU15 3BR.

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<table>
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* Please charge to my Access/Barclaycard/Trustcard account no.

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- Up to 4 x maximum time settings.
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- Programmable operation of a light or a control.

(Kit includes all components, PCB, assembly and programming instructions). ORDER AS CT3000

For a detailed booklet on remote control — send us 30p and S.A.E. (6” x 9” today).

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<td>S120A</td>
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<td>SX210B</td>
<td>4010 CDU 7400 type CDU</td>
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**3782: 6 Black Heatwells will fit 100 and 1020 Readers don't half price offer**

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**100: CAPACITOR PAKS**

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**385: BI-PACK SOLDER- DESOLDERER KIT**

**356: MORE BARGAINS**

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<tr>
<th>Part No.</th>
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<tr>
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**160: SIENRA AM/FM TRANSCEIVER**

**591: SINGLE SIDED FIBREGLASS BOARD**

**D51: TECASBOTY**

**3782: 6 Black Heatwells will fit 100 and 1020 Readers don't half price offer**

**35: 1 Power Soldering Iron Heatshrink**

**48: BI-PACK SOLDER**

**90: BI-PACK PCB ETCHING AND FABRICATION**

**100: CAPACITOR PAKS**

**510: SILICON POWER TRANSISTORS**

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**385: BI-PACK SOLDER- DESOLDERER KIT**

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BI-PAK BARGAINS

TRIACS - PLASTIC
4 AMP - 40V - SX64 - TIG 136G
2 AMP - 40V - SX67 - TIG 102G
60p

SLIDER POTENIOMETERS
All AT 50p PER PK

DOME TWEETER
Dome Tweeter for systems up to 50w Impedance 8 ohms. Frequency Response 2000-20000Hz. Dima 90mm dia. 15mm deep.
OUR PRICE £2.95. O/No. DMT200

MINIATURE TOOLS FOR HOBBYISTS

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SX64 5 A1k Lin

EXPERIMENTOR BOXES - ALUMINIUM - PLASTIC ALUMINIUM BOXES
Made with tough high polish construction with deep lid and screws

SEMINACOENTS FROM AROUND THE WORLD

100 A Collection of Transistors, Diodes, Rectifiers, Bridges, SCR's etc.

1 Amp SILICON RECTIFIERS
Glass Free straw (P402 SERIES) P4040 - 60p
-50p - without... p - play until to...-
All devices - 60p each
Within 100 - £1.00

BI-PAK'S OPTO 83 SPECIAL
A selection of Large & Small size LEDs in Red, Green, Yellow and Clear, plus shaped devices of different types. 7 Segment displays, photo transistors, emitters and detectors. Types like MEL11, FP100 etc. Plus Cadmium Cell ORP12 and germ. photo transistor D817P. TOTAL OF 25 pieces.

MULTITESTERS

1,000 mv Including test leads in Battery
Wattmeter - 0 - 150
DC volts - 0 - 150
AC volts - 0 - 300
DC Currents - 0 - 675
AC Currents - 0 - 50ma
Resistance - 0 - 30k ohms

SILICON BRIDGE RECTIFIERS
Comprising 4 x 15 amp rectifiers

SPECIAL OFFER OF STEREO AUDIO MODULES
Fully built and tested in our factory.

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70/92 Plastic case collector
Like BC 150/150 - 120p

DC VOLT METER WORKBENCH
Model 2740K - £2.50

POWER SUPPLY OUR PRICE £3.25
Power supply this morning any 15 amp socket
Unboxed for safety. Printed reversing switch voltage switch. Input with main plug.
Input - 240V AC 50Hz output - 1.4 5 6
Set - 7.5 6 12V & DC 300 Ma
VAM90

IC SOCKETS
The lowest price ever.

BI-PAK CARGO CHARGER
Universal £12 Battery charger in plastic case with lift up lid. Charge first switch.

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Power supply this morning any 15 amp socket
Unboxed for safety. Printed reversing switch voltage switch. Input with main plug.
Input - 240V AC 50Hz output - 1.4 5 6
Set - 7.5 6 12V & DC 300 Ma
VAM90

SECONDSALE

All components were unboxed.

SPECIAL OFFER FOR Sale £14
Our Special Offer Price For 1 MONTH Only

Send your orders by fax. P3 BI-PAK PO BOX 6 WARE HERTS.

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OUR PRICE £2.95

BI-PAK

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Send your orders by fax. P3 BI-PAK PO BOX 6 WARE HERTS.

OUR PRICE £2.95

BI-PAK

OUR PRICE £2.95
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Unit 4, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD.

**TELEPHONE ORDERS:**
Colchester (0208) 36412.

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WELCOME

### TRANSFORMERS
- **Bridging Transformer**: 100V to 100V.
- **Transformers**: 0-100V.
- **Output**: 0.1-100V.
- **Rating**: 100-1000VA.
- **Switchable**: 0-100V.
- **Input**: 100V-110V.
- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.

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- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.

### CABLES
- **Cables**: 0.1-100m.
- **Output**: 0-100V.
- **Rating**: 0.1-100V.
- **Switchable**: 0-100V.
- **Input**: 100V-110V.
- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.

### MINIATURES
- **Miniature**: 0.1-100m.
- **Rating**: 0.1-100V.
- **Switchable**: 0-100V.
- **Input**: 100V-110V.
- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.

### CIRCUITS
- **Circuits**: 0.1-100m.
- **Rating**: 0.1-100V.
- **Switchable**: 0-100V.
- **Input**: 100V-110V.
- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.

### MULTIMETERS
- **Multimeters**: 0.1-100m.
- **Rating**: 0.1-100V.
- **Switchable**: 0-100V.
- **Input**: 100V-110V.
- **Output**: 0-100V.
- **Transformer**: 100V-110V.
- **Output**: 0-100V.
feature in May—see next month's issue for details—and also expanding the range of our other articles. So instead of the free board, book, tool or component etc. every so often, which you may or may not want or use, you will get more info., more circuits and more reading each and every month.

PE COVERS
Next month you will also notice an immediate change when you buy your issue or when it drops on your doorstep. We are changing the style of our covers. In line with our future contents we are also putting more on the front cover, so if you are just browsing at the bookstall it should give you a better idea of just what is inside. We believe the new style looks more modern, exciting and colourful; your impressions would be interesting.

FEEDBACK
As we have said before we are pleased to hear your criticisms, likes and dislikes as this feedback helps us to produce a magazine which is just what you want. Feedback in the form of IUs and material for Microbus and Microprompt is always interesting and keeps the whole area of "hobby designs" alive.

In recent months the number of contributions to IU have tended to fall. They are always welcome and we should have more room for them from May onwards. So keep the ideas coming; we do pay for each one published at the rate of £40 per magazine page—enough to buy some more components anyway!

In line with our policy we are continually striving to meet the needs of our readers and, with your help, will continue to produce what we believe is the best magazine of its type available anywhere.
Computer Literacy Advances

It was on a wet Thursday back in January that the press responded to an invitation by the BBC to attend a preview and mini exhibition at the World Trade Centre, in London. The preview was of 1983’s ‘The Computer Programme’ Series Two, which by now is well under way. The mini exhibition featured the BBC microcomputer and its various peripheral and software options.

A number of exciting pipeline stage developments were in evidence. What was claimed to be the first public demonstration of telesoftware took place, during which a BBC micro was downloaded with a program from a CEEFAX page. The acquisition worked with simplicity and speed, a dynamic demonstration of how software can be transferred. The BBC has committed itself to the transmission of reliable and worthwhile software, the broadcasting of which commences this spring. Acorn Computers are to manufacture the telesoftware adaptors for use with any teletext adapted TV set. At the preview, the idea of a telesoftware club was mooted.

Among the many impressive extensions to the Acorn computer which were demonstrated, was the BBC Buggy, manufactured by Econometrics of Sheffield. The Buggy demonstrates the principles of intelligent machine control and robotics, and is delivered in kit form, requiring only a screwdriver to assemble it. This training tool is a small, compact unit capable of propelling itself around using two drive wheels, and which has on-the-spot turning capability. The Buggy’s party tricks include following a black or white line, seeking out a light source in a maze, exploring miscellaneous objects whilst mapping them on to a VDU, drawing its own lines, and a repertoire of barcode stunts, one of which involves composing music. The thirteen well thought out programs are completely modular, enabling the user to call upon them as if a subroutine library. Students following the National Extension College computer course will also be able to use the BBC Buggy.

Econet, Acorn’s LAN (Local Area Network) offers a cost effective link-up for the educational establishment, allowing communication by way of a four wire bus between, for example, the physics lab, computer and the school data base, and the mathematics class processor etc. Up to 254 stations may share expensive peripherals like printers and disc drives, thus creating every opportunity to save cash.

Among the BBC microcomputer interfaces are a digitizer pad, a teletext adaptor (CEEFAX and ORACLE), voice synthesiser (taken from the tones of newscaster Kenneth Kendall), disc storage system (up to 800Kbytes), and a second processor unit. This last addition doubles the processing speed by circumventing the need to interrupt calculations whilst outputting data. Data is transferred across “the Tube”. A 6502 or Z80 second processor may be chosen, the latter allowing CP/M operation. At the exhibition, a BBC micro with second processor busied itself designing ULA layouts!

Readers may like to know of the Information Referral service which is run in association with the BBC Computer Literacy Project. This is intended to put viewers in touch with local sources of advice, and provide information about the project. A large S.A.E. should be addressed to: BBC Computer Literacy Project, Broadcasting Support Services, PO Box 7, London W3 6XJ.

In their first step into the educational field Mitsubishi Electric have developed the ‘Sansu Meki-Meki’, a basic maths teaching aid aimed at pre-schoolers and primary school children. The unit has an LCD display which shows the questions and the child’s answers to them. The questions dealing with addition, subtraction, multiplication and division are shown in groups of ten. When the child answers correctly a tiny steam locomotive toots and chugs down a track and a voice synthesiser tells the operator that the answer is correct. If the wrong answer is given the locomotive crashes and a wrong answer is announced. A test score is given at the end of each group of ten questions, a three minute speed drill can also be incorporated. The unit can also be programmed to concentrate on weak points, or similarly add more difficult problems. The company plan further similar products for teaching language, as well as for other subjects for upper grade students, the unit is supplied with batteries and a mains adapter, the price is expected to be under £50.

MATHEMATICS EXPRESSED?

Following the launch of the CG1 chess computer Systema have now introduced two additional models into their range both with extra features. The CG1 unit had a built in sensory board and eight levels of difficulty for a retail price of under £80.

First of the new chess computers is model CG2 which has a full sized sensory chess board and pieces. The CG2 has all the features of model CG1 plus a ‘save’ switch to ‘freeze’ the game at any stage and retain the chess position in its memory until the player is ready to resume the challenge. Other features include keys for under promotion, taking back moves and to set-up or verify positions.

Also introduced is the CG3 travel chess computer. It combines the compact design of the original CG1 with the extra features of the full-size model CG2. The lid snaps into position to keep out dust and a special compartment is provided for the chess pieces. A soft carrying case is available as an optional extra.

The retail price of full-sized model CG2 will be around £50 and the CG3 travel model will be under £40.

Other features of all three models include changeable levels during play, changing sides during play, on passant captures, casting and pawn promotion.

Systema (UK) Ltd., 74/76 South Street, Reading, RG1 4LG. (0734 586429).

Government approval of British Rail’s plans to invest £21 million in new ticket issuing machines will soon bring BR’s ticket offices firmly into the microchip age. £17 million of the investment is for a new all purpose ticket issuing system, APTIS and the remainder, £4 million is for PORTIS a portable version of the main system for use by guards on pay trains. Subject to satisfactory evaluation of the prototypes the new machines should come into operation in mid-1984 and be fully established by the middle of 1986.

SYSTEMA CHESS COMPUTERS
HIS MASTER’S VOICE

The science of electronic speech synthesis is gaining ground rapidly, but speech recognition is hampered by a lack of precision in human articulation. We humans frequently experience difficulty in understanding one another, so how might an inflexible machine cope with the various dialects, or emotional undulations of an individual’s voice?

Marconi Space and Defence Systems have developed, with financial help from the DOL, a speech recogniser with a capacity of 240 words and/or phrases, costing £10,000. It is called the SR–128, and it uses dynamic programming to match voice input with pre-recorded voice commands, or templates as they are called.

The voice matching pattern for each user can be prepared in minutes by way of a learning routine in which the operator repeats his or her personal rendition of the control words, prompted by a 40 character plasma display. Data profiles of the user’s oration are then stored on minicassette. When in use, the SR–126 recognizes quite normal “connected” speech by dynamically pattern matching the content of its solid state memory. It is claimed that the number of active templates may be restricted by applying syntax rules. The system can recognize utterances of up to eight seconds duration, with a response time of 50ms.

There are both military and civilian applications, many of which would be airborne. An SR–128 is installed at the Royal Aircraft Establishment, Bedford, for map display and waypoint identification. Such systems will not only free pilots from physical switch manipulation when using peripheral equipment, but may one day completely outspan the flyer. The potential of machines like the SR–128 to ease the four-limbed juggling act of flying a helicopter is axiomatic.

Other applications include security, where response only to an authorised voice is necessary, be it for access to a restricted area, or ensuring that a vehicle is not illicitly commandeered.

JOYSTICKS

A new range of joysticks has been introduced by Midwich, made of high-quality injection moulded materials, these ergonomic designs fit comfortably into the hand. Each joystick or pair of joysticks is fitted with the appropriate connector for the machine in question, the range is aimed at the BBC micro, Dragon 32 and the Spectrum/ZX81. Since the ZX81 and Spectrum do not have a built-in A to D converter, Midwich have also designed a high-speed, 4 channel controller board, which plugs into the expansion slot. An edge connector is provided for RAM pack, disc drives, etc.

Prices as follows: ZX81, Spectrum and Dragon 32 £15.98 per pair, and for the BBC micro £13.00 per pair, the controllers being £22.95 each. All prices include VAT. All units available from Midwich Computers, Rickinghall House, Hinderclay Road, Rickinghall, Suffolk IP22 1HH (0379 898751).

The Kodak colour-corrected enhanced image system promises a kind of editing of photographs, in the home. Encoding of the film disc core would allow recomposed prints to be ordered by the consumer.

Disc Film! Square Eyes?

Kodak’s innovative disc camera has been described by the Consumers’ Association (Which? report Nov. ‘82) as foolproof but unimpressive in its photographic picture quality. It was summarized as being ideal for the average person wanting straightforward trouble-free snap shots. Eight million disc cameras, however, were estimated to have been sold at the close of 1982. Eight million people who prefer to have no knobs to twiddle before taking a photograph!

Kodak’s eye is still firmly on the future of popular photography. In Cologne, last October, the company demonstrated a possible future option in the shape of a video display unit which allows disc film images to be reproduced on a television screen. The demonstrator scanned a 15-image disc negative, enlarging them and cropping them, and showing the results on a 21 inch TV screen.

A remote control unit allows quick sequencing through 15 disc images under personal control, and facilitates zooming in on a section of image, or recomposing that image for a better view of one of its aspects. Scientists at Kodak say that this system would enable consumers to order prints of their own home-ordered pictures.

The heart of the prototype system is an extremely high resolution charge-coupled image sensor which converts and enhances the optical data ready for television display. A colour array of more than 350,000 elements produces a very detailed TV picture from each whole, or portion of the disc exposure. With a luminance signal bandwidth of greater than 3-5MHz, the potential for picture quality exceeds that of most television receivers.

The video display system is exploratory, with no commitment by Kodak as yet, to manufacture and sell the equipment.

Practical Electronics  March 1983
IC SOCKET

A low-profile i.c. socket, which locks the chip into position and also provides an ejecting action when the chip has to be withdrawn, is now available from Aries Electronics. The EJECT-A-DIP socket can be in 14, 16 and 24 pin configurations.

The socket incorporates a pivoting arm at each end. In one position, these arms lock the device into the socket and the arms are available in three heights to cover the various standard thicknesses of i.c.s. When the arms are pushed outward to release the device they also provide a lever action which ejects the i.c. from the socket without damaging the legs.

The socket itself has gold or tin-plated, spring-tempered, phosphor-bronze bifurcated contacts, designed to take both round or flat pins.

Aries Electronics, Unit E, Metrostore House, Eastways Industrial Estate, Witham, Essex. (0736 519318).

Briefly...

The president of National Semiconductor is often quoted as saying that if the progress of microelectronics over the past two decades was applied to the motor industry, a Rolls Royce would cost $2.75, do three million miles per gallon and deliver enough power to drive the QE2. By the look of things, Mr. Sporck’s Rolls Royce will soon have to fly to keep that parallel up to date, for the bioelectronic device is here—in the laboratory at least!

In the United States, a molecule that can exist in two states, and therefore represent a binary bit, has been successfully synthesised. Mississippi University would seem to be a mere heartbeat away from the birth of the molecular diode. A memory capacity of 1K using this technology would theoretically fit into a line only one micron long, it is reported. This breakthrough brings closer the day of implanted electronics, and its interface to living tissue.

COALS TO NEWCASTLE, FRIGIDES TO THE ESKIMOS, FAIR ENOUGH, BUT BRITISH ELECTRONIC EQUIPMENT TO JAPAN? WELL IT’S TRUE, AND WE HAVE THE THANDAR ELECTRONICS COMPANY TO THANK FOR THIS ENCOURAGING REVERSAL IN THE WAVES OF ELECTRONICS FROM THE EAST. THE EQUIPMENT IN THIS INITIAL ORDER, WORTH £100,000, WAS A QUANTITY OF LOGIC ANALYSERS AND WERE PURCHASED BY A “MAJOR” JAPANESE INSTRUMENT MANUFACTURER.

THE MODEL ORDERED, THE TA 2080, WAS FAVOURED BECAUSE OF ITS ABILITY TO OFFER A COMBINATION OF PERFORMANCE, RELIABILITY, QUALITY AND MOST IMPORTANTLY PRICE WHICH WAS, TO QUOTE THANDAR CHAIRMAN MR. TAYLOR, “UNBEATABLE EVEN IN JAPAN”. THE COMPANY BASED IN ST IVES, HUNTINGDON, EXPORT OVER 50% OF THEIR OUTPUT.

As if by magic, forecast figures are regularly conjured up which naturally find their way into the electronics press. Appearing in Electronics Times (2/9 Dec.), these figures are attributed to International Resources Development, whose study revealed the following: Sales of personal computers will rise from the current level of $1.3bn a year to $3.5bn, and then plunge to $480bn by 1992. Sales of the personal computer’s rival, the “multifunction workstation” will rocket from zero to $650bn in 1984, to $376bn in 1987, and on to $14bn in 1992.

Evidently computers are not so prone to misting over as tall, dark strangers.

POINTS ARISING...

STYLOCHORD (Dec. ’82)

The S024 Top Octave Generator may be replaced directly with the M083 device available from Maplin Electronics (order code YYB1C).

Fibre Optics April 19-21. Porter Tun Rooms, The Brewery (!), Chiswell St., London EC1 E

International Materials Handling April 19-26. Earls Court. I

International Packaging Exhibition April 25-29. NEC B/ham. I

HEVAC (Heating, Ventilation & Air Cond.) Apr. 26-28. Barbican. 0

Biotech May 4-6. Wembley. O

Micro City May 10-12, Bristol Exhibition Complex. F3


Defence Components Expo May 10-12. Metropolitan, Brighton. I

Welsh Amateur Radio, TV & Electronics Rally May 22. Barry Memorial Hall, S. Glam. C

Computers In The City (conf. & ex.) May 24-26. Barbican. 0


Laboratory Edinburgh July 18-20, Appleton Tower, Univ. E

Fibre Optics April 19-21. Porter Tun Rooms, The Brewery (!), Chiswell St., London EC1 E

A7 Institute Of Acoustics sq 031 225 2143

A8 Holographic Exhibitions sq 01 836 6423

A9 Reg. Rowles sq Cardif 356566

A5 Evan Steadman sq 0799 22612

F2 Pontefract & District Am. Rad. Soc. sq 0977 791071

F3 Tomorrow’s World Exhibitions, Bristol

I Industrial Trade Fairs sq 021 705 6707

K Douglas Temple Studios sq 0202 20533

L1 World Trade Cntr., Europe Ho., London E1

N Institute Electrical & Electronic Engineers

Online sq 09274 28211

T Trident sq 0822 4671

V1 Jack Tootill, Ipswich Radio Club

Z BETA Exhibitions sq 01 405 6233

Z1 IPC Exhibitions sq 01 643 8040

Countdown ...

Please check dates before setting out, as we cannot guarantee the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.


CAD North Mar. 1-3, Belle Vue Ex. Cntr., Manchester Z1


Local Networks Mar. 8-10, Royal Lancaster Hotel, London. O


Brighton Electronics March. T

BEX Leeds Mar. 16-17, Dragonara Hotel. K

INSPEX Mar. 21-25, National Exhibition Cntr. Birmingham International. Z1


Compec Wales Mar. 22-24, Cardiff University. Z1


Laboratory Manchester Mar. 23-24. New Century Hall, Corporation St. E

American Holography Mar.-June inc. Light Fantastic Gallery, Covent Garden, London. A8


Practical Electronics March 1983
Practical Electronics  March 1983

Space Watch...

MISSILE FROM MARS

Headlines were generated when a meteorite was discovered recently in Antarctica because it is the opinion of most of those who have examined it, that it is from Mars. At the Johnson Space Centre considerable excitement was demonstrated when the piece of rock weighing about 17.5lb was displayed. The characteristics are different from any previous bodies of meteoritic origin. Naturally it now raises the problem that there must be more of this material on the surface of the Earth. This sample was found by a team funded by the National Science Foundation, the Smithsonian Institution and the National Aeronautical and Space Administration.

At the moment the main problem being studied is the manner of this piece of another planet arriving and impacting the Earth. There are some dissenters that it is in fact from Mars but Laurence E. Nyquist, who has identified it, has shown that such an event is possible. He is head of the Planetary and Sciences Division at the Johnson Space Centre where his latest work was undertaken. His conclusions are based on the study of the Viking orbiter photographs. A number of the craters on Mars have a configuration which would indicate that they were made by the impact of bodies arriving at an oblique angle. It has been calculated that bodies of the size to have a velocity of the order of 7.88km/sec. would be scattered across the Martian orbit. The dynamics of the relative orbits of Mars and the Earth would certainly make it possible for material to fall as meteorites. The real question is how long it might have been in space. This is regarded as not longer than 2 million years. In that case it must have come from a large body nearby. The sample is large enough to support years of study. There is also a chance of getting a meteorite which has repercussions both in the personal and the political areas of the changing eating habits of the people who live in cities. There are a number of things which could assist the explanation of this trend. Indeed a great deal is going on in the areas of the changing eating habits of the communities. So much indeed that within a very short time it will be found that many projects will be set up and grants applied for the proliferation of useless knowledge. Perhaps a little exposure of some of the so-called research in the area of man and his environment will sort the valid from the invalid. As the Year 2000 approaches perhaps it will be possible to get feet set on a useful path which deals with the true reality.

NEW MINERAL FINDINGS

Some of the findings using the instruments of the second shuttle mission have now been published. It was possible to detect other clay minerals where in the previous observations from space only Laponite was really identified. Using the multispectral infrared radiometer in an area between Kharga and Aswan in Egypt, it was possible to identify exactly kaolinite a hydrous aluminium silicate clay mineral and another of the same group, montmorillonite. These are important finds because they are useful guides to the finding of ore deposits of iron. This new facility means that both topographical data and mineralogical data can be acquired simultaneously over wide areas. A first saving is then to halve the costs and time compared with previous geological surveys.

JOINT VENUS MISSION

Cooperation between Russia and France has been working very well and now the most ambitious project is being discussed regarding what might be called a massive assault on the problem planet Venus. The target date for this mission is 1989. A French statement indicates that there will be probes, landers and balloons used in this attempt. It is not deemed practical to land a moving vehicle at this time, mainly because more certain knowledge of the terrain is needed.

Leading up to the 1989 mission will be two others. The first will involve the Soviet Vega -- Venus/Halley Comet mission. Originally the French were to supply two large balloons with meteorological instruments which would be released into the Venusian atmosphere. Because of the modifications for the Halley Comet part of the mission the large balloons were later deleted. In place of them the Soviets are preparing two small balloons and the French are designing suitable meteorological instruments for attachment to the balloons.

A new project has been agreed and this will involve the launching of polar and equatorial satellites for the study of the Earth's atmosphere and ionosphere. This mission will be called Intercall.

Initial studies have begun on another project called Satellitte d'Astonomie Gamma, (SAGA) to study gamma ray sources. This was a mission offered to France by Russia. The final decision on this project was later dropped when for financial reasons they had to abandon it earlier in the year. The instruments already developed can be incorporated in the new satellite. It would seem that the Soviets are anxious to push this project, perhaps to beat the American mission for a Gamma ray observatory. The final decision on this project will be made at the next space reunion between the French and the Russians this year.

Frank W. Hyde
The brow of a hill; the dip in a country lane—each can cause surprise local freezing. With no change in lustre, a road can turn from being just plain wet to iced over. Building this device is a worthwhile project, for it will discreetly arm the driver with a piece of information which could save his life.

Many motorists have tales of skidding on so called "black ice", most of these, fortunately, without unhappy endings. It is possible to drive perfectly safely on ice, providing of course, that you know you are doing so. Cocooned in a car with the heater going, a driver can often fail to realise just how cold it is outside, and get caught by surprise when he tries to go in one direction and the car goes off in another.

The PE Ice and Lights Alarm can be put together for a few pounds, and as well as providing a visual and audible warning that the temperature outside is freezing, it also provides an audible warning that the car lights have been left on. The device can save you from both a flat battery and a flat car!

**OPERATION**

The unit operates as follows: If the ignition is switched on whilst the temperature outside is freezing, or the car is driven into a region where the temperature is freezing, then the unit will emit a bleep for about a second. An I.E.D. illuminates all the time the ignition is on and the outside temperature is freezing.

Also, if the ignition is switched off and the car lights are still on, the unit will emit a pulsed bleep for about two seconds. This is long enough to remind that the lights are still on, but not so long as to be annoying if this is intentional.

**CIRCUIT**

The circuit diagram is shown in full in Fig. 1. The temperature sensor is the base-emitter junction of a BC182L transistor. A silicon p-n junction has a temperature coefficient of about 2-2mV per degree centigrade.

A 78L05 voltage regulator i.e. supplies a stable reference voltage to the base of the sensor transistor, TR1, via a potential divider chain. When the sensor temperature is higher than zero, the threshold voltage of the transistor is low enough for the voltage on its base to turn it on. This removes the current from the base of TR2, so this is off, and so is TR3.

Should the temperature of the sensor drop, the base-emitter threshold voltage will rise, and there will not be enough voltage at the base to turn the transistor on. When this transistor is off, TR2 is turned on via R1. This turns on TR3 via R6, and hence the I.E.D. Resistor R5, and D1 provide a small amount of hysteresis, by reducing the base voltage of TR1.

When the car lights are off, the I.E.D. current passes through both R10, and R9 through the lights, and the I.E.D. glows brightly. When the lights are on, the end of R9 is at +12V, hence the I.E.D. is dimmed, to prevent dazzle at night. Diode D2 prevents the I.E.D. from being excessively reverse biased when the lights are on.

Resistor R13, C4, IC1a and IC2a form a positive edge-to-pulse converter. Pin 11 of IC2 has a positive going pulse of about one second duration following a 0 to 1 transition on pin 1 of IC1. This circuit is used in preference to the usual series capacitor one, as the latter puts a reverse voltage on the capacitor.

Fig. 2 shows the essence of the circuit, and Fig. 3 the associated waveforms. The input to the gate can be considered to be a logic '0' if the input is below the threshold voltage (approximately half the supply voltage). The output of a NOR gate is low if either of its inputs is high.

When this pulse output is high, this causes the output of IC2c to be low. This enables the oscillator IC2d and IC1d. IC1e and IC1f provide a bridge output drive to the ceramic sounder X1, giving 24 volts peak to peak signal here, producing a very adequate sound.

The remainder of the circuit is concerned with the lights left on alarm. D3 and D4 are included so that the circuit is powered from either the lighting, or the ignition circuit. The circuit has another edge-to-pulse converter, this time a falling edge is converted to a negative going pulse of about 2 seconds duration at the junction of R15 and D5. These two components give the equivalent of an OR function. The pulse occurs when the ignition input becomes low. If the lights are still on, then there is power to operate the rest of the circuit.

The pulse enables the oscillator IC2b and IC1c which operates at about 10Hz, and this gates the output oscillator on and off via IC2c.
CONSTRUCTION

Fig. 4 shows the p.c. layout for the P.E. Ice Alarm, and Fig. 5 the component locations. Leave the l.e.d. wires long if it is to be mounted in the box.

The sensor transistor, TR1, is fitted at the end of about two metres of wire, as this obviously has to be outside the car. Cut the transistor legs to about 6mm in length. Strip about 3mm from the connecting wire insulation and slide about 10mm of 1mm bore rubber sleeving over the wires. Carefully solder the black wire to the emitter of the transistor and pull the sleeving over the join. Repeat with the green wire for the base and the brown wire for the collector. Fig. 6 shows the transistor base connections.

Twist the three transistor wires together and thread them into 2 metres of 5mm bore PVC sleeving. Glue the transistor into the sleeving with the end of the transistor level with the end of the sleeving, and make sure that the end is water tight.
COMPONENTS...

**Integrated Circuits**
- IC1 4069
- IC2 4001
- IC3 78L05

**Transistors & Diodes**
- TR1, TR2 BC182L (2 off)
- TR3 BC212L
- D1-D5 1N914 (5 off)
- D6 3mm Red I.e.d.

**Capacitors**
- C1, C2, C6 100n 25V. Ceramic disc (3 off)
- C3 10u 16V. Electrolytic
- C4, C5 2μ 63V. Electrolytic (2 off)
- C7 1n 50V. Ceramic disc

**Resistors**
- R1 47k
- R2, R8, R9, R10 1k (4 off)
- R3 15k
- R4, R7 2k (2 off)
- R5, R15, R19 120k (3 off)
- R6, R12 10k (2 off)
- R11 47
- R13, R17, R1B 470k (3 off)
- R14, R16 1M (2 off)
- All resistors 1W 5% carbon film

**Potentiometers**
- VR1 500 preset

**Miscellaneous**
- Verobox type 21024
- Wire
- Sleeving
- Cable ties
- P.c.b.
- Adhesive pads
- X1 PB2720 Ceramic sounder

**Constructor's Note**
A complete kit of parts is available from: PIMAC Systems Ltd., 20 Bloomfield Road, Birmingham B13 9BY. Price £6.95 includes VAT and postage.

---

**Fig. 6. BC182L connections**

Drill the box base and the lid according to Fig. 7. Use a paper hole punch to make a hole in the centre of a 25mm square of double sided adhesive pad, stick the pad to the front of the sounder, with the holes concentric, then stick this to the inside of the lid of the box over the hole drilled.

Prepare another cable using 600mm of black, orange and yellow wires in 500mm of 5mm PVC sleeving. Thread this and the temperature sensor cables through the holes drilled in the box.

The p.c.b. will be held in the bottom of the box using more double sided adhesive pad, and the l.e.d. pushed through the small hole in the box. Do not fix it yet, though, until the unit has been tested. Connect up the sensor and power wires, and the wires to the sounder.

**TESTING**
Connect a source of power between the black wire (negative) and orange wire (positive)—a 9 volt battery will do for testing. Touch the yellow wire to the positive terminal for a few seconds, then to the negative terminal. If all is well, the unit will emit a pulsed bleep for about 2 seconds—this is the lights left on alarm.

Mix up some crushed ice and water, and stir it with the sensor for a minute or two. This will cause the sensor to be at 0 degrees centigrade. Leave the sensor in the water and slowly rotate the calibration pot clockwise until the l.e.d. just comes on. When this happens the sounder should operate for about a second.

If all is well, fit cable ties over the ends of the two cables to prevent them being pulled through the box, and stick the unit into the box. Pass the l.e.d. through the hole in the side of the box, and screw on the lid.

**INSTALLATION**
Fit the box to a suitable place on or under the car dashboard using more adhesive pad. Thread the wires under the dashboard, this can often be done through the windscreen demisting vents.

Connect up the power cables as follows:
- **Black** Chassis
- **Orange** Side lights or panel lights
- **Yellow** Ignition power

Thread the sensor cable through into the engine compartment, then into a position under the car, where it will not be in the air stream from the radiator, for example. Fix it securely in place. Keep the cable away from hot parts of the engine and the ignition wiring. Use cable ties to hold the cable in place.

**POSITIVE EARTH VEHICLES**
The circuit is designed for use with vehicles having a negative earth system. The easiest way to adapt the circuit for positive earth is to reverse everything. Thus, fit all the diodes and electrolytic capacitors the other way about. Use a 79L05 in place of the 78L05 (but be aware, the pin-out is different), and use a 4011 i.c. in place of the 4001 for IC2. In addition, cut the p.c. tracks to pins 7 and 14 of the i.c.s, and reverse them. Use BC212L transistors for TR1 and TR2, and BC182L for TR3.

---

Practical Electronics March 1983
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PROGRAMMABLE FUNCTIONS

THE Microcontroller keyboard has two keys labelled "PF1" and "PF2" whose use has not so far been discussed. These keys can be configured to provide two user-definable function keys, instead of the dummy functions which are pre-defined by DISBUG at start-up. After power-up, or restart, pressing PF1 or PF2 causes a display with a prompt of "1" or "2", respectively, with the next key depression causing a return to the "...DIS..." prompt.

The map of the DISBUG RAM region shown in the first datasheet indicates that there are two two-byte stores labelled PF1SRA and PF2SRA which start at locations 03F2 and 03F0, respectively. These are used by DISBUG to hold the start addresses of two subroutines which will be called by the command processor to service the PF1 and PF2 keys. The initialisation values in these two stores are the same (F964), and point to a default service routine within the monitor. Each pointer may, however, be changed using the memory editor to point to an alternative routine (usually in RAM) to perform a special function.

As a demonstration of this facility, changing the contents of PF1SRA from F964 to F98F will redefine PF1 to behave exactly the same as the RESTART key. It should be remembered, however, that PF1SRA and PF2SRA will both be restored to their initial values following a power interruption or a restart.

DEFINING USER FUNCTIONS

Fig. 1 shows how a user function routine must be structured. When PF1 or PF2 is recognised by the command processor, the "1" or "2" prompt will be displayed, and the key code will be passed to the command processor, the "1" or "2" prompt will be structured. When PF1 or PF2 is recognised by the command processor, the "1" or "2" prompt will be structured. When PF1 or PF2 is recognised by the command processor, the "1" or "2" prompt will be structured. When PF1 or PF2 is recognised by the command processor, the "1" or "2" prompt will be structured.

The routine listed below is one which can be used to redefine PF1 to provide a display of the current value of the real time clock. DISBUG maintains a count of seconds since power-up or restart in RAM location called TICK; the count is two-byte, and can thus indicate up to approximately 18 hours. Pressing the PF1 key will cause the seconds count to be displayed as four hex digits, and the display will be updated with the new value every time the "...DIS..." prompt. To use the function, enter the routine in RAM using the memory editor; the routine is relocatable and so may be placed in any convenient memory space. Then, use the memory editor again to set PF1SRA to point to the start of the routine in register A. The routine may choose to overwrite the prompt (see datasheet 3), depending defined function routine once for each keystroke, so the number of calls may usefully be counted to keep track of where the function has reached. DISBUG uses the CSW store to hold such a value, and calls an appropriate lower level processing routine (using a look-up table) to process each key entry in turn. Other functions which are performed by DISBUG, and hence are not required within the user routine, are keyboard scanning, decoding, code conversion, latching (looking for new key depressions), and display driving. The user-defined function routines will use the DISBUG stack by default, and may assume that there are eight bytes free on entry; real time clock interrupts and further subroutine levels may, however, extend stack usage into the user stack area. If necessary, therefore, the user stack should be redefined to start at 0390 (rather than 03A0) at the start of the user program by coding LDS/#0390 (BE 03 90) as the first instruction.

REAL TIME CLOCK FUNCTION

The routine listed below is one which can be used to redefine PF1 to provide a display of the current value of the real time clock. DISBUG maintains a count of seconds since power-up or restart in RAM location called TICK; the count is two-byte, and can thus indicate up to approximately 18 hours. Pressing the PF1 key will cause the seconds count to be displayed as four hex digits, and the display will be updated with the new value every time the "...DIS..." prompt. To use the function, enter the routine in RAM using the memory editor; the routine is relocatable and so may be placed in any convenient memory space. Then, use the memory editor again to set PF1SRA to point to the start of the routine. The new function is now ready for use.

![Real time clock display routine](image)

Readers may wish to experiment further with this example by using PF2 to allow the seconds count to be reset to zero or, more difficult, allow the count to be set to pre-defined value. It should be remembered that power-up and restart will reset the values of TICK, PF1SRA and PF2SRA, but that any code written in RAM should be preserved and thus may be reactivated by re-writing the pointers in PF1SRA and PF2SRA.

M. Tooley BA and D. Whitfield MA, MSc
THE frequency meter published in Practical Electronics in May '82 was designed to measure radio frequencies up to 600MHz, and for the necessary resolution, 8 digits were needed. However, there are many occasions when much lower frequencies need to be measured, and only 4 1/2 digits would be perfectly adequate, this project aims to cater for these needs. Intersil produce a series of 4 1/2 digit counters: 7224, for l.c.d.; 7225, for l.e.d.; (and 7236 for vacuum fluorescent), and details will be given as to how to use either of these. Complicated logic could be designed to provide the necessary store, reset and inhibit pulses, but a much neater and more convenient solution is to use another Intersil device, the 7207A, designed specifically for this function. The chip requires a crystal frequency of 5.24288MHz, and will give 0.1, and 1 second gates, as well as the necessary pulses to control the main counter. Fig. 1 shows the block diagram of the meter.

HOW IT WORKS

The complete circuit diagram of the meter is shown in Fig. 2. The input frequency is fed via blocking capacitor C1 to the input of IC1, a CMOS op-amp connected as a comparator with hysteresis. The other input pin is d.c. biased with R2 and R3, whilst R5 and R6 provide a Schmitt trigger with approx. 0.1V hysteresis, changing state at 2.45V and 2.55V (assuming a 5V supply), to give some protection against noisy input signals. The output from the op-amp consists of square waves at the same frequency as the input, and these go via S2a (explained later) into the input (pin 32) of the counter IC2, that will drive the I.c.d. display direct. This has count inhibit, reset, and store pins on 31, 33 and 34 respectively, and these all require a pulse to OV to operate, but in a specific sequence.

First the count inhibit must go high so that the counter is enabled. At the end of the gate time (0.1 or 1 sec) this must go low as the store pin goes low to update the output latches, then the reset pin must go low to finish the sequence ready for the next count. The 7207A produces all the necessary pulses in the right order, with the exception of the count inhibit pulse which needs to be inverted. This is performed by one gate of IC5. The 7207A has its own built-in oscillator, requiring a crystal between pins 5 and 6, and two capacitors, which allows trimming to 5.24288MHz. There is also a multiplex frequency output of 1.6kHz but this is not used. The count inhibit pin is also used to control a pnp transistor that activates an I.e.d. to show when a count is in progress.

The outputs from the 7224 are connected direct to the display segments, with the backplane pin of the display connected to pin 5 of the 7224. Whilst the meter was intended primarily for the audio range, 0–20kHz, it is very easy to insert a switch and a 4017 to divide the incoming square waves by 10, enabling much higher frequencies to be measured, with a 10Hz resolution. S2 is a double pole switch, and the second pole is used to enable another gate of the 4070 to invert the backplane frequency and activate...
Fig. 2. Complete circuit diagram of the Frequency Meter

one of the 'flags' incorporated in the display to show that the prescaler is activated. Fig. 3 shows what pin is connected to each 'flag', and the author chose to use pins 2 and 39 to give a divide (-) sign, but this is simply a matter of preference.

The power supply, if included, consists of a 0-6V 250mA p.c.b. transformer, smoothing capacitor and 5V regulator, with C6 and C7 included to aid stability (Fig. 4). The current consumption of the unit is very low, using all CMOS devices, and battery power is a realistic possibility...e.g. a PP3 9V battery connected to the input of the regulator. BE WARNED...the maximum supply voltage for the counter is 6V. When a battery is used R12 and D4 can be ignored to conserve battery power. If readers would prefer an I.e.d. display (non-multiplexed), the 7225 can be used with exactly the same circuit and p.c.b., except that pin 36 must be grounded (via the pads provided on the p.c.b. for a link), and pin 5 changes from being the backplane pin to a brightness pin (+V for max, 0V for min). A variable brightness control can be provided if a 100k pot is connected across the supply, with the wiper to pin 5. Otherwise, display segment pins are the same. The second pole of S2 can then be used to switch on an I.e.d as an indication of which range is in use.

For those readers who would like to use a vacuum fluorescent display, the 7236 can be employed, with minor changes to the p.c.b., however, the power supply requirements are more complicated, and constructors are advised to consult the Intersil data before selecting this option.

CONSTRUCTION

Constructors are advised to use a p.c.b. for ease of construction, and a suggested design is given in Fig. 6 with the component layout shown in Fig. 7. Mount the components,
ensuring correct polarity where necessary, and then check the board before mounting it in the case using two bolts and spacers. The interconnections were made using ribbon cable and Veropins and if done carefully there should be no problems. A SUE series switch bank from Ambit was used and the front panel was drilled and cut according to Fig. 5 and the bezel, i.e.d.s etc were mounted. In the prototype, two types of input sockets were included: a phono, and two 4mm sockets, but this is of course dependent on individual requirements. The rear panel was drilled to accept the mains lead strain-relief bush, and then all the necessary connections were made according to Fig. 8. After a final check the
unit can be switched on, calibrated against a known frequency, and then the case can be bolted together.

CONCLUSION

With no incoming signal, the unit will probably read 50 (mains pick-up), but this will disappear as soon as a signal is applied. Please note that the 'low' input of IC1 is not at earth potential and so should be isolated if an earthed metal case is used. The unit will easily read up to 100kHz, depending on amplitude, above which it is suggested that readers build the 8 digit meter. On the 0–20kHz range, if a frequency above 20kHz is applied, the 7 digit will remain lit, and misleading results will be displayed. To avoid confusion, it is suggested that readings always be made on the high range to start with, and then switched down if necessary.
DIGITAL TV

If anyone out there is still convinced that the current craze for microprocessors and digital circuits is nothing but a passing fad, I may have some bad news for them, because yet another analogue circuit bastion is about to come under siege, and this time battle will be joined right under our noses in the living-room TV set.

Of course, we have already seen some peripheral skirmishing and some easy victories for the digital cavalry in the form of the first teletext and remote control irregulars, but the latest onslaught will strike right to the very heartland of analogue circuitry, where defences were once thought to be impregnable.

The strike force now being assembled by ITT comprises six divisions of battle hardened VLSI digital chips armed to the teeth and ready to take a few of the blighters with me at least!

BIG BUBBLE

Imagine your pet microcomputer shorn of that troublesome cassette recorder and running a full blown disc operating system with half a megabyte of available storage to hold your compiler, word processor, and space-invader software. Nice thought, but a double-density mini-floppy disc drive is likely to result in a second mortgage or a divorce, and then there are all those motors and heads and drive belts to go wrong, so maybe cassettes aren't so bad after all.

But wait! There is an alternative way to that CM/P Utopia you have long dreamed of, in the form of a big new bubble chip from Intel. Hot off the press, their monster new bubble memory, the 7114, offers 4 million bits of non-volatile storage capacity on a chip about half an inch square living in a small 20 pin package.

Bubble memories don't use capacitors or flip-flops to store data like other semiconductor read/write memories. Instead they store data bits as microscopic magnetic loops formed on a magnetic substrate manufactured using a similar fabrication technology to that developed for more conventional devices. Although they operate in a mainly serial mode, more like a floppy disc than a RAM chip, the time to reach a random data item is much shorter than anything that can be achieved with an electromechanical device such as a disc drive, with the 7114 achieving an average access time of only 40 milliseconds.

Perhaps the two most important advantages of bubble memories are their high storage density and their ability to store data without power for long periods, and these features make devices like the 7114 an attractive proposition for disc replacement. The big disadvantage of bubbles is that each chip is expensive, so it is usually uneconomical to make them removable like discs. This could be overcome by loading data into the bubble initially from say, a cassette, a process which would only be necessary occasionally when system software needs to be changed or expanded.

In the 7114, data is stored in 8 octants, each of which has 80 minor loops of 8,192 bits for a total of 4,194,304 bits of storage capacity. Also on the chip are some spare storage loops and a "boot-loop" which is programmed by the manufacturer with information on any faulty loops which testing shows up. During system initialisation, the contents of that boot-loop are read by the 7224 bubble memory controller chip (also available from Intel) which subsequently patches in spare loops to make good any deficiencies.

It is too early to find a 7114 based bubble-disc system available for general use on home computers, but I think we can expect to see one before too long.

LOSS LEADER

Power transistors using MOS rather than bipolar technology have been around for several years now, and their high input impedance and fast switching capability has enabled them to replace bipolar devices like the famous 2N3055 for many applications.

One problem that these MOS devices have always had however, is that when used as a switch, their "ON" resistance has been rather too high for comfort, and certainly a lot higher than that of comparable bipolar transistors. A high "ON" resistance can impose unacceptable losses in some applications, so MOS device manufacturers have been trying hard to improve matters.

A new device in the Siemens SIPMOS power family, the BU215, seems to have the measure of the problem since it sports an RDS_. of only 30 milliohms. This new capability will undoubtedly open up many new applications areas for MOS devices, especially where power has to be switched with the minimum of resistive loss. The BU 15 is a low voltage device for use in 50 volt systems, but in the SIPMOS range there are about 60 different devices, with some operating up to 1kV. One application worth considering is the remote digital control of car lighting systems to reduce the wiring costs, but no doubt there are many others.

AVAILABLE

Devices featured in Semiconductor Update should, under normal circumstances, be available from good component retailers, but bear in mind that retailers will often not receive stocks of a device until some time after it has been featured in Update.

R.W. Coles

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Floppy disc drives

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Getting it Wrong

Sixty years ago when Henry Ford's mass-produced, cheap, universal car (the Model T) was rolling off the production line he saw it as a tool of liberation for the common man. He went even further, forecasting that when the automobile became as numerous in Europe and Asia as in the United States there would be no more war. The automobile, he proclaimed, was the product of peace.

In the event the internal combustion engine became the prime mover in modern warfare and a prime cause of violent death in peacetime, some 8,000 killed on the roads in the UK last year.

Industrialists, of course, tend to be engrossed in the quality of their products, their marketing, and profit. Ford made a fortune through knowing his job. A clever man but not perhaps in the first rank of great thinkers.

Let's then switch to an acknowledged great thinker, an economist who had little interest in money except in its redistribution. Although Karl Marx was buried 100 years ago his name lives on, respected, revered or reviled according to political taste. He developed a political and economic theory from social conditions prevailing in Western Europe and more specifically from observation of industrial activities in England, in his day the great centre of the 19th century industrial revolution.

Marx held the conviction that a communist revolution could come only from an industrial society, spearheaded by workers. In fact the revolution came in pre-industrial Russia, subsequently in peasant China and other non-industrial countries. Apart from inspiring a diluted form of socialism, communism has had little impact on industrial Western Europe and, in the UK, which Marx imagined to be fertile revolutionary ground, the impact has been least of all.

Henry Ford got it wrong because the great massacre in the trenches of the 1914-18 war was still fresh in the mind and, in 1923, nobody anticipated the appearance of Adolf Hitler. Similarly, Karl Marx was a creature of his own time seeing only the then long hours and drudgery of factory life. He can be excused for not seeing that in an enlightened capitalist society a production line worker might enjoy the same or Detroit would enjoy in years to come a far higher standard of living that he himself enjoyed or even dreamed about. And, moreover, a standard superior to that achieved by ordinary people in what Marx had conceived as a worker's paradise.

Guessing

It is possible for us, in the late decades of this century, to be more perceptive? We now have the benefit of instant worldwide communications plus advanced electronic data processing of statistics gathered yearly, weekly, daily, even hourly. Economists, social scientists, defence experts have constructed computer models to handle their respective data to predict the outcome of events. Yet with all this elaborate apparatus, as an end result we only have general trends, feeble guides easily distorted by disturbances that can and do happen almost anywhere.

Looking back to only three years ago I find I was not reporting unemployment. The great topic then was the oil crisis and how alternative energy was needed for salvation. Today the world is awash with oil. There is rationing at the wells in an effort to maintain prices instead of rationing of use at the filling station. Nobody with or without computing aid foresaw such a complete reversal. Equally, nobody predicted the Iranian revolution, the invasion of Afghanistan, the Iran/Iraq war, the Falklands war, the Israeli thrust into the Lebanon, Solidarity and martial law in Poland, or East/West warmish detente degenerating to an approximation of cold war. All these affected international trade and continue to do so.

Who, three years ago, predicted 10 million unemployed in Western Europe, 10 million jobless in the United States? Or that oil-rich Mexico would become virtually bankrupt, not to mention most of South America, large parts of Africa and the whole of Eastern Europe?

Such is the fragility of society that modern economic forecasting with all its electronic aids is little more than guessing, the computer today's equivalent of the crystal ball, an aid to concentration. A recent comparison of Treasury forecasts for 1983 with those of three respected independent teams, all using computers and economic modelling, revealed none of the leading economic indicators in agreement though they had a common trend. None were sufficiently up-to-date to reflect an unforeseen fall of five percent in the value of sterling.

Productivity

In the ocean of uncertainty that has afflicted us in the past three years the only consistent current has been the good overall performance of the electronics industry, predicted throughout in these columns without aid of computer but with little fear of being proved wrong. A pity that the NEB-backed electronic office company Nexos floundered with a write-off of £34 million of taxpayers' cash, but heartening to see ICL pulling back into profit. But, viewed as a whole, electronics has been and is the only major growth sector in manufacturing industry.

The snag is that all the expansion in turnover, profits and order books does not lead to a corresponding increase in employment in the industry itself. At shop floor level the old hand-wired products have disappeared and with increasing use of LSI and VLSI the labour content ever decreases.

Even worse from the national and political viewpoint, a substantial proportion of the output is skilfully designed to put people in other industries out of work in the interests of productivity gains.

It is interesting to note that even now, after massive shedding of labour in the older industries, Britain is only 13th in the world league table for competitiveness, actually slipping back a place on the previous year. It is little comforted in West Europe slipped worse, from 8th to 15th, or that New Zealand slumped from 10th to 20th place.

Leaders are Japan, Switzerland, USA, West Germany, Canada and Australia in that order according to the European Management Forum which uses a complicated formula reported to consist of 245 criteria to arrive at their conclusions. When crowing about productivity gains we too often overlook the probability that all our competitors are making similar progress. We have to run to stand still in relative terms. We need to run even faster to gain on the leaders.

On the employment front the one heartening aspect is the apparently insatiable demand for graduate electronics engineers and applied physicists, particularly those with expertise in microprocessor hardware and software, and in telecommunications.

Offshore

Electronics has done well for North Sea oil and has done well out of it in exploration, monitoring, control and communications equipment. A typical oil platform can have as many as 20,000 information points to provide an operational overview and malfunction alarm system, with input data constantly scanned and analysed by computer. The experience gained in the hostile environment of the North Sea has snowballed into export orders from other parts of the world.

A general misconception is that Britain has now an oil-based economy. True we are listed in the top ten producers of North Sea oil and have done well out of it in exploration, monitoring, control and communications equipment. But offshore oil and gas together represent only some five percent of our Gross National Product, less than the construction industry and a mere fraction of that of manufacturing industry. In fact, despite present difficulties, we remain relatively a rich country with a well-diversified economic base.
Demonstrating the ‘Experimentor’ breadboard system from GSC with a combination protected two tone case alarm by R. A. Penfold

If you have never built projects before and particularly if you have never tried a solderless breadboard this is for you. For qualification, a breadboard is a basic framework on which electronic components can be mounted and wired for preliminary circuit tests, so called because the foundation units were actually wooden breadboards. However, with the ‘Experimentor’ System from GSC featured here we have moved far from this rudimentary description.

The most fascinating aspect of solderless breadboarding is that designs can be conceived or copied and their applications explored with the promise of total component retrieval at the end. This means that the suitability of a published circuit for a particular role can be explored or rejigged before hard-wiring.

The key feature of the ‘Experimentor’ breadboard is the basic connector. This is slotted to form five independent pairs of sprung fingers which are placed behind a row of holes in an insulating carrier. The five contacts are electrically common, that is, any leads plugged into the same group are connected together.

Beside the groups of common contacts run the two supply lines made up of parallel strips of connector.

The hole spacing on the board makes up a 0.1in. grid which is compatible with virtually all electronic component mounting arrangements. A 0.6in. centre channel allows the mounting of integrated circuits and other devices with wide spaced leads.

THE SYSTEM

The Experimentor System (Model Exp-304) consists of the breadboard, two pre-etched pre-drilled p.c.b.s and a 50 sheet Scratchpad with each sheet printed with a full sized layout of the hole and connection pattern of the breadboard on which design layouts can be recorded. This means that the p.c.b.s can be loaded from the breadboard and soldered once a design has been finalised.

A simple circuit is now presented to demonstrate the system. To gain familiarity you should try to relay the design to the free Scratchpad with the intention of cutting back on link wires and board space used. It can then be built on a breadboard and tested.

This unit is designed for use in a brief-case, shopping bag, etc., and an audible alarm is activated if someone opens the case or bag in which it is placed. It could also be used in a cupboard or drawer in which valuables are stored. The alarm is triggered by a transition from darkness to relatively bright conditions, and modifications to the case (or whatever) in which the alarm is used are therefore unnecessary.

The circuit has both switch-on and switch-off delays so that there is time to place the unit in the case and close the case before the alarm becomes active, and there is a short delay before it sounds once the unit has been triggered. This gives the user time to switch it off before the alarm operates. The switch is a simple combination type so that there is no easy way for anyone who is unfamiliar with the combination to quickly switch the unit off.
THE CIRCUIT

Fig. 1 shows the block diagram of the Case Alarm.

A photocell is used to monitor the light level and it triggers a monostable multivibrator when a suitable increase is detected. However, a delay circuit is coupled to the monostable and prevents it from operating until a few seconds after switch-on so that the delay is obtained. The two-tone audible alarm is operated from the output of the monostable, but another delay circuit is connected between these two stages so that the switch-off delay is produced.

The alarm would normally be switched off soon after it has sounded, but it will anyway after about one minute since this is the length of the output pulse from the monostable.

The full circuit diagram is shown in Fig. 2.

IC1 is used as the basis of the monostable, and the 7555 is used in preference to the standard 555 because of its lower current requirement. This gives the circuit a current consumption of only about 90 microamps and enables the circuit to be powered economically from a small (PP3 size) 9 volt battery.

At switch-on C3 is uncharged and zero volts is supplied to pin 4 of IC1, thus preventing the monostable from functioning since an input potential of about 0.5 volts or more is needed at pin 4 of IC1 in order to permit normal operation of the monostable. C3 charges by way of R5 though, and after about ten seconds the potential fed to IC1 pin 4 from C3 (via the potential divider formed by R6 and R8) is sufficient to give normal operation of the monostable.

R1 and photocell PPC1 form a potential divider connected across the supply lines, and with the cell subjected to dark conditions there is virtually the full supply potential at their junction due to the consequent high resistance of the latter. If PPC1 is subjected to a transition from dark to light conditions a negative signal is produced due to the large fall in its resistance. This signal is coupled to the trigger input of IC1 by C1 and the monostable is activated. R2 and R4 bias IC1's trigger input above the trigger threshold voltage under standby conditions.

R2 and C2 set the nominal output pulse duration at a little...
over a minute, and the alarm signal is switched off at the end of this period. The circuit as a whole is not switched off though, and the unit will be retriggered if PCC1 is again taken from dark to light conditions. If preferred, the automatic switch-off feature can be eliminated by omitting R3 and replacing C3 with a shorting link.

ALARM SIGNAL

The two-tone alarm signal is generated by two CMOS astables which use the two input NOR gates of IC2 in a well known configuration. IC2c and IC2d are used to generate an audio frequency squarewave signal at a frequency of about 2kHz or so, while IC2a and IC2b are used as a low frequency (about 2Hz) astable which generates a squarewave modulation signal. The output of the modulation oscillator is coupled to the input of the tone generator via R13, and this provides frequency modulation with the tone generator being switched either side of its normal operating frequency.

The output of the tone generator is fed to a piezoelectric transducer which is very efficient at the frequencies involved here, and gives a reasonably loud alarm signal despite the limited output current available from IC2d.

Under stand-by conditions the output of IC1 is low, TR1 and TR2 are cut off, and the positive supply is not applied to the alarm generator circuit. When the unit is triggered and IC1’s output goes high, TR1 is biased on and in turn biases TR2 hard into conduction so that the positive supply is fed to the tone generator circuit and the alarm sounds. However, there is a short delay while C4 charges via R7 to a high enough potential to bring TR1 into conduction, and this gives a delay of about two seconds between the circuit being triggered and the alarm being activated.

When the unit is switched off D2 largely discharges C4 into the supply lines and D1 similarly discharges C3. C2 discharges via internal circuitry of IC1. The circuit is therefore ready to operate properly as soon as it is switched on again.

The on/off switch is actually two six way rotary switches connected in parallel, and each switch only cuts the supply in one of its six positions. It is therefore necessary to have both switches in the correct position in order to turn off the alarm. Without knowing in advance which is the correct position for each switch it is obviously impossible to quickly find these positions, and nothing more elaborate than this simple combination lock technique is needed in this application.

IC2 is a CMOS device and the appropriate handling precautions should be taken when dealing with this component, but as it is a very inexpensive device it is probably not worthwhile fitting it in an IC socket. IC1 is also a CMOS integrated circuit, but as it has a very effective internal protection circuit it does not require any special handling precautions.

When checking the completed unit bear in mind that it responds to a change from dark conditions to comparatively bright conditions after the switch-on delay has elapsed. Simply switching the unit on and leaving it in a normally lit room, or taking the unit from darkness to light immediately after switch-on will not result in the alarm being triggered. ★

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**Fig. 3. Wiring diagram**

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**Photograph of the built breadboard**
FEW people realise that the increasingly popular industrial robot has been in working existence since 1962; the result of a patent filed in 1954 by George Devol and the business acumen of Joseph Engelberger. However, much of the literature we come across today is not so much concerned with these chmb, re-programmable, open-loop machines, but with the ‘sensible’ or second generation robots—these are the impetus behind the recent upsurge of robotic interest. The initial stages of robot development have already passed, the next stage of growth is in robot intelligence and its associated ‘intelligent’ functions.

The first point, which must by fully appreciated, is that robots are machines and, providing our ethics are stable, always will be. As machines they are provided with a limited intelligence in order that they may make a number of valid decisions and thus reduce human intervention to a minimum. In other words robots are versatile machines which can work on their own. To achieve this the robot can be on one of two possible levels of development: The first generation robot, as mentioned above, is generally senseless (n.b. it has an open-loop control system). The operation of such machines depends upon the robot’s repeatability—the action of repeating tasks over and over with little or no loss in accuracy. The open-loop system assumes good repeatability and thus assumes a specific and constant output will be achieved for a given input. Hence, first generation robots fall short of our requirements: Being open-loop they have no feedback concerning the actual output and, the robot has no knowledge or perception of either its surroundings or its workpiece.

The second generation is attempting to overcome this unawareness by equipping machines with senses and applying artificial intelligence techniques in order that the senses may be used in a human-like manner. In a nutshell, the most critical element in robotics is the interface with the environment, both in sensing (input) and manipulating (output). Until recently the current technology offered much on the output side but was lacking considerably on the input interface. Obviously the direction for research and development is in the application of sensors, the question therefore is how?

HUMAN MODELLING
The human being is the best all round example of a perceptive, receptive and reactive control system. Because of this engineers are continually looking towards the human ‘modus operandi’ for solutions to robot design. First generation robots based many of their characteristics on the human arm (Fig. 1). For example many robots can swivel and sweep about a shoulder joint, bend at the elbow, bend and swivel at the wrist, and have various hands fitted (end-effectors). Naturally, second generation robots are inspired by human senses and the operating mechanism of the brain.

Each of our senses is dependent upon a particular, dedicated sensor mechanism which converts informative stimuli from the environment into electrical signals for the nervous system, and thence processed in the brain. The extremely complex arrangement which constitutes the human sensory system can be summarised according to the type of physical input and hence the corresponding response mechanism evoked. They are:

VISION
The perception of electromagnetic radiation in the 400–760 nm wavelength.

HEARING
The perception of oscillations of air pressure in the 20–20kHz frequency band.

TASTE/SMELL
Chemoreception of odorous molecules.

TOUCH
a) The perception of physical contact
b) The perception of electromagnetic radiation in the form of heat (>760 nm wavelength).

Fig. 1. Anthromorphology of a robot arm
All these sensory mechanisms are also capable of providing the associated direction of a particular stimulus, the reason being that more than one receptor acts at any one time and thus the brain is able to compare stimuli within both dynamic and directional frames of reference.

To generalise, the ability to detect a stimulus, find its range and to determine its relative direction are both necessary and sufficient for the intrinsic intelligence of the control system to respond to, and interact with. The greater the amount of useful data supplied to the controller, then the more complex an interaction is possible to increase the complexity of the workpieces and their orientation, handle a variety of components, and cope with non-uniform backgrounds (e.g. picking single components out of a bin of many types of workpieces all mixed together).

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Experimental robotic hand and arm (Courtesy of Southampton University)

**Fig. 2. Comparison between human and machine vision**

The process which gives sight to robots is directly based on the human model. This consists of a lens, receptor and control unit (Fig. 2). Our control over such a system is unconscious, but to a computer there are two major problems: Firstly the scene has to be analysed into a number of discrete areas, each of which must be quantified according to the system's operating parameters. These are a series of rules which are valid for interpreting the nature of the image. By 'nature' we mean the length and position of boundaries between objects, light intensity, surface orientation to the camera, reflectance, etc. Secondly, all this data has to be analysed to make a tangible 'picture'. This is usually a vast amount of input information. For a single television picture, in colour, approximately 1Mbit of data is required for digital transmission (e.g. 1 page of PRESTEL, TELETEXT, etc.). This amount of data handling contains the intrinsic problem of speed. If the computer is unable to process its data extremely quickly then the manipulator may be given instructions which are simply too late to be of any use. In practical systems this means that the robot's camera receives an image, processes the useful data, and then directs the manipulator in the appropriate direction. The whole operation must take place in the order of 0.1 seconds. This demands a great amount of computer power and even then is pushing it to the limits.

The basic difficulty involved is the way in which computers operate. Information is processed serially, that is, one calculation after another. Attempts have been made to improve the data handling of microprocessors by using hardware solutions such as arithmetic units and other miscellaneous functions. Also, there have been recent developments in array processors which act as a series of independent CPUs but constrained to a function within a single architecture. This then provides a form of parallel processing which is ideally suited to pattern recognition systems. Present research is also concerned with the development of new languages incorporating a decision making structure which therefore lends itself to sensory analysis applications (e.g. LISP, PROLOGUE, etc.). The techniques employed are drawn from current artificial intelligence findings.

The remaining parameter controlling robot vision is cost. Even with the recent drastic reductions in hardware prices, the vast power required does not come cheap. Due to this fact there are a variety of seeing robots on the market ranging from rudimentary, 'low cost' types, to the higher end of the market offering a very sophisticated machine. Typically the basic intelligence levels can detect a specific wavelength of light (in some cases this is infra red), assess its intensity and thus define crude borders for a fixed presentation of the workpiece.

The intermediate state-of-the-art offers 'grey-level' processing which in simple terms means that the analysis of a scene incorporates an undescribed state between the black and white pixels, and the associated software allows for this; thus light intensity thresholds are accounted for, which in turn allows for slight variations in the workpiece finish, background complexity, and non-uniform illumination.

The most sophisticated levels of intelligence offer a full analysis of the scene; the number of available pixels is generally
greater thus offering a finer definition, the speed of operation is close to real time, and other factors such as colour recognition, shape and orientation, limit setting and adaptive manipulator control are generally available at considerable cost.

TOUCH
For intelligent behaviour the use of vision as a sensory organ not only has excellent power and a peculiar fascination for researchers, but, as mentioned above, has severe practical limitations such as cost, speed and definition when applying our current technologies. On the other hand, a much more viable proposition on the grounds of finance, speed and ease of implementation is that of tactile sensing. In addition to these 'pros', is the argument that the final result of a vision system is for the manipulator's end effector to touch the workpiece and so, development of a strong tactile sensory perception minimises the emphasis of the less practical visual facet.

Referring again to the human model we find that touch is a collection of several types of sensory receptors (Fig. 3). The sense embraces a position sensory (stretch receptors), two types of pressure detectors (one for impact, one for continuous loading), overload sensors (pain detectors such as structural damage or chemical attack interpreters), and heat detection mechanisms. In other words our skin is provided with a multiplicity of multifunctioning sensory organs. However, despite the vast amount of data input there is very little pattern recognition possible. In fact a simple experiment with two pins will show that many areas of the body are indiscriminant over a distance of less than 20mm between points (e.g. shoulder blade region, chest, etc.). The reasons for this are many, the major one being that many sensors use the same nerve channels. This is exemplified by our peculiar response to certain stimuli (e.g. a tap on the back of the neck can often make the toes twitch) and forms the basis for acupuncture. This apparent lack of ability is probably due to our high visual competence in pattern recognition thus eliminating any need for a duplicate role in the tactile system.

What then is the value in developing tactile sensing? Firstly, touch has the distinct advantage over vision in that it is three dimensional in its geometric and its physical structure; hence the vast amount of interpolation which is necessary with a 2D picture is redundant in the tactile domain. It is the geometric factor which makes touch such a valuable sense; this is exemplified in the fact that we use our hands to feel things—the culmination of shape and skin give us direct spatial feedback.

In denigrating the direct pattern recognition abilities of skin the other sensory assets must not be overlooked. The pressure sensors, for example, are extremely sensitive in detecting movement of several microns: (e.g. hairs, grit and dust are perceived when merely falling onto the skin). The remaining major ability touch exhibits is the detection of surface texture. This is achieved by picking up vibrations set up when our fingers are passed over the surface of a material. Our finger ends are specially developed for this purpose in the form of ridges and whorls (fingerprints). Texture detection is largely dependent on relative movement of the skin surface against the sample surface.

Transferring our knowledge from the biological touch processes to the industrial robot gives quite a range for inventiveness; the reason being that there is very little known about the actual workings of biological touch sensors. This being the case, many ideas are currently being experimented with.

For impact detection simple on/off switches are sufficient. Several methods have been used, from sprung flexible circuit board to small piezo-electric elements.

The measurement of load requires some quantitative system, but there are no commercially available sensors which copy the biological model; the response being logarithmic with approximately 30 discrete levels. Strain gauges have been used to some extent but they are limited due to their physical size and their poor susceptibility to noise. Various other resistive devices are being tested. One example is the use of graphite loaded neoprene rubbers in the form of two cords crossed over one another (Purbrick, Univ. of Warwick). The system works logarithmically due to the compression of the two circular cross-sections against each other; however there are still some problems with fatigue life. Another system is to use a felt made form carbon fibres (Dr. M.H.E. Larcombe, Univ. of Warwick). The method of working is the same as with the rubber cords but multiplied many times. Arrays of piezo-electric elements have been used for load sensing, the method being that of measuring the developed potential difference across the device due to the exerted force. The problem arising with piezo-electric cells, however, is that the developed voltage decays with time due to the finite input impedance of the measuring equipment. Thus due consideration must be given to time constants when using this method.

Piezo-electric cells are also used in surface texture and slippage detection. The reason being that they are basically microphonic and as such are suitable vibration transducers. Similarly very small acoustic microphones have successfully been used in many different configurations.

Fig. 3. Cross section of the human skin showing sensory receptors

Early prototype robotic hand (Courtesy of Southampton University)
Various other techniques are still being developed to give a full sensory complement to a manipulator. Research is being undertaken for both industrial robots and in the realm of prosthetics (bionics). Due to the relative ‘simplicity’ of tactile sensing (to vision), the concept of producing a fully articulate human hand is very close to reality. Several establishments have undertaken such work, one of which, Southampton University/Hangar Ltd., is now preparing the production models. Producing a hand is far more viable, and probably useful, than aiming for artificial sight. This particular hand uses sensory feedback in several of the forms described above to aid control of a number of preprogrammed manoeuvres and hence acting closely to that of a human hand. Knowledge gained from this research is being re-routed into industry by applying the techniques to commercial robots. (hand in hand?)

HEARING

Auditory sense is not widely used in robotics, however there are one or two cases. The subject of hearing can be divided into two sections: rangefinding and spoken instruction.

The rangefinding aspect provides an intermediary between vision and touch. Several systems have been developed using radar and sonar ‘send and return’ techniques. work has been undertaken at the University of Alabama, USA, in modelling an echolocation system directly parallel to that of the bat. It involves energising an array of transmitter elements and then comparing the phase differences of the reflected waves. The system is then able to determine the direction and the range of an object within its environs. A similar technique is being used by the Wolverhampton Polytechnic/Chubb & Son’s Lock and Safe Co. Ltd. teaching company, where an echolocation system presents a viable measurement of distance between a welding rod and a steel joint. In such a hostile environment this proves to be a worthwhile method since touch sensing defeats the objective and vision is usually saturated due to the extreme brightness of the welding arc.

The purpose of using speech recognition is that human beings can tell robots what to do without being tied down to any programming language. This delves deep into complex artificial intelligence techniques. Unimation (UK) Ltd., displayed a speech receptive PUMA robot at the Automan exhibition in summer 1982, but it was confined to a very limited amount of short syllable words. To make robots understand human speech, we must in turn understand the way in which we construct our language. In its base terms, speech recognition is the receipt of aural stimuli and the subsequent interpretation into sounds, then words, then sentences. As humans we are able to focus on one person speaking and developing our own understanding of what he means. Obviously this is very difficult for a computer and because of this little development has taken place. The major problem is not one of signal analysis, despite the complexity of the human voice, but that of understanding. People do not enunciate words clearly and crisply, words merge into each other, word endings are not either clear or correct, words are omitted, etc., and so continuous speech recognition is well beyond our present grasp. Nevertheless much work is being undertaken in this field and there are signs that the barrier is not insuperable.

For the time being industry is only just accepting first generation robots, the operations of which are obviously limited. Very shortly there will be demands for more sophisticated, second generation robots, fully employing their senses of vision, touch and hearing. The more a robot can do for itself, the less it needs to be instructed, the safer and more efficient it becomes. In the twenty or so years of robot existence many people have spent a lot of time copying human characteristics in order to achieve greater machine intelligence and perceptiveness of the environment. From our basic understanding of ourselves it becomes very easy to accept that a human being is human and a robot is, and always will be, a complex and limited machine. ♠
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LOUDSPEAKER DIAPHRAGM

Loudspeaker designers are continually searching for the perfect material from which to mould their cones and diaphragms. Paper produces good results, but is affected by atmospheric conditions. Plastic is immune from atmospheric effects, but is often insufficiently rigid or chemically unstable, especially when exposed to daylight with its ultraviolet content. Over recent years there have been numerous patents for "magic" additives to improve the stability and performance of plastic loudspeaker cones. The latest, and one of the most interesting, comes from Kuraray Company of Japan. European patent 0 061 270 suggests that the performance of a polymer sheet can be greatly improved by incorporating mica flakes in the mix. The patent claims are very broad, covering virtually any percentage by weight of mica additive. So if the patent is granted, and held valid, it would cover any loudspeaker diaphragm made from a mix of polymer and mica flakes.

PSEUDO STEREO

RCA, in New York, has filed a string of European patent applications (numbered 0 060 097) on further developments in the company's ongoing quest for a system to synthesise acceptable pseudo stereo from a mono TV signal. The company has previously patented (see Practical Electronics May 1981, page 53) a synthesis chip for incorporation in a TV set. Now RCA proposes a modified system that can be hooked up to a home hi-fi system. The circuit diagram given may suggest ideas for the home experimenter who would like to build their own synthesis circuits.

The crux of the RCA idea is to split the incoming mono audio signal into two halves and put notches in the frequency response of each half. These notches are deliberately mis-matched so that a peak in one channel corresponds to a dip in the other channel. So overall energy dispersion is constant. According to RCA this produces a distributed sound field that just extends between the loudspeakers. If the phase differential is less than 90° the distribution is too narrow and at phase angles above 90° it is too wide. The frequency distribution was chosen through analysis of the spectral characteristic of bass, tenor, alto and soprano voices, so that all voices appear to emanate from front centre while the sound of music is spread.
Provides switched negative earth supplies of 4.5V, 6V, 7.5V and 9V at 1A

Here are many situations in which it is convenient to use a normal domestic cassette player, radio or other item of battery powered equipment in the car. Unlike car radios, CB sets and specially designed car accessories, most domestic equipment is usually unsuitable for operation directly from a vehicle's 12V supply. Typically, portable equipment is designed to use a number of 1.5V cells, with an overall supply somewhere in the range 4.5V to 9V; portable televisions are the usual exceptions, and most will operate from a 12V supply.

The use of dry batteries can be satisfactory if only occasional and limited use is required. Frequent usage, however, quickly becomes expensive and inconvenient; battery changes are needed more often due to higher volume levels required. The accessory power supply to be described allows most items of battery powered equipment to operate from a standard car cigarette lighter socket. Any equipment which requires a negative earth supply of 4.5V, 6V, 7.5V or 9V may be used, and a regulated output of up to 1A is available. Should no appropriate socket be available, the unit may be wired directly to the vehicle's accessory circuit.

The accessory supply is protected against overload, is simple to construct and install, and requires no setting up procedure. The unit is protected against incorrect connection, and is built in a rugged and compact case. The overall cost is less than £10; a sum which will rapidly be covered by the savings on replacement dry batteries.

The input voltage is likely to contain a substantial amount of noise, and the decoupling capacitors are used to obviate this.

Circuit Description

The circuit for the accessory power supply is shown in Fig. 1. The vehicle's 12V supply is taken from the cigarette lighter socket via PL1, or from the vehicle's accessory circuit if no such socket is fitted. An in-line automotive fuse, FS1, is used to provide protection against possible failure conditions. Reverse polarity protection is provided by D1 as a wrongly polarised supply will forward bias it and cause FS1 to blow.

The voltage regulator, IC1, features internal over-current and over-temperature protection. The device is intended for use in variable voltage power supply applications, and is supplied in a 4-pin plastic package with a metal heatsink tab (which is connected to the common supply rail). The output voltage is set by means of the resistor network R2 to R6, selected by means of S1 a. The way in which the output varies with resistor setting is shown in Fig. 2. An indication of which output has been selected is provided by four miniature l.e.d.s, D2 to D5, via S1 a. The series output diode, D6, serves two distinct functions. Primarily it allows an output voltage of less than 5V to be produced (this is not otherwise possible, as shown by the equation in Fig. 2) by providing an almost constant voltage drop of approximately 600mV. In addition, the diode provides protection against the unit being accidentally connected back-to-front.

Fig. 1. Circuit for the power supply unit. Note that R3 and R6 are each made up of two resistors as in the components list.
Fig. 2. Setting the output voltage for IC1. Here $V_{out} = 5 \left( \frac{R_a + R_b}{R_b} \right)$ and should typically be at least 2V lower than $V_{in}$.

**ASSEMBLY**

A small printed circuit board is used to mount the majority of components inside the diecast box which is used to house the accessory power supply. The component layout for this board is shown in Fig. 4, with the corresponding copper foil pattern shown in Fig. 3. If preferred, constructors may use a similar sized piece of 0.1in. pitch Veroboard in place of the p.c.b. The use of terminal pins is recommended in order to facilitate the connection of the wiring and of the regulator device. The regulator i.c. itself is fixed directly to the base of the diecast box, which it uses as a heatsink, and is positioned close to the p.c.b.

The diecast box should be drilled to allow mounting of the printed circuit board, regulator i.c., i.e.d.s, and the switches. Two additional holes at the rear, lined with rubber or plastic grommet material, are required in order to allow the passage of the input and output power leads; suitable measures should also be taken to anchor these leads. A wiring and layout drawing for the complete unit is shown in Fig. 5. It should be noted that the components in the resistive divider chain are mounted directly on the tags of the selector switch, S1, and two of these resistors, R3 and R6, are actually composites of two components wired in series to give the required value.

**COMPONENTS**

<table>
<thead>
<tr>
<th>Capacitors</th>
<th>Resistors</th>
</tr>
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<tbody>
<tr>
<td>C1 100µ 16V electrolytic</td>
<td>R1 1k</td>
</tr>
<tr>
<td>C2 100n polyester</td>
<td>R2 100</td>
</tr>
<tr>
<td>C3 100n polyester</td>
<td>R3a 1k</td>
</tr>
<tr>
<td>C4 100µ 16V electrolytic</td>
<td>R3b 100</td>
</tr>
<tr>
<td></td>
<td>R4 680</td>
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<td></td>
<td>R5 470</td>
</tr>
<tr>
<td></td>
<td>R6a 1k</td>
</tr>
<tr>
<td></td>
<td>R6b 1-5k</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 1N4001</td>
</tr>
<tr>
<td>D2 0.1in. green i.e.d. plus clip</td>
</tr>
<tr>
<td>D3 0.1in. yellow i.e.d. plus clip</td>
</tr>
<tr>
<td>D4 0.1in. amber i.e.d. plus clip</td>
</tr>
<tr>
<td>D5 0.1in. red i.e.d. plus clip</td>
</tr>
<tr>
<td>D6 1N4001</td>
</tr>
<tr>
<td>IC1 µA78GU1C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 3P4W rotary switch</td>
</tr>
<tr>
<td>S2 SPST ultra miniature toggle switch</td>
</tr>
<tr>
<td>FS1 1-5A fuse and in-line holder</td>
</tr>
<tr>
<td>PL1 Accessory socket plug</td>
</tr>
<tr>
<td>PL2 Auxiliary supply connector for the portable equipment (e.g. the Maplin universal plug HH38R)</td>
</tr>
</tbody>
</table>

Diecast box 120mm x 65mm x 40mm
Printed circuit board
Terminal pins
Knob
Testing

When the p.c.b. assembly is complete, it should be carefully checked for dry joints and solder bridges between tracks. A careful visual inspection of the whole unit should include verifying that polarised components (i.e.d.s., diodes, etc.) are correctly orientated. The unit is now reset on either a 12V d.c. supply or on a car battery, via the accessory socket if appropriate.

Connect PL1 to the 12V supply, with S1 set to the 4.5 volt position and S2 set to 'Off'. Connect a suitable voltmeter to PL2. When S2 is switched on, D2 should be illuminated and an output indication of 4.5V should be obtained; any reading within ±5% of the expected value is acceptable. Should no output be obtained and no i.e.d. illuminated, a check on the polarity of the supply, on FS1, and the polarity of D1 and D6 should be made prior to a more detailed examination of the circuit. An incorrect output voltage indicates a possible problem with the resistive divider chain, R2 to R6. A correctly illuminated i.e.d. but no output, could be due to an incorrectly polarised output diode D6.

When the initial test has been completed satisfactorily, the three other ranges should be checked to ensure that their modes function correctly, and that the output voltage is correct.

In use, range changing should be done without any load connected since momentary transients are possible. When installing in a vehicle, it should be borne in mind that the diecast box is connected to the negative rail by virtue of the common tab on the voltage regulator i.e. As mentioned earlier, the accessory power supply may either be connected in to the vehicle's accessory circuit (when S2 and PL1 may be omitted), or supplied from the cigarette lighter socket. The unit may be simplified for dedicated use at a fixed output voltage by removing S1 and three i.e.d.s, and replacing the resistive chain R2 to R6 by two single resistors of appropriate value.

The accessory power supply may be used to supply continuous currents of up to 1A at the selected output voltage. It should be remembered, however, that with a 13.2V input and an output of 4.5V at 1A, the unit will be dissipating approximately 9W and a certain amount of warmth is to be expected.

Control layout of PSU

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The first part of this series was devoted to interfacing systems which involve purely digital control. This month we shall be concentrating on the interface between the digital world of the microprocessor and the analogue world associated with many external systems and devices.

Digital signals (i.e. those which exist in two states; logic 0 and logic 1) are essential to the operation of logic systems. Analogue devices, by definition, require a continuously variable control signal rather than one which is just simply 'on' or 'off'. Hence there is a need for an interface which can convert digital input signals to analogue output signals, and vice versa.

This second article in the series therefore considers some of the techniques and devices used for digital to analogue conversion. Also included is a practical example of a complete 8-bit digital to analogue converter. Full constructional and setting-up details are also given. This unit is eminently suitable for interfacing a wide range of analogue output devices and thus will be invaluable to anyone using an 8-bit microcomputer (including the PE Microcontroller) in control applications.

**DIGITAL VERSUS ANALOGUE SIGNALS**

In digital systems two voltage levels are used to represent the binary digits, 0 and 1. Most signal waveforms encountered in the digital world are therefore composed of a series of pulses; the voltage level at any particular instant being in one state or the other. In analogue systems an infinite number of voltage levels are employed and waveforms are therefore continuous rather than discrete. Typical time related digital and analogue signal waveforms are shown for comparison in Fig 1. A digital representation of an analogue quantity may be produced by sampling the waveform at regular intervals. The smoothly changing curve of Fig 1b can, for example, be sampled repeatedly and a digital code generated which approximates to the actual voltage level at the instant of sampling. This process, which is illustrated in Fig 2, is known as analogue to digital conversion and we shall be looking at this in a little more detail next month. If, alternatively, a digital code is used to generate a particular voltage level, an analogue signal can be synthesised in discrete steps, as shown in Fig 3. This technique is, of course, known as digital to analogue conversion.
DIGITAL TO ANALOGUE CONVERSION

One simple method of digital to analogue conversion involves the use of a binary weighted resistor network. A typical arrangement of such a device is shown in Fig 4. The switch symbols are used to represent the logic conditions present on each of the four input lines; logic '0' is represented by OV whilst logic '1' is represented by +V. Since four input lines are provided the device caters for a 4-bit natural binary coded input, however extra lines can be added as appropriate. An eight bit digital to analogue converter would, for example, require a further four inputs such that one resistor was provided for each input line.

The binary weighted resistor network is followed by a high input impedance amplifier stage which effectively buffers the network and helps to minimise the adverse effect of loading on the circuit. The amplifier is usually a conventional operational type with the summing junction of the resistor network taken to the inverting "virtual earth" input of the integrated circuit.

The lowest value resistor, R, of the network corresponds to the highest binary weighted input or 'most significant bit' (MSB). The highest value resistor, 8R, corresponds to the lowest binary weighted input or 'least significant bit' (LSB). The current through each resistor is inversely proportional to its resistance and hence the most significant bit will produce a current which is twice that produced by the next most significant bit, and so on. The currents are summed at the input of the amplifier and a voltage is developed which is an analogue representation of the digital input applied to the output lines. The principal disadvantage of this method of conversion is that it requires a number of different resistor values and, where a digital input of 8-bits, or more, is to be catered for, the values of the resistors become somewhat impractical.

Another method of digital to analogue conversion employs a somewhat more complex resistor network which is known as an "R-2R" ladder network. Since only two values of resistor are required, this arrangement overcomes the most significant disadvantage of the binary weighted method. Fig 5 shows a simple 4-bit digital to analogue converter which uses an R-2R network. Each successively lower weighted input produces an output voltage which is exactly half that produced by the preceding input.

The analogue output of a simple 4-bit digital to analogue converter is shown in Fig. 6. Since there are 16 different input conditions, the output voltage can take any one of 16 different voltage levels. The output voltage resulting from a binary input code of 0000 is, of course, OV. The further 15 different input codes permit 15 additional voltage levels, incrementing by the same voltage interval on each successive binary step. The increment in voltage level will be equivalent to the voltage produced by a binary input code of 0001 which is known as the 'least significant bit voltage', VLSB. The voltage level resulting from a binary input code of 1111 will be the full scale output voltage less VLSB (remember that there are only 15 discrete voltage steps excluding the first step which is, of course, zero). The output voltage level produced by a binary code of 1000 (decimal 8) will be exactly half the full scale voltage, and so on. If desired, the output voltage of the converter can be scaled by means of subsequent amplification or attenuation.

Before examining a practical solution to the problem of digital to analogue conversion it is, perhaps, worthwhile introducing some of the terms and expressions which are often encountered with such arrangements. Of these, 'accuracy' and 'resolution' are by far the most important.
ACCURACY AND RESOLUTION

The accuracy of a digital to analogue converter is a comparison of the actual output with that which would be predicted from a particular input condition and is usually expressed as a percentage of the full-scale or maximum output voltage. The output of a binary ladder network will, unfortunately, only be as ’good’ as its input and hence the applied voltage (often called the ’reference’) must be highly accurate and extremely stable. Furthermore, the resistors used in the network must themselves be highly accurate. Conventional off the shelf resistors are neither accurate nor stable enough for use in ladder networks. Close matching of resistors is, fortunately, not a problem when monolithic construction is employed.

The accuracy of a digital to analogue converter is generally equivalent to half the voltage change associated with the least significant bit. The typical accuracy of a 4-bit converter is plus or minus 3% whereas that of an 8-bit converter is plus or minus 0.2%.

The resolution of a digital to analogue converter is the smallest increment of voltage that can be produced. It is thus essentially the voltage which is represented by the least significant bit (i.e. the smallest obtainable voltage increment). Resolution is thus a function of the number of input bits and the reference voltage. A 4-bit converter permits 16 different output states and thus its resolution is equivalent to 6.25%. With a reference input voltage of 1V this is a resolution of approximately 63mV. An 8-bit converter would improve this resolution to approximately 3.9mV.

Besides accuracy and resolution, three further terms are often encountered in conjunction with digital to analogue conversion. These are ‘offset error’, ‘setting time’ and ‘monotonicity’. The offset error associated with a digital to analogue converter is the output voltage produced in response to a digital input consisting of all zeros. The settling time of a digital to analogue converter is the time taken for the output to settle within plus and minus 1 LSB of its final value after a change of input code. Finally, a digital to analogue converter is said to be monotonic if it does not miss a step (or take any reverse steps!) when a full digital input sequence is applied.

THE ZN428 D TO A CONVERTER

The ZN428 is a versatile monolithic digital to analogue converter which incorporates an input data latch facility for updating from a microprocessor data bus. It is thus ideal for interfacing to the system data bus of any 8-bit microcomputer or microcontroller. The internal architecture of the ZN428 is shown in Fig 7. The principal internal elements of the ZN428 are; a data latch, a switch array, an R-2R resistor network and an accurate voltage reference. The latching action is controlled by an ENABLE input. When this input is held low the data inputs drive the device directly. When the ENABLE input is held high the input data word is held in the data latch and the output remains unaffected by the state of the data bus. In this condition the digital to analogue converter appears transparent to the microcomputer.

The ZN428 requires a nominal +5V supply at a typical current of 20mA. The device offers true monotonic operation and the offset voltage is less than 5mV. The settling time is typically less than 1µs and linearity better than plus or minus 0.5 LSB. (This corresponds to plus or minus 10mV in a 5V full scale arrangement). The accuracy and resolution will, of course, depend upon the external components and particular circuit configuration employed. It is thus unrealistic to quote typical figures in this context other than to mention that the accuracy and resolution of the practical digital to analogue converter described later can be expected to be better than plus or minus 0.25%.

The equivalent circuit of the data latch inputs of the ZN428 are shown in Fig. 8. The input current consumed by the data inputs is typically less than 50µA for a high (logic 1) condition and -5µA for a low (logic 0) condition. In common with nearly all logic devices, the input voltage must NEVER be allowed to exceed the positive supply voltage.

Fig. 7. Internal architecture of the ZN428 digital to analogue converter

The equivalent circuit of the output of the ZN428 is shown in Fig. 9. This consists of a voltage source connected in series with an output resistance of approximately 4kohm. In order to prevent loading of the output, the following stage should have an input resistance which is much greater than 4kohm. Hence, for most applications, a high input impedance buffer stage is required. The analogue output voltage is given by the relationship:

\[
V = \frac{n}{256} \times V_{\text{REF}}
\]

where \( n \) is the decimal value of the binary input code and \( V_{\text{REF}} \) is the reference voltage.

The ZN428 contains its own internal reference. This is provided by an active band-gap device, the simplified equivalent of which is shown in Fig. 10. The device is equivalent to a highly accurate 2.5V Zener diode and exhibits an extremely low internal impedance. Two external

Fig. 8. Equivalent circuit of the data inputs of the ZN428

Fig. 9. Equivalent circuit of the output of the ZN428
Fig. 10. Simplified equivalent circuit of the ZN428 internal reference

components are required in conjunction with the internal reference; a resistor to set the reference current and a capacitor to decouple the reference voltage. In order to achieve a high degree of voltage tracking where several converters are employed, a single voltage reference may be used to drive up to five ZN428's. If required, the internal reference may be dispensed with and an external voltage reference may be connected to the reference input, pin-6. Such external reference should exhibit a slope resistance of less than 2.5 ohm/N, where N is the number of converters employed.

A PRACTICAL D TO A CONVERTER

Having described the basic features and characteristics of the ZN428 i.c., we shall now consider the design of a practical digital to analogue converter which may be configured for either unipolar (single polarity output) or bipolar (dual polarity output) operation. The circuit diagram of the practical digital to analogue converter is shown in Fig. 11. Eight data inputs are provided with simple resistive voltage dividing networks comprising R1/R11 to R8/R18. A similar network, R9/R10, is provided for the ENABLE input. The general specifications are as follows:

**SPECIFICATION**

**OUTPUT VOLTAGE RANGE:** 0 to ±12V max. (unipolar operation—see note), 0 to ±12V max. (bipolar operation—see note)

**OUTPUT CURRENT:** 10mA max. (without power amplifier module), 1A max. (with power amplifier module)

**OUTPUT IMPEDANCE:** Normal output; 500ohm typical. Complementary output; 40ohm typical. Power amplifier module; less than 0.1ohm

**ACCURACY:** Typically better than 0.2% (10V output)

**RESOLUTION:** Typically better than 20mV (10V output)

**SETTLING TIME:** Typically better than 10ns (5V step)

**D.C. SUPPLY VOLTAGE:** 7V to 15V

**D.C. SUPPLY CURRENT:** 75mA typical at V_S = 12V

**DATA INPUT CURRENT:** 'High' (logic 1) input; 60nA max, 'Low' (logic 0) input; −5µA max

**ENABLE PULSE WIDTH:** 100ns min.

**NOTE:** Complementary outputs are available in both operating modes.

**Practical Electronics March 1983**
values have been chosen so as to permit direct connection to the PE Microcontroller integrated peripheral drivers (IC16, 17, 18 and 19 of Fig. 1.9 in November 1982, PE). The voltage level produced by these drivers is approximately 17V in the high (logic 1) condition and OV in the low (logic 0) state. Where the digital to analogue converter is required to be interfaced with a conventional TTL compatible data bus, resistors R1 to R9 should be replaced by short circuit links and R10 to R18 should be omitted. To cater for other values of data bus logic levels it is, of course, only a relatively simple matter of selecting appropriate resistor values for R1 to R18 inclusive (e.g. for operation from a 12V system, R1 to R9 should be 1.5k and R10 to R18 should be 1k). Note that, as mentioned earlier, it is important that the voltage level on the data bus should not be allowed to exceed the ZN428 supply voltage. In this particular circuit arrangement the ZN428 operates from a regulated +5V supply and hence the voltage appearing at the data and ENABLE inputs of IC1 should not be greater than +5V.

The analogue output of the ZN428 at pin 5 takes a value between OV and 2.56V (the value of the internal reference voltage). This results in an output voltage characteristic of 10mV/bit (i.e. \( V_{\text{LSB}} = 10\text{mV} \)). For many applications, however, a greater full-scale output voltage is required and hence IC2 is included to provide both amplification and a degree of isolation for IC1. IC2, a conventional operational amplifier, is used in a normal non-inverting configuration. In IC1, a conventional operational amplifier, increases the overall settling time. A second operational amplifier, IC3, operates as a unity gain inverting stage to provide a complementary output voltage. External offset adjustment (null) is provided by VR1, whilst VR2 provides unipolar operation with the logic coding shown in Table 1. This shows that a data input of 00000000 produces an output of OV whereas a data input of 11111111 results in an output of \(+V_{\text{FS}} - V_{\text{LSB}}\). For bipolar operation R21 must be added. In this case offset binary coding is employed such that a data input of 00000000 produces an output of \(-V_{\text{FS}}\) whereas a data input of 11111111 again produces an output of \(+V_{\text{FS}} - V_{\text{LSB}}\). An output of OV results from a data input of 10000000, as shown in Table 2.

The circuit requires several internal supply rails; a well regulated +5V supply for the ZN428 and plus and minus 15V rails for the operational amplifiers. In order to permit simple interconnection to almost any system, these rails are derived from a single nominal +12V d.c. input. This voltage may, however, be anywhere in the range of +7V to +17V, thus permitting direct connection to the +12/17V unregulated supply rail of the PE Microcontroller. The input current will not normally exceed 100mA. The +5V regulator, IC4, is a conventional monolithic type. An encapsulated d.c. to d.c. converter module, IC5, is used to provide the plus and minus 15V output rails. This device operates with an efficiency of approximately 75% and the output voltage is maintained within ±4% of the nominal 15V at load currents of up to 34mA. Constructors should, however, note that, unlike IC4, this device is not short circuit protected.

<table>
<thead>
<tr>
<th>DIGITAL INPUT CODE</th>
<th>ANALOGUE OUTPUT VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>0</td>
</tr>
<tr>
<td>00000001</td>
<td>( V_{\text{LSB}} )</td>
</tr>
<tr>
<td>01000000</td>
<td>( \frac{1}{2} V_{\text{FS}} - V_{\text{LSB}} )</td>
</tr>
<tr>
<td>01111111</td>
<td>( \frac{1}{2} V_{\text{FS}} )</td>
</tr>
<tr>
<td>10000000</td>
<td>( V_{\text{FS}} )</td>
</tr>
<tr>
<td>10000001</td>
<td>( V_{\text{FS}} + V_{\text{LSB}} )</td>
</tr>
<tr>
<td>11000000</td>
<td>( \frac{1}{2} V_{\text{FS}} )</td>
</tr>
<tr>
<td>11111110</td>
<td>( V_{\text{FS}} - 2V_{\text{LSB}} )</td>
</tr>
<tr>
<td>11111111</td>
<td>( V_{\text{FS}} - V_{\text{LSB}} )</td>
</tr>
</tbody>
</table>

**TABLE 1 Coding table for unipolar operation**

offset and gain adjustment are provided by means of VR2 and VR3 respectively. C2 improves HF stability and, in conjunction with the slew-rate limiting characteristic of the operational amplifier, increases the overall settling time. A second operational amplifier, IC3, operates as a unity gain inverting stage to provide a complementary output voltage. Low value series resistors, R24 and R28, provide a measure of protection in the event of an inadvertent short circuit at the output. Selection of either unipolar or bipolar operation is provided by means of R21. When R21 is omitted the circuit provides unipolar operation with the logic coding shown in Table 2.

<table>
<thead>
<tr>
<th>DIGITAL INPUT CODE</th>
<th>ANALOGUE OUTPUT VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>(-V_{\text{FS}})</td>
</tr>
<tr>
<td>00000001</td>
<td>(-V_{\text{FS}} + V_{\text{LSB}})</td>
</tr>
<tr>
<td>01000000</td>
<td>(-\frac{1}{2} V_{\text{FS}})</td>
</tr>
<tr>
<td>01111111</td>
<td>(-\frac{1}{2} V_{\text{FS}})</td>
</tr>
<tr>
<td>10000000</td>
<td>0</td>
</tr>
<tr>
<td>10000001</td>
<td>(+V_{\text{LSB}})</td>
</tr>
<tr>
<td>10000001</td>
<td>(+\frac{1}{2} V_{\text{FS}})</td>
</tr>
<tr>
<td>11000000</td>
<td>(+V_{\text{FS}})</td>
</tr>
<tr>
<td>11111110</td>
<td>(+V_{\text{FS}} - 2V_{\text{LSB}})</td>
</tr>
<tr>
<td>11111111</td>
<td>(+V_{\text{FS}} - V_{\text{LSB}})</td>
</tr>
</tbody>
</table>

**TABLE 2 Coding table for bipolar operation**

Components

**Resistors**

| R1–R9 | 2k7 (see text) (9 off) |
| R10–R18 | 1k (see text) (9 off) |
| R19 | 470 |
| R20 | 390 |
| R21 | 10k (see text) |
| R22 | 22k |
| R23 | 10k |
| R24 | 27 \( \frac{1}{2} \)W |
| R25, R26 | 10k (2 off) |
| R27 | 4k7 |
| R28 | 27 \( \frac{1}{2} \)W |
| VR1, VR2 | 22k miniature horizontal skeleton pre-set (2 off) |
| VR3 | 10k miniature horizontal skeleton pre-set |

All fixed resistors, except where otherwise stated, are \( \frac{1}{2} \)W 5%.

**Capacitors**

| C1 | 2µ2 35V tantalum |
| C2 | 47p ceramic |
| C3, C4 | 10n polyester (2 off) |
| C5 | 220µ 10V axial electrolytic |
| C6, C7 | 100µ 16V p.c. electrolytic (2 off) |

**Semiconductors**

| D1 | red LED |
| IC1 | ZN428E |
| IC2, IC3 | 741 (2 off) |
| IC4 | 7805 |
| IC5 | d.c.—d.c. converter module |

**Miscellaneous**

| PCB | Terminal pins (5 required) 24-way edge connector |
| Low profile d.i. sockets (2 x 8-pin and 1 x 16-pin) |

**Constructor's Note**

Components and PCB are available from Howard Associates, 59 Oatlands Avenue, Weybridge, Surrey KT13 9SU (s.a.e. for details).
CONSTRUCTION

The digital to analogue converter is assembled on a single-sided p.c.b. measuring approximately 77 x 147mm. The p.c.b. is designed to mate with a 24-way edge connector thus, allowing ease of connection to a system whilst retaining the ability to interchange boards where necessary. The p.c.b. foil layout is shown in Fig. 12 and the corresponding component overlay is given in Fig. 13. Low profile sockets should be used for each of the dual-in-line integrated circuit devices. Heat sinking will not normally be required for the series regulator, IC4.

Construction is extremely straightforward and the following sequence of component assembly is recommended: terminal pins, i.c. sockets, resistors, capacitors, i.e.d., pre-set resistors, IC4 and IC5. When complete the p.c.b. should be carefully examined for correct placement and, in the case of polarised devices, orientation of components. The remaining i.c. devices should then be carefully inserted into their sockets and the unit is then ready for testing and initial adjustment.

TESTING AND INITIAL ADJUSTMENT

Testing and initial adjustment is best carried out using the arrangement shown in Fig. 14. Nine miniature s.p.s.t. toggle switches are required; eight to simulate the data bus inputs and one to provide the ENABLE input. These toggle switches should be connected to the appropriate pins of a 24-way edge connector, carefully following the pin numbering
shown in the figure. To prevent confusion, it is recommended that the switches be labelled appropriately! A regulated 12V d.c. supply should be connected to pins 1 and 2, taking care to observe the correct polarity. The power supply should preferably include a means of electronic over-current protection. However, if no such supply is available, a 500mA fuse in the positive supply lead will at least offer a measure of protection. A d.c. voltmeter, or multi-range meter on the d.c. voltage range, should be connected with its negative input lead to 0V and its positive lead to a probe or miniature crocodile clip.

A d.c. milliammeter should, initially, be included in the positive supply lead. The supply should then be switched "on" and the supply current should be noted. This should be in the range 50mA to 80mA and under no circumstances should it exceed about 150mA. If the fuse blows, or if the overcurrent trip operates, carefully check for inadvertent short circuits or incorrect wiring of the edge connector. Having established that the d.c. supply current is normal check that D1 is illuminated. This I.e.d. indicates the presence of the +5V supply and indicates that the unit is "active". The voltage of the +12V and +5V rails can then be checked; the latter should be within plus or minus 200mV of its nominal value and should remain within 1% of its actual value as the d.c. supply input is varied over the range 8V to 15V. The adjustment procedure for either unipolar or bipolar operation will be given next month.

NEXT MONTH: Power amp module.

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March 1983
This month's add-on card for the ULTIMUM is a ROM Emulator (Romulator). It complements the PROM programmer of last month making the development of control systems, based on commercially available single board controllers or home brew systems, possible. The Romulator described here can emulate most of the single rail 1k, 2k and 4k PROMs as well as a large proportion of the three rail varieties.

Emulation

Emulators come in two forms. The larger development system emulators plug into the microprocessor socket and will emulate memory (ROM and RAM) as well as the processor itself. These emulators are very useful when designing a development system from scratch. They usually provide some form of real time tracing which makes fault finding simpler. Such emulators usually cost several hundred pounds and, as such, are rather too expensive for the average enthusiast.

The second class of emulator emulates ROM only. The ROM being emulated is substituted with a header/cable assembly which is connected to memory filled from another system. For most applications this simpler (and much cheaper) form of emulation is quite adequate. The Romulator falls into this latter category.

The Romulator is a card which plugs into one of the sockets on the ULTIMUM motherboard. It can be used as standard static RAM by your computer, and may be filled with any code (or used as extra space for BASIC programs) and accessed as any other RAM in your system. When switched into emulation mode, it may be inserted into any other system to emulate PROM or ROM. Fig. 5.1 shows a typical example of such a set up.

The main advantages of this type of system are:
1) Programs can be developed on your host system which has many tools available (such as an assembler/disassembler and a screen to monitor RAM contents). The system being developed may only have an absolute minimum of tools and interfaces.
2) Any programs developed on the Romulator can be protected from overwriting by the system being developed as they can only be accessed as ROM. This is particularly useful when developing machine code programs which have a marked tendency to crash.
3) Once a program has been tested, it can be programmed onto ROM using the PROM programmer board. No intermediate paper or magnetic tape increases the chance of a successful transfer of data. Once programmed, the PROM can be inserted into the system being developed and the emulator removed for further use.
4) The alternative is to buy a separate emulator complete with its own processor. These usually cost as much as your main computer and it seems (to us at least) a waste of a computer to buy another system just for development.

The Circuit

The circuit is shown in Fig. 5.2. It does not need to be complicated as most of the extra circuitry for an emulator is provided by the motherboard and your own system.

There are three basic elements: the decoding (motherboard and off-board), the multiplexing circuits (selecting between emulator signals and motherboard signals) and the memory itself.

The decoding allows the board to be mapped into your computer as 2k or 4k portions. If you do not require a full 4k emulator, some memory can be omitted and the board can be mapped to occupy 2k of memory. The main decoding is done by IC8 which provides 16 lines each corresponding to a 4k boundary. Selection of a 2k boundary is achieved by additional decoding provided by bringing A11 into IC8.

The multiplexers are made of three quad two-to-one line multiplexers which can be set to accept signals from the motherboard or the emulator header. The selection is handled by a line fed from the port on the motherboard. When the port is set up, the multiplexers are set to accept signals from the motherboard, so that the board looks like ordinary memory.

Toggling the port line (marked as External Select in Fig. 5.2) will cause the signals from the motherboard to be deselected and the read/write control signals are disconnected to prevent spurious accesses from conflicting with signals on the emulator header.
Fig. 5.2. Full circuit diagram
ASSEMBLING AND SETTING UP

Refer to the overlay (Fig. 5.3) for component placement. The usual order of assembly applies, ie. Sockets and discrete components first, followed by a thorough check of your soldering and then insertion of the i.c.s. The header is prefabricated, as this is an insulation displacement assembly requiring special equipment.

To test the board, set up the mapping options. A maximum of three links are needed. Leave the emulator cassette and the d.i.p. header off for the moment. Insert the card into the motherboard and power up (not the other way round). Set up the port on the motherboard (as per ULTIMUM article) so that the external select 2 line is a logic '0' and the external select 1 line is a '1'. You should then be able to read and write to the memory on the Romulator. Any memory test can be used to check for proper function.

To test the emulator, you can either use a second system or plug the emulator into a PROM socket somewhere in your own system, as the Romulator is quite capable of emulation on your own computer.

Once you have loaded a suitable program into the Romulator memory, you switch to emulator mode by making the External Select 2 a logic '1' and the external select 1 a '0'.

Two points to note. Firstly, do not insert the emulator socket in upside down, this may damage the Romulator memory or the system. Secondly, some systems make rather strange uses of the Read and Chip Select control signals to decode the ROM. Check a circuit diagram if in doubt.

NEXT MONTH: The phoneme speech card.

The memory itself is fast static RAM organised as two off 2k x 8. Various speeds of RAM are available allowing development of the newer fast processors. Allowing for leads and buffers a 200µs PROM can be emulated using 100ns RAM. The static RAM is always powered from the motherboard. A buffer is provided on the data lines to drive the emulator cable assembly.
**WINE HEATER THERMOSTAT**

Although this circuit was devised to control a 22W heater plate under a 1 gallon wine demijohn to hold a nominal temperature of 22°C, with the larger relay used it can be used to switch much higher powers, and with the components shown, it has an adjustment range of 9°C to 31°C with a dead range from 0.9°C to 1.4°C. Other applications could be in darkrooms or greenhouses, etc.

TR1 and D2 are deliberately over dimensioned. D1 prevents negative $V_{be} > 0.6V$ on TR1. An alternative approach would be to use a single-ended supply, although this could cause problems with the increased values of R1, R3, VR1, if one tries to keep the signal and reference near the middle of the 741's input range rather than relying on common-mode rejection; the ratio of $R_4 \times VR_2$ to the input source impedance ($R_2 + VR_1$) governs the dead range, and for about 1°C this ratio needs to be around 6000, leading to impractical values for a source impedance much greater than the present 1040 or so.

Andrew Fogg, Maidenhead, Berks.

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**INTRUDER ALARM**

Even with constant weekend use during the summer months, most boats, or caravans, are left unattended for an extremely high proportion of the year and some form of alarm system is therefore highly desirable to frighten off intruders.

It will be evident from the circuit diagram that the unit is switched-off until the trigger connects it to the battery negative, whereupon TR2 immediately conducts, closing the relay and thereby latching on the supply, since initially the capacitor is uncharged and the base of TR1 is also positive. C1 now commences to charge slowly via the 100 kilohm resistor causing the base to become progressively more negative until the transistors cease conducting and the relay opens. With the values shown, the alarm cuts off after one to one and a half minutes, but different periods of operation can be obtained by trying other capacitors.

The trigger contacts are constructed from spring-metal strips (e.g. draught excluder), or, more elegantly, with reed contacts and magnets. In this system the trigger contacts are required to be open, so ensure that they can be closed by the magnet (or are of the 'change-over' type) to suit your particular installation requirements.

The foregoing also applies if you decide on switch-pads for placing under carpets.

R. P. Machrell, Lytham St. Annes, Lancashire.

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A selection of readers' original circuit ideas. Why not submit your idea? Any idea published will be paid for at £40 per magazine page.

Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not in the text.
THIS circuit counts digital pulses up to 9999 and then resets to 0000, a socket is provided to carry out the 10,000th pulse. Clock pulses enter IC2 via the "Clock In" socket. This counts the input pulses to ten and resets to zero carrying the tenth pulse to IC3 via pin 12.

Similarly IC3 counts tens carrying the hundredth pulse to IC4, and so on along the chain. The unit can have the chain shortened or extended if desired.

The pulses are counted visibly on four rows of ten I.C.D.S (TIL209) which the 4017 drives directly. The small circuit around IC1 is an anti-switch bounce circuit generating clean pulses when S1 is pressed which reset the display to zero. When S1 is open circuit the voltage to the reset pins is 0V, the condition necessary for automatic reset on the tenth count. After any count from 0000 to 9999 a facility is added to trigger an external circuit, e.g. an alarm, model railway points, the radio etc.

IC6a is wired as an inverter to save using extra space with inverter chips.

The circuit can be used to measure digital frequency, as a stop watch once the input frequency is known, as a photographic or kitchen timer and as if this is not enough it can be used as an intriguing display on the mantelpiece at parties.

Power is applied externally in the prototype but can be built into the unit very simply.

Michael J. Walker,  
N. Ascot,  
Berks.

---

THIS probe uses a 7400N consisting of quad dual input NAND gates, and detects high, low and open circuit with pulse stretching on high and low indications so that any combination of signal will be visually detected. The thresholds are 0.8V and 2V.

The assembly should easily fit into a plug case with flying leads for the supply and 0V connections and a needle probe. Pulse stretching may be increased with larger capacitors.

G. Coleman,  
Rochester,  
Kent.
WINDSCREEN WIPER CONTROL

This circuit will vary the speed of a car's windscreen wipers from one sweep per second to around one sweep per minute. When switched on IC1 will start to oscillate at a rate set by VR1 which in turn switches RLA1. This in turn supplies the wiper motor power at the same time intervals. The conventional switch can now be disregarded. If the washer pump is wired to a pushbutton it can be removed altogether. D1 soaks up any back e.m.f. from the relay coil while C2 and C3 suppress the spike caused by IC1's output going high.

A.D. Billington, Rotherham, S. Yorkshire

TOUCH-SWITCHED

SPEAKER MUTING

This unit was designed for a friend who had a set of extension speakers conflicting with a telephone in his bedroom. He specifically requested touch switches since, although much more expensive than a 2 pole 3 way switch, they are more pleasant to use and are aesthetically pleasing.

The touch switches are a resistive type as these are easier to implement than the capacitive variety. The three switches set up the JK flip-flop inputs when touched, and the oscillator formed by IC3b,c, C2, R11 clocks the outputs to the required state which will then be held by the flip-flops. An ordinary 7473 is used to allow the I.E.D.s to be driven directly.

Note that points M and F should be connected to identical circuits as to the left of point X.

The relays are 2 pole to provide switching for a stereo pair of speakers. R1 at 100 7W is adequate for up to around 35W input. For amplifiers which dislike high impedance loads, R1 could be shunted with a 10 25W resistor to ground (or the return line if the speaker connections are left floating as shown). R1 is calculated for about 20db of muting against 8 speakers. Clearly a single secondary transformer and a bridge rectifier could be substituted for T1, D4 and D5.

Andrew Fogg, Maidenhead, Berks.
COMMERCIALVY available cruise control units for petrol engined cars work on the principle of a speed sensor connected to an electronic unit which converts speed differences to an electrical output. This drives a solenoid valve on a vacuum operated servo (Fig. 1) which operates the throttle. When the speed is below the preset cruising speed the servo is activated and it opens the throttle to regain speed. When the speed is above the preset speed the throttle is released by the servo. Fig. 2 shows the valve arrangement in the servo.

Speed may be sensed by means of a device on the speedometer cable, on the drive shaft or by using the pulses on the ignition coil primary (or points).

The servo should be purchased from suppliers or servicers of cruise equipment and a suitable unit is manufactured by Associated Engineering. The solenoid valve in the servo has a coil resistance of about 45 ohms and operates as follows;

- rising voltage: suction opens 6.3V
- vent closes 7.3V
- falling voltage: vent opens 6.6V
- suction closes 5.0V

The circuit can be divided into D/A converter, memory with clock and bistables, difference amplifier and servo drive, as shown. The power supply is regulated to 11-0 volts by means of TR5, TR6, TR7, D4. An i.c. regulator cannot be used due to the small voltage drop available.

The engine (and therefore car) speed is sensed from the pulses at the points by TR1, IC1 and IC2 which form a D/A converter and the output of IC2 is linearly proportional to revs. TR1 acts as an inverter to trigger the 1.5ms monostable IC1. The voltage across C4 is proportional to revs. IC2 acts as a voltage follower with gain. VR1 adjusts the gain to give an output on pin 6 of a maximum of 5.5V at 6000 r.p.m. for a 4 cylinder engine.

IC3, a dual counter, forms a digital memory for the analogue voltages. The two counters are cascaded and the outputs feed a ladder resistor network which is used as a 256 step memory from 0 to 5.5V. The memory resolution is thus 0.021V per step or approximately 0.4 m.p.h. The memory is activated in the following manner. When S1 is switched to "Engage" the "a" section of electronic switch IC7 closes and produces a reset on IC3. When S1 is released to its centre off position the negative edge trigger formed by IC5a is activated which in turn sets the bistable formed by IC6c and d. The output on pin 11 goes low to produce an "enable" on IC3. Since IC5 "c" and "d" form a clock running at 1.5kHz continuously, IC3 now commences to count upwards from zero and the voltage output of the ladder network rises in 0.021V steps per 0.6ms. As soon as the voltage equals or exceeds the D/A output the output of IC4 goes low and triggers the negative edge trigger of IC5b via IC7b which was switched on by the bistable IC6c and d. The trigger pulse switches the bistable into a reverse condition with pin 11 high and pin 10 low and IC3 is then disabled from counting further. At the same time the output of IC4 is isolated. The memory is therefore fixed at the D/A voltage the moment S1 is released to off.

A second bistable IC6a and b was triggered on when S1 was switched to "Engage" and this in turn switched on IC7 "c" and TR4. Current is thus able to flow through the solenoid of the servo. During "Engage" IC7d and TR3 were also switched on to energise the solenoid. The servo now produces an acceleration. On releasing S1 to off, IC7c and TR4 remain on while IC7d and TR3 are switched off, removing the acceleration.

IC8 acts as a differential amplifier with a large offset voltage. If the voltage on pin 3 equals that on pin 2 (D/A output equal to memory) then the output on pin 6 equals the offset voltage set by VR3. TR2 acts as a voltage follower to drive the servol in the servo. Should the car slow down then the voltage on pin 2 is less than on pin 3 of IC8 and the difference is amplified in the ratio of VR2 to 10k and added to the offset voltage. The servo is thus energised more and exerts more pull on the throttle to accelerate the car. The reverse happens if the speed is in excess of that set in the memory and the amplified difference is subtracted from the offset voltage. The servo is then de-energised and a deceleration occurs.

To release the cruise control the bistable IC6a and b is de-activated by pressing the "Stop" switch S2. This turns off IC7e and TR4, isolating the solenoid. However, the memory is not affected and if subsequently S1 is switched to "Resume", the bistable is re-activated and TR4 is switched on again without disturbing the memory as D2 isolates the positive pulse from the negative edge trigger and reset circuit.

A similar release action is obtained by pressing the brake pedal to activate the stop lights and therefore putting a positive pulse on the bistable to de-activate it. A similar switch to that of the stop lights can be fitted to the clutch pedal to de-activate when the clutch is depressed. This prevents the engine racing during gear changing.
Note that IC8 is not connected to the regulated supply but is connected to the 12V to 14V supply to enable a full 12V to reach the solenoid.

VR1 to 3 are set after installation. Initially they can be set at mid position. VR1 is set to produce a voltage of 5-5 on pin 6 of IC2 at maximum revs. Since this is difficult to do in practice, setting can be done at half revs to give 2.75V.

A road test is required to set VR2 and VR3. Drive at a constant speed on a level road and engage the unit, noting the exact speed. Adjust VR3 until the two speeds are within 0.5 m.p.h. of each other. VR2 sets the gain of IC8 and thus the sensitivity of the unit. Ideally the gain should be as high as possible for least speed variation but at high gains a surge tends to occur. Should the car tend to accelerate and decelerate repeatedly when the unit is engaged without becoming steady, then surge is occurring and the gain should be reduced. A gain of 20 to 30 should be satisfactory.

While S1 is being held on "Engage" the car will accelerate gently and continue to do so until S1 is released, at which point the cruise control takes over. A new higher speed can be set up by moving S1 to "Engage" without first releasing the unit, allowing the car to accelerate to the new speed and then releasing S1.

With a clock frequency of 1-5kHz the memory is set in about 100 milliseconds on release of S1, so speed variation during setting is of no importance.

The vacuum servo is self-restricting regarding throttle opening as there is no vacuum at full throttle to operate it. Throttle opening is limited to about 50% or 60%. This can be overcome by using a vacuum reservoir as shown in Fig. 6. Speed control is, of course, limited to the power of the engine during hill climbing (at 60% throttle) and to compression on downhill runs.

The solenoid valve in the servo must be mounted vertically with the vacuum pipe below for correct operation. The link to the throttle must have a sliding joint to allow normal throttle operation.

R. Immelman, Somerset West, South Africa.

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Fig. 5. P. s. u

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Fig. 6. Vacuum circuit

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Fig. 7. Brake and clutch circuit

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Fig. 8. Differential amplifier and servo drive

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Practical Electronics March 1983
TWO of the most popular microcomputers currently on sale, the Acorn Atom and the Dragon, have many similarities because they both use the same video display chip, the Motorola 6847. This versatile chip not only contains 64 programmed characters for a 32 x 16 text display, but will also give graphics displays up to a resolution of 256 x 192.

However the 6847's internal character set does not include lower case, and so both the Atom and the Dragon display lower case as inverted upper-case characters.

NEW CHARACTERS FOR ATOM

The following circuit shows how to add an external character generator to the 6847 to provide 256 different characters in the alphanumeric display modes. The circuit can be added as a plug-in module, and no alterations are necessary to the Atom (or Dragon).

With careful choice of the new character set lower-case can be added, while retaining compatibility with the Atom's existing VDU software. The circuit was designed by W. A. Chadwick of Welwyn, and the following description is based on his letter.

CIRCUIT DESCRIPTION

The new character generator is stored in a 4k x 8 EPROM. The top 8 address lines of this are connected to the 6847's Video Data Bus; see Fig. 1. When the 6847 puts data onto these lines they will select one of 256 groups of 16 EPROM locations. Each displayed character is 8 dots wide and 12 scan lines deep, so that the first 12 EPROM locations of each group contain the precise bit patterns for each character.

The lowest 4 address lines of the EPROM are connected to a row counter (74LS161). This counter is clocked once per scan line by the HS signal from the 6847 and so will sequentially select character row information from the EPROM. The 6847 provides a clear control, RP, every 12 scan lines for the row counter. The beginning of each display frame contains a border of non-active display lines, but unfortunately the 6847 does not provide an RP pulse to clear the character counter for the first character row. Thus, to ensure that the top line of the display is displayed correctly the Frame Synch (FS) signal is used to preset the row counter to 9 at the beginning of each frame.

When using the graphics modes of the 6847 the video data must be passed on to the chip unchanged. The control line A/C is used to select between alphanumeric and graphics modes. Since only 12 out of every 16 ROM locations are used for each character display frame, the EPROM and row counter are sufficient to select the required character by careful address assignment.

The EPROM's E2 location contains a 100nF capacitor, with the PN junction of a 2N5428 transistor connected to H. This circuit will work satisfactorily with any EPROMs which operate from +5V or +12V power supplies.

The circuit was designed by W. A. Chadwick of Welwyn, and the following description is based on his letter.
played, the 4 unused locations in each case are programmed to contain logical mappings of the top 8 address lines. The signal A/G is used to hold the row counter preset to row 12 or above when graphics are selected, thus causing the ROM to appear transparent. To illustrate how this works the coding of a single character is shown in Fig. 2.

![Character Coding](image)

**CHARACTER SET**

To maintain compatibility with existing software, the following character set is recommended:

<table>
<thead>
<tr>
<th>Character Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 to 1F</td>
<td>@ to @ as standard Atom.</td>
</tr>
<tr>
<td>20 to 3F</td>
<td>$ to $ as standard Atom.</td>
</tr>
<tr>
<td>40 to 7F</td>
<td>A to Z, inverted</td>
</tr>
</tbody>
</table>

Two examples of possible character sets following this design are given in Fig. 3. The only limitation of this set is that if the cursor is placed on an upper-case character it will appear as lower-case and vice-versa.

![Character Sets](image)

**POSSIBLE EXTENSIONS**

In the Atom the 6847's Colour Select Signal CSS is used to select between two possible sets of four colours. However, on monochrome displays this signal has little use, and so it can alternatively be used to add extra facilities to the character generator board. At power-up the CSS signal is set to logic 0. By gating CSS with A/G it is possible to cause the counter to preset to either row 14 or row 15 depending on the state of CSS. If rows 13 and 15 are programmed with a true logic mapping, and rows 12 and 14 with an inverted mapping, as shown in Fig. 2, then the CSS signal (which is controlled by bit 3 of the port at address B002) can be used to invert the entire graphics display. The circuit in Fig. 1 shows the links made for monochrome use to provide this facility; for colour use, both links should be changed so that CSS operates in the usual way. Good animated effects can be achieved with the colour graphics modes by drawing the background colour, then changing CSS to make the drawing instantly visible. An alternative use for CSS would be to switch between one of two character-generator EPROMS, one compatible with the existing Atom software, and the other giving 256 totally different display characters.

**FASTER ATOM**

Three other ways of improving the Atom's circuit have been submitted by Richard Brain of Devon. First, the Atom can be persuaded to run at 2MHz rather than the usual 1MHz by fitting a switch as shown in Fig. 4. Note that some of the other components, such as the memory on the 8255, may not be capable of the extra speed, and faster versions may have to be fitted.

![Circuit Diagram](image)

The second modification, shown in Fig. 5, speeds up the rate at which characters are printed to the Atom's screen. Normally, character output is synchronised with the FS output of the 6847 to prevent screen noise. By feeding a high frequency to the 8255 this delay of 1/60th of a second is circumvented. The third modification, shown in Fig. 6, eliminates screen noise on the Atom by giving the micro and the 6847 display generator the same clock source. Note that this means that the microprocessor speed will not be exactly 1MHz, and programs recorded using the cassette interface will have to be re-saved at the new frequency.

**ZX81 ANAGRAMS**

Over the past year several readers have sent in programs for the ZX81 to produce random anagrams of a given word. The shortest of these, taking 13 lines, is shown in Fig. 7 and it fits into an unexpanded ZX81. It was submitted by G. Wheaton of Bolton, and he writes:

醇酸是用酸性基酸与醇溶液而得到的，醇酸的合成方法有多种。醇酸与醇反应生成羟基化合物，这种化合物在水解作用下可以发生酸碱中和反应。醇酸是一种重要的化学原料，广泛应用于制药、染料、化妆品等领域的生产。醇酸的合成方法主要有酯化法、酯交换法和酯交换法。酯化法是醇酸合成的主要方法之一，其原理是酯化反应。

![Anagram Program](image)
10 INPUT A$  
20 LET L = LEN A$  
30 FOR F = 1 TO L  
40 LET X = INT(RND*L+.1)  
50 LET Y = INT(RND+.1)  
60 LET Z$ = A$(X)  
70 LET A$(X) = A$(Y)  
80 LET A$(Y) = Z$  
90 NEXT F  
100 PRINT A$  
110 IF INKEY$ = "" THEN GOTO 10  
120 SCROLL  
130 GOTO 30  

Fig. 7. Program generates random anagrams of a word on the ZX81.

Fig. 6. Circuit eliminates screen noise on the Atom display.

Fig. 8. Programs calculate mortgage repayments on the (a) ZX81, and (b) Spectrum.

the answer. The program helped me win the coveted prize of a Piccadilly T-shirt from the local commercial radio station."

"The program is fairly easy to understand; lines 70 to 130 shuffle the letters of the inputted word and lines 140 to 180 print out the resulting arrangements of letters; lines 30 to 60 set up the array B."

**ZX81/SPECTRUM MORTGAGE REPAYMENTS**

The following programs, shown in Fig. 8, will be of use to all those who are repaying a mortgage, or are contemplating taking one out; they were submitted by J. W. H. King of York. In use simply type RUN, and then answer the questions presented on the screen. When satisfied that all is correct, type CONT followed by ENTER (or NEWLINE), and the repayment amounts for each period, and annually, will be shown.

### MORTGAGE REPAYMENTS

```basic
10 REM MORTGAGE REPAYMENTS
20 PRINT "What Capital Sum?"
30 INPUT C
40 PRINT C
50 FOR HOW MANY YEARS?
60 INPUT Y
70 PRINT Y
80 PRINT "How many payments per year?"
90 INPUT N
100 PRINT N
110 PRINT "Annual Interest?"
120 INPUT I
130 PRINT I
140 LET R = I/100
150 PRINT "To obtain periodic repayments ENTER --CONT--"
160 STOP
170 CLS
180 LET A = (R/N+1)**Y
190 LET B = C/SR/N/(A-1)
200 PRINT "Periodic repayment= 
210 PRINT "Total annual repayment= 
220 REM ENTER RUN to start
```

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<th>Secondary Voltage</th>
<th>Current</th>
<th>Price</th>
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<td>115V</td>
<td>115V</td>
<td>100mA</td>
<td>£9.20</td>
</tr>
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<td>£9.20</td>
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<tr>
<td>240V</td>
<td>240V</td>
<td>240V</td>
<td>100mA</td>
<td>£9.20</td>
</tr>
</tbody>
</table>

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**Practical Electronics** March 1983
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