PRACTICAL ELECTRONICS

AUGUST 1983

SIMPLE SOLAR POWERED PROJECTS....

TRANSISTOR CHECKER: THERMOMETER

SOIL MOISTURE METER

CONTINUITY TESTER

COMPUTER DIAGNOSIS

LOGIC ANALYSER

Part One

ROBOT VISION

Plus! Used Computer & Equipment Bargains
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 TI 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.

Very high resolution 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.

GENESIS P102 PROCESSOR BOX AND HAND HELD CONTROLLER

Example prices and specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>S101</td>
<td>Base: 19.5&quot; x 11&quot; x 7.5&quot;</td>
<td>£195.00</td>
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<tr>
<td></td>
<td>Lifting capacity: 1500gm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arm length between axes: 14.0&quot;</td>
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<td></td>
<td>Weight: 29Kg</td>
<td></td>
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<tr>
<td></td>
<td>4 axis model in kit form</td>
<td>£425</td>
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<td></td>
<td>5 axis model in kit form</td>
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<td>Weight: 29Kg</td>
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<td>Arm length between axes: 14.0&quot;</td>
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<td></td>
<td>Weight: 29Kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 axis model in kit form</td>
<td>£675</td>
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</table>
| Complete Systems as shown in Photograph on right
| S101    | 4 axis system in kit form                         | £681.50 |
|         | 5 axis system in kit form                         | £737.50 |
|         | 5 axis system Ready Built                        | £1450   |

With prices starting below £1,000 the Genesis range of general purpose robots provides a fast, reliable 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 operates from a single phase 240 or 120V AC supply or a 12V DC supply. The machine can be supplied with up to 6 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 handheld controller or alternatively the systems can also be interfaced to an external computer via a standard RS232C link.

World Leaders in Electronic Kit Design and Supply

Portway Industrial Estate
Andover Hants SP10 3WJ

Phone Enquiries (0264) 64455

Export enquiries to:
Powertran International, Hollom Down Farm, Lopcombe, Salisbury, Wilts. SP3 1BP.
Tel 0264 781545 Telex: 477407 ZENMON
CONSTRUCTIONAL PROJECTS

SOLAR POWERED PROJECTS by R. A. Penfold
- M/W Radio
- Soil Moisture Meter
- Thermometer
- Inebriation Detector
- Continuity Tester
- Transistor Checker

LOGIC ANALYSER by D. Mandelzweig
Stores 1K or 8-bit words at up to 5MHz

GENERAL FEATURES

ROBOT VISION by Geoff Mortimer and Liz Newbury
The latest systems explained

VERNON TRENT AT LARGE

SEMICONDUCTOR CIRCUITS by Tom Gaskell BA (Hons)
Voltage converter (ICL 7660)

DEGLITCHING TECHNIQUES by L. N. Owen
Defining and overcoming unwelcome transients

MICROPROMPT
Hardware and software ideas for PE computer projects

NEWS AND COMMENT

EDITORIAL

NEWS AND MARKET PLACE
Including Countdown

SPECIAL OFFER-CASSETTES

SPACEWATCH by Frank W. Hyde
Extra-terrestrial activities chronicled

BAZAAR
Free readers' advertisements

INDUSTRY NOTEBOOK by Nexus
News and views on the electronics industry

PATENTS REVIEW
Infra-red link-Stereo TV

STRICTLY INSTRUMENTAL by K. Lenton-Smith
Yamaha pianos

READOUT

INGENUITY UNLIMITED
Transistor analyser—Electronic die—Car lights on reminder—Micro multiplexed display
Roger 'bleep bleep'—Steam whistle—Ni-Cad battery charger—High Z input for voltmeters

OVERSEAS SUBSCRIPTION AGENTS

SPECIAL SUPPLEMENT
MICRO-FILE by R. W. Coles
Filesheet 9 68000 between pages 38 and 39

OUR SEPTEMBER ISSUE WILL BE ON SALE FRIDAY, AUGUST 5th, 1983
(for details of contents see page 39)
Call in at our shop for demonstration of any of the C12 COMPUTER Grade BASF Cassettes in 4 x 4 matrix keypad (reed switch assembly) £4.

**ZENITH 12" Hi-RE.S, Green Monitor**

**SOFTY - 2.** The complete Microprocessor development kit, including programming instructions. Accepts any 24 pin 5V single rail EPROM. Supplied fully built & tested.

**WEMON.** Watford’s 4K Ultimate Monitor IC for Superbrain & UK10.

**ZENITH 12" Hi-RES, Green Monitor 40/80 column switch select, valid for BBC or liberty.

**SANYO 14" colour monitor, RGB & V/H sync. screened metal cabinet** £199.

**MIRCOVITEC 14" colour monitor, RGB input. Lead incl.** £249.

**TEX EPMOR ERASER.** Erases up to 32 ICs in 15-30 min. £33.

**TEX EPMOR ERASER with the Solidate-30 minute Electronic Timer.** £43.

**SOLID STATE 30 minute Electronic Timer** for above ERASERs. £14.

**Spares** 'UV lamp bulbs £9.

**POWER SUPPLY** Regulated, Variable from +5V to 12V at +5V, 3A, $5. £40.

**MULTIRAIL PSU KIT.** Output: +5V/5A; +12V, +25V; -5V, -12V @ 1A. £40.

**4 x 4 matrix keypad (reed switch assembly)** £4.

**C12 COMPUTER Grade BASF Cassettes** 40p.

**8" & 9" Fan fold paper (1000 sheets)** £7 (150p).

**Teleprinter Roll (no VAT)** £3.50.

(P&P on some of the above items is extra)

**LETTERING SYSTEMS** Just phone your order through, we do the rest. 0923-50234.
FREE CAREER BOOKLET

Train for success in Electronics Engineering, T.V. Servicing, Electrical Engineering—or running your own business!

ICS have helped thousands of ambitious people to move up into higher paid, more secure jobs in the fields of electronics, T.V., electrical engineering—now it can be your turn. Whether you are a newcomer to the field or already working in these industries, ICS can provide you with the specialised training so essential to success.

Personal Tuition and 80 Years of Success
The expert and personal guidance by fully qualified tutors, backed by the long ICS record of success, is the key to our outstanding performance in the technical field. You study at the time and pace that suits you best and in your own home.

You study the subjects you enjoy, receive a formal Diploma, and you’re ready for that better job, better pay.

TICK THE FREE BOOKLET YOU WANT AND POST TODAY

ELECTRONICS
ENGINEERING
A Diploma Course, recognised by the Institute of Engineers & Technicians as meeting all academic standards for application as an Associate.

T.V. & AUDIO SERVICING
A Diploma Course, training you in all aspects of installing, maintaining and repairing T.V. and Audio equipment, domestic and industrial.

ELECTRICAL ENGINEERING
A further Diploma Course recognised by the Institute of Engineers & Technicians, also covering business aspects of electrical contracting.

RUNNING YOUR OWN BUSINESS
If running your own electronics, T.V. servicing or electrical business appeals, then this Diploma Course trains you in the vital business knowledge and techniques you’ll need.

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British Code of Advertising Practice
Advertisements in this publication are required to conform to the British Code of Advertising Practice. In respect of mail order advertisements where money is paid in advance of delivery, the code requires advertisers to fulfil orders within 28 days, unless a longer delivery period is stated. Where goods are returned undamaged within seven days, the purchaser’s money must be refunded. Please retain proof of postage/despatch, as this may be needed.

Mail Order Protection Scheme
If you order goods from Mail Order advertisements in this magazine and pay by post in advance of delivery, PRACTICAL ELECTRONICS will consider you for compensation if the Advertiser should become insolvent or bankrupt, provided:
1) You have not received the goods or had your money returned; and
2) You write to the Publisher of PRACTICAL ELECTRONICS summarising the situation not earlier than 28 days from the day you sent your order and not later than two months from that day.

Please do not wait until the last moment to inform us. When you write, we will tell you how to make your claim and what evidence of payment is required.

We guarantee to meet claims from readers made in accordance with the above procedure as soon as possible after the Advertiser has been declared bankrupt or insolvent.

This guarantee covers only advance payment sent in direct response to an advertisement in this magazine not, for example payment made in response to catalogues etc, received as a result of answering such advertisements. Classified advertisements are excluded.

ICS
Dept K627
160 Stewarts Road
London SW8 4UJ
01 622 9911 (all hours)

Bi-Pak Ltd
(17) 004 3074

Access & Visa accepted

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ADVERTISING

JUST OUT!

OUR GREAT NEW CATALOGUE

Presented with a Professional Approach and Appeal to ALL who require Quality Electronic Components, Semiconductors and other Accessories ALL at realistic prices.

There are no wasted pages of useless information so often included in Catalogues published nowadays. Just solid facts i.e. price, description and individual features of what we have available. But remember, Bi-Pak’s policy has always been to sell quality components at competitive prices and THAT WE STILL DO.

We hold vast Stocks “in stock” for fast immediate delivery, all items in our Catalogue are available ex stock.

The Catalogue is designed for use with our 24 hours “ansaphone” service and the Visa/Access credit cards, which we accept over the telephone.

To receive your NEW 1983 Bi-Pak Catalogue, send 75p PLUS 25p p&p to:-

Bi-Pak Ltd
(17) 004 3074

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160 Stewarts Road
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01 622 9911 (all hours)
WHAT USE A MICRO WITHOUT A PRINTER?

NEW A.D.M. 80 COL. DOT MATRIX WITH TRACTOR FEED. BACKED BY ONE OF BRITAIN'S LARGEST MANUFACTURERS, IT IS NOW STOCKED BY US.

SPECIAL LAUNCH PRICE
£311.00 + VAT. Carriage £7.50 or collect from our warehouse.

CROFTON ELECTRONICS LTD.
35 GROSVENOR ROAD, TWICKENHAM, MIDDX. 01.891 1923/1513 Tel: A295093

ORIC AND SINCLAIR COMPUTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
<tr>
<td>Oric 1 48K computer</td>
<td>£147 (£158)</td>
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<td>£112 (£113)</td>
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<td>ZX microdrive n/a</td>
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<td>£35.74 (£39)</td>
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<td>ZX81 16K RAM pack</td>
<td>£38.04 (£42)</td>
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OTHER COMPUTERS

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<th>Model</th>
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<tr>
<td>Colour Grease</td>
<td>£116 (£118)</td>
</tr>
<tr>
<td>SBC Model B</td>
<td>£424 (£440)</td>
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<td>Texas T199/A</td>
<td>£139 (£149)</td>
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<tr>
<td>Atari 800</td>
<td>£47.78 (£51)</td>
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PRINTERS

The Epson MX80FT/3 has been replaced by the almost identical CTI CP100 £262 (£282) and the very similar Star DPSI0 £201 (£205). Other models include the Epson PX100 £217 (£225), the Star DPS50 £201 (£205), the Sinclair G100A £89 (£99), the Oki Microline 82A £168 (£180). The Byperiter offers compatibility with nearly any other printer available on the market.

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<td>Commodore 64 £399 (£399)</td>
<td>Vic. 20 £130 (£140)</td>
</tr>
<tr>
<td>Commodore Cassette Recorder</td>
<td>£60 (£64)</td>
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SWANLEY ELECTRONICS


UK prices are shown first. UK customers must add postage (£1 on Sinclair products, £3.50 on other computers and drives and £4.50 on other printers) and 15% VAT. The bracketed prices are European export prices and include insured airmail postage to all the countries of Europe including Norway, Sweden, Finland, Denmark, Spain and Italy. No VAT should be added to export prices. We are the leading computer export specialists. Official UK credit orders welcome from government laboratories and educational establishments.

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WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognized as world leaders.

BIPOLAR MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power Watts</th>
<th>Load Impedance Ω</th>
<th>Distortion Typ.</th>
<th>Supply Voltage Typ.</th>
<th>Base size</th>
<th>HT gain</th>
<th>Price inc. VAT</th>
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<tbody>
<tr>
<td>H16</td>
<td>11.5</td>
<td>8.6</td>
<td>0.01% &lt; 0.005%</td>
<td>10 V</td>
<td>70x30 x 4</td>
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<tr>
<td>H14</td>
<td>9.6</td>
<td>8.6</td>
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<td>10 V</td>
<td>70x30 x 4</td>
<td></td>
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<tr>
<td>H12</td>
<td>7.5</td>
<td>8.6</td>
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<tr>
<td>H11</td>
<td>5.5</td>
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<tr>
<td>H10</td>
<td>4.6</td>
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<td>70x30 x 4</td>
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<tr>
<td>H9</td>
<td>3.6</td>
<td>8.6</td>
<td>0.01% &lt; 0.005%</td>
<td>10 V</td>
<td>70x30 x 4</td>
<td></td>
<td>£6.50</td>
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</table>

Most pre-amplifier modules can be driven by the PSU and can be added as desired. A separate PSU 30 is available purely for pre-amplifier modules as required for £17.60 inc. VAT.

MOSFET MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power Watts</th>
<th>Load Impedance Ω</th>
<th>Distortion Typ.</th>
<th>Supply Voltage Typ.</th>
<th>Size mm</th>
<th>HT gain</th>
<th>Price inc. VAT</th>
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</thead>
<tbody>
<tr>
<td>MOS 129</td>
<td>11</td>
<td>8.6</td>
<td>0.01% &lt; 0.005%</td>
<td>10 V</td>
<td>70x30 x 4</td>
<td></td>
<td>£17.60</td>
</tr>
<tr>
<td>MOS 291</td>
<td>12</td>
<td>8.6</td>
<td>0.01% &lt; 0.005%</td>
<td>10 V</td>
<td>70x30 x 4</td>
<td></td>
<td>£17.60</td>
</tr>
<tr>
<td>MOS 290</td>
<td>9</td>
<td>8.6</td>
<td>0.01% &lt; 0.005%</td>
<td>10 V</td>
<td>70x30 x 4</td>
<td></td>
<td>£14.12</td>
</tr>
</tbody>
</table>

Practical Electronics August 1983
WITH A LOT OF HELP FROM ELECTRONICS LTD

PROFESSIONAL HI-FI THAT EVERY ENTHUSIAST CAN HANDLE...

Unicase

Over the years I LP has been aware of the need for a complete packaging system for its products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of I LP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi-fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

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### UNICASES

<table>
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<th>HiFi Separates</th>
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<td>LP1X 30W-4Ω Mono</td>
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<td>US4X 120W-8Ω MOS Power Slave</td>
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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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Practical Electronics August 1983
CABLE—A BREAKTHROUGH?

With the recent news of a cable service for most UK homes and the exciting possibilities that have been dreamed up by the media it is sobering to read what follows, written more than eleven years ago by Fred Bennett who was then editor of PE.

"With commendable boldness and confidence in the future growth of telecommunications for domestic purposes, the Post Office is currently involved in the installation of a 'communication main' system in the new city of Milton Keynes, now arising in Buckinghamshire. Every house in the new city will be linked to this communication system. The cables will, so far as possible, be laid in a communal trench, with the other essential services, water, gas, electricity, and drainage.

"A standard telephone pair forms part of this 'main'. This cable is accompanied throughout, right up to every front door, by a high performance coaxial cable. Besides being capable of carrying radio and television signals, this wideband coaxial cable provides for the transmission of two-way signals such as could be employed to operate viewphones and computer data terminals, and permits the carrying out of other useful functions, like the remote reading of gas and electricity supply meters.

"What happens in Milton Keynes may become the pattern for the future throughout the country. At any rate, this pioneer installation is worth noting and musing upon. It could herald another technological explosion making direct impact upon the domestic or 'consumer' section. We don't doubt that fertile minds will seize eagerly the opportunity it promises for further imaginative and useful exploitation of electronics."

Obviously with the increase in consumers resulting from wide scale cabling the cost of suitable equipment will fall. However, we cannot help wondering if it will all be worthwhile when the use of Viewdata is still so limited. The wonders of Information Technology will not be forced on a community that sees little advantage in the system. The availability of a vast range of cheaply hired video cassettes already reduces the chance of any "film channel" being successful.

As Vernon Trent indicates this month, technology can move as fast as it likes, the consumers are setting their own pace.

PRICE INCREASE

Unfortunately rising costs have forced us to make a cover price increase. From next month PE will cost an extra five pence; this is slightly less than a six per cent increase. The last increase was a year ago.
Farewell Analogue TV

It was hardly likely that the humble domestic television receiver would remain outside the swelling compass of digital technology for much longer. The bell tolls, and ITT is the campanologist with its ‘‘Digivision’’ system.

Until now, digital electronics has been applied only to two sections of the television set, these being the infra-red remote control and the local oscillator of the tuner. The situation has changed dramatically. In what is claimed to be the biggest revolution in television since the introduction of colour 30 years ago, ITT’s Digivision offers an entirely new system which changes fundamentally almost every section of the receiver. Although Digivision is designed to receive conventional TV broadcast signals, it is almost 100 per cent digital in operation, and it is already on the commercial horizon. Receivers based on the Digivision chip set will be on sale in West Germany, the country of origin, in late 1983. They will become available in the UK in early 1984.

ITT expects that in the future 50 per cent of all television sets sold throughout the world will incorporate Digivision. An understandable anticipation, it being the culmination of a 10 year, £20m investment project.

The benefits of a micro’ based receiver, to both the user and the service engineer, are manifold. The end-user gets a television which makes an “intelligent” effort to optimise reception under all conditions (including ageing) by comparing performance characteristics with factory preset values stored in memory, and, naturally, making all necessary adjustments automatically. Sound quality is also improved with digital processing right to the loudspeaker (mono or stereo) using pulse-width modulation.

The service engineer will benefit from a tool that ITT calls an “electronic screwdriver”. This diagnostics computer runs tests and makes adjustments to the receiver’s EAROM data by way of an umbilical cable. The chassis has only one preset potentiometer. The engineer will be able to carry out most adjustments from the front of the set, following prompts on the screen.

Some amazing possibilities accompany the digital television era. Line and field storage is envisaged, which will allow display scanning standards to be defined and varied locally. For example, a 625 line, 50 fields/sec interlaced picture could be displayed at 1250 line, 150 fields/sec non-interlaced, yielding improvements in subjective definition and stability. Picture data storage will also make possible selective “zoom” and “freeze” of any broadcast picture. Noise, interference and flicker will be eliminated, and ghost images will be “exorcised”. The intriguing prospect of pictures from other channels being inset into one corner of the channel being watched, is with us.

These features by no means represent the extent of exciting possibilities that

Piezoelectric Plastic

The electronics hobbyist of yore, enthused by experimentation with an OC71 transistor, a piece of paxolin and a tobacco tin, would have scoffed at the idea of discovering electronics, or physics using pre-designed circuits conveniently packed into little plastic bricks, no matter how many leads emerge from them. But he wouldn’t have scoffed at the opportunities afforded by a new product from Metal Box’s R&D lab’s at Wantage, which opens up a whole new can of worms (as they say) for the experimentalist.

Think what could be done with a sheet of piezoelectric plastic which can be cut to any shape or size, to make a custom transducer. The idea is not new; the Japanese (of course) have been making a similar material for some time, but it has never been widely available. Metal Box make theirs from polyvinylidene fluoride (PVDF) which is metallised, and undergoes rather special treatment to give it the potential to be used in microphones, loudspeakers, impact detectors and push buttons, and who knows what else?

When acting as an audio transducer the material can be its own diaphragm, opening up amazing possibilities, which include large area microphones, flat loudspeakers, vibrating surfaces or platforms and ultrasonics. Other applications spring to mind: How about a flexometer (if there is such a thing)? Or an optical deflector, or perhaps an acoustically controlled LF oscillator? Or even a liquid atomiser?

The pure experimentalist’s odyssey is assured with this film, because it is also pyroelectric, enabling it to be used for thermal im-
Viewdata Bargain

The PAT Viewdata adaptor shown here is available for £55 (including VAT, plus postage) but before you reach for your cheque book there is just one point we should mention! Although they are in the manufacturer's packing and are new and unused they can only be purchased from J. Bull (Electrical) Ltd., untested and without guarantee. However, the components alone are worth more than the cost and “if all else fails” the GI chips could be used for your own design system. The unit shown in the photo is now providing Prestel in the PE office, following installation of a jack (£15) by British Telecom. The equipment is beautifully made and at the price is obviously too good to miss, provided you are prepared to take a chance. But make up your mind quickly as the quantity is limited.

Also from J. Bull is an excellent Amstrad a.m./f.m. tuner head. F.M. coverage is 87.5—108MHz at 2.5pV for 30dB signal to noise and a.m. coverage is: m.w. 525-1650kHz, l.w. 155-270kHz at 320pV/M.

Connections for a tuning meter, stereo beacon and a.f.c. switch are provided. With the addition of a 12V supply and simple stereo amp this would make a high quality hi-fi system, as it was originally intended to do in the EX222 receiver. The tuners are new and the price is £6, including VAT plus postage.

J. Bull (Electrical) Ltd. (Dept PE), 34-36 America Lane, Haywards Heath, Sussex RH16 3OU. Tel: 0444 454563.

Amorphous Solar Cells

Mitsubishi Electric Corporation of Japan has managed the successful manufacture of an experimental 100cm² solar cell with an energy conversion efficiency of 8.25%. Although this may not sound like a very exciting event, this level of efficiency is claimed to be the world's highest for such a large element size.

The high performance solar cell, which comprises one amorphous germanium and two amorphous silicon layers, has an open-circuit output of 2.2-2.4V. It is low cost, using less than 1% of semiconductor materials as compared with a single crystal solar cell, and furthermore large element sizes are possible. Exposure to the sun gradually changes the characteristics of conventional cells, but does so far less with Mitsubishi's cells. Production costs are also lower, since the amorphous cell can use a cheap and comparatively unsmooth steel plate as its substrate.

As part of the solar cell research venture called the "Sunshine Project" Mitsubishi is in charge of amorphous cell development. The project, started in 1980 by the Japanese Agency of Industrial Science and Technology, had targeted the objective of a 10x10cm element with an efficiency greater than 8% by the close of 1982. This it achieved, and now Mitsubishi is working towards the production item.

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

United Components: Two new enhancement mode, 400MHz power f.e.t.s, UMPI & UMP2. Operating from 25—30V, UMPI gives 5W at 1100V gain, and UMP2 gives 10W at 7dB. Almost infinite VSWR mismatch tol.

♣ New stackable rectangular (2 x 5mm) i.e.d. series. The high efficiency MV5X123 is available in red and yellow and high brightness green.

♣ Optically isolated gate, triac driver i.e. (6-pin) called MCP30XX series. 120 & 240V versions can drive up to 24VA loads. Pin replacements for MOC3000 series.


♣ Rastra: The CH1812 module provides Direct Connect Protective Hybrid (DCPH) interface to telephone line, conforming to regulations. Measures 0-66 x 2-1 x 1-1 in.

♣ DAC 9311-16 series comprises 16-bit latched D to A in monolithic technology. Features 0-0008% linearity, 2-chip construction, I/P registers, low power, HL-REL 24-pin d.i.p., 2 & 4 quadrant multiplication, single +15V supply. Cheap, ultra-robust commercial device. Rastra Electronics, 275 King Street, Hammersmith, London W6 9NF.

♣ Ferranti: TO92 style radio receiver, designated ZN414Z is the widely available TRF circuit, now in alternative package. Motor speed controller i.e. called ZN411E provides precise speed control for electric power drills. On-chip shunt regulator, soft-start and reverse capability. Hall effect compatible “Tacho” I/P, and current limit. Ferranti Electronics, Fields New Road, Chadderton, Oldham, Lancs OL9 8NP.

♣ Siliconix: Six new additions to the VN series power f.e.t.s offer 250W ratings, BVdss from 60-500V at 20A. These TO-3 packaged devices have op-resistance of 0-035—0-3. Siliconix Ltd., Morrison, Swansen SA6 6NE.

♣ Motorola: The marriage of the DIAC and the TRIAC results in a bilateral switch called the SIDAC, which conducts up to 1A when the voltage across it exceeds 115V for the MKIV-115, and 135V for the MKIV-135. Housed in "surfmetic" 50 axial lead packages, it is intended for pulse applications and fluorescent lamp starters. Motorola Ltd., York House, Empire Way, Wembley, Middlesex.
In the quest for the superconducting switch one early attempt (called the Craytron) achieved a switching action by way of the transition from superconductor to normal metal—an action that was too slow for practical application. Another attempt, a three-terminal device invented at Argonne National Laboratory, did show small-signal current gain; but the most widely known breakthrough, called the Josephson Tunnel Junction switch, functions with promisingly high speed and low power.

However, IBM's Thomas J. Watson research centre in Yorktown Heights, New York, has come up with a superconducting "transistor." The patented device is called the "quiteron" by its inventor, Sadeg M. Faris (shown in the photograph, holding a wafer of experimental samples).

The quiteron has yet to be optimised, but it is the first three-terminal superconducting device that can both amplify and switch, consequently having potential applications in analogue and digital circuitry. Like the familiar Josephson Junction, the quiteron is a cryogenic device that employs superconductivity, a phenomenon occurring near absolute zero (0 deg. K, or -273 deg. C) at which temperature certain metals lose all resistance to electrical current flow. The two devices are, nevertheless, based on entirely different principles.

The quiteron consists of two tunnel junctions formed by three thin films of superconducting materials separated from one another by two, even thinner, films of insulating material. Structures of this nature have been studied before, but the quiteron is the first to make use of the "non-equilibrium" superconductivity phenomenon known as the "heavy quasiparticle Injection Tunneling Effect." The name quiteron was derived from this.

The secret of Siemens' success, where others have failed, in combining the flatness of the plasma display with the high intensity/resolution and colour potential of the c.r.t., is in the fact that its plasma is not used as a source of light, but as a source of electrons. The electrons are then guided by a specially developed grid to a conventional phosphor screen. The flat display developed by Siemens of Munich, West Germany, can illuminate up to 10^6 pixels without compromising other parameters—as in the past. The 14 inch plasma-discharge panel shown in the photograph is only six centimetres thick.

Because plasma acts as an electron source, as opposed to the hot cathode in a conventional c.r.t., this display requires a mere 4kV for its acceleration electrode (c.r.t. requires 20kV), and so it produces virtually no X-rays. This is a nice feature since the display will first begin to appear in VDU applications; and with a resolution of 3.1 dots/mm horizontally, and 2.5 dots/mm vertically, arbitrary graphical images are possible. Power drain for the entire panel is 20W, and flicker is eliminated by a refresh frequency of 80Hz.

The display surface is perfectly flat, which allows a good focus right into its extreme corners. Also the electron flight-path is much shorter than in a c.r.t., being one millimetre between the control plate and the phosphor, so that the natural divergence of the beam electrons due to mutual electrostatic repulsion is minimised. This improves the focal sharpness still further.

As a VDU, the display may be driven entirely digitally, each pixel being addressable on a row and-column basis. Pulse durations determine illumination levels, thereby allowing a full greyscale. But there is nothing grey about the future of this development, which is quite capable of invading the television market in due course.

Trains and Boats and Planes

"What is this life if, full of care, We have no time to stand and stare?"—William Henry Davies.

And what better place to stand and stare than the South Kensington Science Museum's new gallery called "Telecommunications — A Technology For Change," which is heavily sponsored for its first year of life by STC to mark the company's Centenary.

The visitor may enjoy the story of telecommunications by way of two adjoining galleries. The first describes the subject's chronology, whilst the second demonstrates the technologies that make distant communication possible.

Life-size mock-ups include the telegraph office at Tonbridge railway station in 1850, a ship's radio cabin of 1910 and the radio operator's position in a World War II Lancaster bomber.

Tape recorded reminiscences of life in the service of cable companies throughout the period 1920-1950 add to the atmosphere, and working demonstrations and computer graphics displays illustrate aspects of modern telecommunications techniques. Packet switching and pulse code modulation principles are illustrated in this way, and a simulation of the System X digital exchange increases the visitor's understanding of services we all take for granted. A purpose-built cinema shows films produced by STC, but for those with an itch to twiddle knobs there is the remote controlled camera and monitor which may be operated by visitors. This installation oversees the museum's entrance, from a vantage point on the neighbouring Victoria and Albert Museum.
**PANEL METERS**

A recently formed company called Martel has been set up to manufacture and market low cost, high quality instruments, control modules and counter timers.

Two particularly interesting items, from their range, are the MCM 3554/1 voltmeter and the MCF 4544/1 frequency meter. Both of these versatile digital panel mounting instruments have been designed by Martin Kent, the author of many projects published in PE.

The two instruments which are fully assembled and calibrated have many applications including uses in multimeter, thermometer and pH meter designs.

The voltmeter, based around the 7126 chip, has a ±200mV full scale and 3½ digits (0.5in high). The frequency meter, based around the 7224 chip, has three ranges (2MHz, 200kHz and 20kHz) and 4½ digits. Both meters are available to PE readers at a special offer price (valid to 31.8.83) of £9.95 plus VAT for the voltmeter and £19.95 plus VAT for the frequency meter. Data sheets are supplied with both devices. Martel Instruments Limited, Knight House, Foxhill Road, Southminster, Essex.

**PRINTERS**

Two new printers have just been launched by Oric Products and Crofton Electronics. The Oric unit which is the first peripheral for the Oric 1 is a colour system with an interface. The printer is priced at £169.95. The second unit is the AMD printer which is similar to the Epson having the Graftrax plus facility and is a 80 column, tractor feed machine with a parallel Centronics port. Crofton are offering the machine at a special launch price of £311.00 plus VAT and £7.50 carriage.

Crofton Electronics Ltd., 36 Grosvenor Road, Twickenham, Middlesex.

and Finally...

The recently formed Irish Amateur Computer Club is seeking to add to its throng of 70+ members, with a particular desire to enrol more "hardware specialists". The IACC currently meets at least once a month in the Power's Hotel, Dublin (second Sunday of each month 10am to 2pm). Members receive regular bulletins and newsletters, and enjoy a good range of benefits and events. Sub-groups are envisaged, concentrating on specific tasks, topics and brands of computer.

For further details contact: Nigel Carey, 166 McKee Avenue, Finglas East, Dublin 11.

**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.

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IBM User Show July 12–14. Wembley. O

Internoise (noise control conf.) July 13–15. A7


Star '83 Aerospace July 21–24. RAF Greenham Common. Z1


BARTAG Rally (radio teleprinter) Aug. 29. Sandown Park, Esher, Surrey. E2

Light Aviation Show Sept. 1–3. Cranfield Institute, Bedfordshire. Z1

Electro West Sept. 6–8. Bristol Exhibition Centre. Q

CAST (Cable And Satellite Television) Sept. 11–14. NEC. F5

Weldey Sept. 12–16. NEC B/ham. I


Personal Computer World Show Sept. 22–24. RDS Hall, Dublin. V


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A7 Institute of Acoustics £ 031-225 2143

B9 Cyril Bogod, British Am. Elect. Club £ 0222 707813

D4 Network £ 0282 5226

E Evan Steadman £ 0799 22612

E2 BARTG 89 Linden Gdns., Enfield, Middx.

F5 Cable & Satellite £ 01-487 4937

G2 Clapp & Poliak £ 01-747 3121

F Industrial Trade Fairs £ 021 705 6707

G2 Alan Taylor £ 01-486 1951

J3 Computer Marketplace £ 01-930 1612

L2 D. T. Wilson, 4 Conway Ave., Peterborough M

Montbuild £ 01-486 1951

O Online £ 09274 2821

P Exhibitions for Industry £ 08833 4371

T Trident £ 0822 4671

V SDL Exhibitions £ 01-705 6707

Z1 BETA Exhibitions £ 01-405 6233

Z1 IPC Exhibitions £ 01-643 8040
COMPACT DISC SYSTEMS

This year’s Spring Trade Shows saw the arrival of the audio compact disc (CD), the revolution in recorded sound. Since its launch back in March of this year every major record company has announced that it will enthusiastically support the CD format.

It is estimated that over 1000 titles will be available by the end of the year and most of these will be made in Hanover, West Germany by PolyGram but plans are already underway by two UK manufacturing companies to establish CD pressing plants in this country.

The Fisher AD800

The real breakthrough with CD has been that both the hardware and software producers worldwide have accepted the format originally developed jointly by Sony and Philips as the world standard with over 30 manufacturers now licensed.

Although at around £500 the systems are expensive many retailers believe the sales of CD units will be followed by an increase in speaker and amplifier sales because many people will prefer to buy their new systems from scratch.

For this reason Philips have produced a “flat membrane” range of speakers which they have designed for use with CD. The company say the new speakers reduce distortion and improve the overall sound quality when compared to normal speakers on both CD and conventional systems.

Another manufacturer following this line of thought is Pioneer who have updated their HPM series of speakers with power capabilities ranging from 90W to 240W. Included in the wide range of models on show were the Fisher AD800, the Marantz CD-73 and the Hitachi DA100. The Fisher AD800 model is fitted with a detachable storage unit which can hold up to five discs and enables the AD800 to fit a 19in. rack system. Once the disc is placed in the holder it is automatically taken into the unit and the front loading door closed. The AD800 allows easy selection search of 16 tracks in any sequence and touch controls include fast forward, reverse/play/pause and stop. Priced at £479.95 inc. VAT the AD800 comes complete with the ADP105 CD storage unit.

The Marantz CD-73 system is a drawer loading unit which can be programmed to play track selections in any order, to skip specific tracks or to repeat them. The CD-73 is priced at £559.90 including VAT. The Hitachi DA100 also has random programming and skip features and includes a disc scan facility which when used will give a brief sample of the current disc program and then advances to a point 30 seconds ahead on the disc and plays another brief sample. The DA100 is priced at around £500.

MINI-MINDER

With the ever-increasing popularity of home intruder detection systems comes the inevitable jockeying for market position by the manufacturers.

Songuard are offering a system which incorporates an ultrasonic device that can be placed where protection is needed without actually running any wires. Known as the Songuard Bug it will act as a miniature detector and can be attached to doors, windows, cupboards or even the jewellery box. What’s the catch? Well the only non-wiring is between the device and its receiver, but it is indeed a very handy contrivance. The freestanding detector and alarm unit will retail at around £169.

The Songuard system is modular and also includes personal attack buttons, entry/exit keyswitch units and internal/external siren units. All auxiliary paraphernalia is also available from Songuard, Sales and Service, Mill Mead, Staines, Middlesex (0784 62016).

SORD GAMES

The home computer market abounds with versatile machines competing for our custom and the M5 is no exception. Manufactured by Sord of Japan and marketed in the UK by Computer Games Ltd its graphic capabilities will undoubtedly be the main selling point. With sixteen colours available the user will be able to create impressive animations from scratch or by using a pre-programmed cassette. With a BASIC 1 manual, p.s.u., connecting leads and two game cassette the M5 will retail at around £190 inc VAT.

Interestingly, ‘joypads’ will also be available—the joy ‘stick’ being replaced by a rather large button which when pressed at the relevant point on its circumference will transfer that directional information.

Also from CGL are a range of chess computer games including the Pocket Micro with a folding board. Players will be able to interrupt a game at any stage, pack it away and re-start at a later date. This feature will make the game unique, it will retail at around £32.
**WATER BABY**

Remember when the Walkman units first encouraged us to whistle while we worked, or jog with Jimmy Young? Well if you so desire you can now sing in the surf with a completely water-proof and sand-resistant model. The Sony Sports Walkman WMFS has a disc drive system designed to reduce distortion. It incorporates an FM tuner and belt-clamp.

The Walkman will soon be available from retailers at around £111.

On the other side of the micro-electronic fence comes a new range of calculators from Sharp. A series of packs is the latest idea and besides the usual scientific types we now have one for the shopper, motorist, student, handyman, salesman and lady. There is also of course the inevitable school-pack which includes the ever-popular ruler, protractor and compasses etc. Function permutations are immense and it seems to make good sense to keep calculators simple and direct the resultant machines at a particular market requirement, hence the new range.

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**HOME PHONE SYSTEMS**

The telephone which seems to have been forgotten by everyone as a consumer product has recently been given a revival of interest due to two new designs from Fidelity Radio.

The telephone which seems to have been forgotten by everyone as a consumer product has recently been given a revival of interest due to two new designs from Fidelity Radio.

**The Wanderer**

The first is the Fidelity Wanderer a completely cordless handset which can be used up to 200 metres from its base unit. The base unit itself is plugged into the normal BT socket and is also connected to the mains. The cordless handset incorporates a push-button dialling system and operates on frequencies of 47.46/47.54 MHz from the handset to the base and 1.642/1.782 MHz from the base to the handset. The unit also features a unique digital coding system to prevent unauthorised dialling from other handsets in the same locality, a single push-button redial facility, a memory which stores a number entered whilst the phone is in use (ideal for Directory Enquiries), a call button on the base unit to page the handset user and an automatic recharging system for the Ni-Cad batteries. The Wanderer will retail at around £170.

**The TAS-1G**

The second design is the clock radio phone, the CRP 100, which incorporates the three facilities of a radio, alarm clock and telephone in one unit. It operates in precisely the same way as a conventional clock radio but has an automatic cut off when the telephone receiver is lifted. The radio operates an LW, MW and FM with selector switches for the radio, alarm radio, alarm buzz and off. A snooze touch sensor is provided and the readout is from a red l.e.d. display.

The TAS-1G from Sanyo is a basic telephone answering system which has several interesting features particularly its ability to detect the pay-tone from call-boxes. The machine accepts the call but automatically pauses until the pay-tone has finished before giving its recorded message. This avoids the caller losing part or possibly all of the message whilst the coins are being inserted. It will retail at around £148.

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**NO CHARGE**

Rechargeable batteries are becoming increasingly popular and Sanyo, the largest manufacturer of Ni-Cads, have experienced a doubling of demand over the last year for batteries and chargers in the UK.

To maintain their market position Sanyo have updated their Cadnica range of batteries, improving their sealing so they remain leakproof longer and enhancing the overcharge and overdischarge (forced discharge) resistance. A typical forced discharge occurs when batteries with different levels of charge are not fully recharged and therefore balanced before being used in one piece of equipment.

Sanyo have also introduced a new universal multicharger, the NC1239, which is capable of charging every battery in their range, whilst the NC-AM1 charger for HP7 batteries is a solar-powered system which is driven by a high power solar panel developed by Sanyo.
The MW radio, like the other five projects in this set, has been designed to operate at low levels of supply voltage and current. In fact, this receiver will operate quite well at a supply voltage of 1 volt with a current consumption of under 1 milliamp. In other words it requires an input power of under 1 milliwatt for satisfactory results. Under reasonably bright conditions this enables the set to operate from just two small solar cells.

THE CIRCUIT

The receiver is a simple MW Band type which has a ferrite rod aerial and an output which is intended to drive a crystal earphone (and which is unlikely to be suitable for any other type of earphone or headphones). Circuits using a couple of silicon transistors were tried, but the final design gave significantly superior results using a ZN414 plus a single transistor audio stage, and the full circuit of the set is shown in Fig. 1.

The ZN414 is ideal for this type of application as it gives a level of performance which is superior to that provided by most discrete T.R.F. designs, and it requires a nominal supply potential of only about 1.2 volts at a supply current of approximately 1 milliamp. It provides r.f. amplification, a.m. demodulation, and a simple automatic gain control (A.G.C.) action.

The ZN414 has a high input impedance so that it can be fed direct from the tuned winding of the ferrite aerial and the low impedance coupling winding is left unused. R1 is used to bias IC1 via the aerial winding (so that this resistor does not shunt the input impedance of IC1), and C1 couples one end of the ferrite aerial to the negative supply rail. R2 is the load resistor for IC1 and C2 is the r.f. filter capacitor for the detector stage of IC1. Note that IC1 obtains its positive supply only via R2 and there is no direct connection from IC1 to the positive supply rail.

The audio output level from IC1 is up to about 30
Fig. 1. Circuit diagram of the MW Radio

millivolts r.m.s., and this is just about sufficient to drive a crystal earphone at reasonable volume. However, better results are obtained using a small amount of audio amplification, especially when receiving weaker stations or when the supply voltage has fallen to a barely adequate level.

A simple common emitter audio amplifier based on TR1 is therefore used to boost the output from IC1. An amplifier of this type would normally be expected to have a voltage gain of about 40dB (one hundred times) or more, but in this case the voltage gain obtained is only about 20dB (ten times) or so due to the very low levels of collector current and voltage that are used.

D1 and D2 are used to prevent the supply voltage from exceeding a suitable level, and C1 is a supply decoupling and smoothing capacitor. The output from the solar cells can contain a certain amount of noise, including mains hum if an artificial light source is used to power the circuit. Noise is not too much of a problem, though, mainly due to the very slow response time of solar cells, and C4 should give adequate smoothing when necessary.

CONSTRUCTION

With the only exceptions being the earphone socket (SK1) and solar cells the components are mounted on the printed circuit board. Details of the printed circuit are shown in Fig. 2 with the component layout shown in Fig. 3.

The specified tuning capacitor requires a single 10mm diameter mounting hole, and the mounting bush and nut of this component can be used to effectively bolt the completed board inside the case. Note that the case must be made from a non-metallic substance, otherwise it will screen the ferrite aerial and prevent any signal pick-up. With a little ingenuity it should be possible to use any variable capacitor having a maximum value of about 250p to 350p in the VC1 position.

The ferrite aerial used in the prototype is an Ambit MWC2 aerial coil fitted on a 140mm x 9.5mm ferrite rod which is in turn mounted on the printed circuit board using a pair of plastic mounting clips. These are bolted to the board using short 6BA bolts and fixing nuts. The set also works well using a Denco MW5FR ferrite aerial (which comes complete with a 140mm long ferrite rod), and this can be mounted on the board using a couple of large “P” type cable grips. The unit should, in fact, work perfectly well using any normal
medium-wave ferrite aerial. Whatever aerial is used, only the larger winding is used and the small coupling winding is either removed or just ignored.

It is possible to use a shorter ferrite rod if a 140mm type will be too long to fit in the selected case. It is also possible to break a piece from a ferrite rod to shorten it, but sawing through the rod is practically impossible as ferrite is an extremely hard material. The rod can usually be persuaded to break at the desired point by filing or cutting a groove around the rod at this point, but great care must be taken when breaking the rod. It can easily take three whole rods to make one half if due care is not taken. Do not use a ferrite rod of less than about 75mm in length.

Obviously the solar cells must be mounted on the exterior of the case with the sensitive surface facing outwards. The set will operate from a couple of MS4A solar cells in direct sunlight, even if this is of the weak winter variety. However, three cells give better results and enables the set to work even in bright overcast conditions. The solar cells are connected in series, and with the MS4A type the sensitive surface is the dark side of the component. It is the negative leadout wire which connects to this side of the cell and the positive leadout which connects to the underside of the device.

As the circuit has such a low current requirement it should be possible to use any other solar cells as a power source, although very high current types would not be a very practical choice. Medium current types do not really have any advantage over low current types in applications where only a low current is required. The output voltage from a solar cell remains virtually constant as the load current is increased until a certain threshold level is reached, and the output voltage then falls sharply with the output current remaining virtually constant. If the light level received by the cell is reduced this gives a reduction in the output voltage, and the voltage obtained will be virtually the same whether a low or high current cell is used.

For operation in relatively low light levels it is therefore necessary to use several cells in series rather than just using two or three high current cells. Using a dozen or more cells in series is not an economically attractive proposition, but inexpensive 6, 9 and 12 volt solar panels are available and represent a more practical alternative. Using a 9 volt panel it was found to be possible to operate the set even on a dull winter day, or from artificial light (which provides a similar light level).

**IN USE**

The position of the coil on the ferrite rod controls the frequency coverage of the receiver to some extent, and the coil must be placed in a position that permits full coverage of the band. VC1 gives slightly more than complete coverage of the MW Band, and this slight excess of coverage prevents the positioning of the coil from being too critical.

Despite the simple A.G.C. action of the ZN414 the set can be overloaded in strong reception areas, but if necessary the directivity of the ferrite aerial can be used to reduce the strength of received signals.
SOIL MOISTURE METER

A soil moisture meter is really just a form of resistance indicator, and units of this type rely on the fact that the resistance through dry soil is very much higher than the resistance through a comparable sample of moist soil. Soil moisture meters are used primarily with potted plants where the surface of the soil can be very dry even though the soil only a little deeper may be quite wet. This can lead to over-watering and possibly the demise of the plant. The probes of a soil moisture meter avoid this by penetrating about 25 to 50mm below the surface of the soil so that the moisture reading obtained does not just indicate the moisture content of the surface soil, and can be used as a reliable guide.

Circuits of this kind indicate the soil moisture content in a variety of ways such as producing an audio tone that rises in pitch with increasing moisture content, or having a LED indicator which flashes at a rate that depends on the water content of the soil. A number of systems were tried, and the one finally adopted was to simply use a low cost moving coil meter to provide the moisture indication. This may seem less imaginative than the alternative methods, but it gives a clear and unambiguous indication of the soil's moisture content, and it enables a low voltage low current circuit to be used.

THE CIRCUIT

The very simple circuit of the Soil Moisture Meter appears in Fig. 1. Using a circuit consisting merely of the probes and the meter connected in series across a low voltage supply was found to give a slightly inadequate level of sensitivity. The final circuit, therefore, uses an emitter follower buffer stage to drive the meter, and R2 is used to shunt the input of this stage so that the sensitivity of the unit can be adjusted and set at a level that makes it easy to interpret meter readings.

![Fig. 1. Circuit diagram](image1)

D1 and D2 stabilise the supply voltage at about 1.3 volts so that consistent results are obtained. S1 can be used to switch ME1 across the supply lines (via series resistor R1) so that a check to ensure that an adequate supply voltage is present can be made.

Under direct sunlight two solar cells in series are sufficient to power the circuit, but it would probably be better to use three cells in series as the unit would then operate on any reasonably bright day. Using a solar panel as the power source, the unit would operate under comparatively dim conditions, and the actual power level taken by the circuit is only about 0.5mW or less.

CONSTRUCTION

Fig. 2 shows the printed circuit design for the Soil Moisture Meter. If the specified meter is used the completed board can be soldered onto the tags of the meter, and the tags can be bent through 90 degrees so that the board fits vertically behind the meter. It should be possible to use any meter having a full scale deflection sensitivity of about 1mA or less.

The probes can be made from a pair of inexpensive test prods of the type sold as replacements for multimeters. The two prods must be fixed together so that they are a constant distance apart when measurements are made and consistent results are obtained. There should be no problem in gluing or taping the two prods firmly together. Of course, any similar arrangement which provides a couple of thin metal prods about 25 to 50mm long should work equally well.

![Fig. 2: P.c.b. design](image2)

ADJUSTMENT

It is important to carefully adjust VR2 to give the unit a suitable level of sensitivity if the unit is to give useful and helpful results. The most reliable way of setting VR2 is to first set up a few samples of soil having various moisture levels. VR2 should be given a setting that only gives a large deflection of the meter with the probes pushed into moist soil.

![Fig. 3. Component layout](image3)

COMPONENTS...

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>R1 4k7 1/2W 5% carbon, VR1 470k 0.1W hor. preset</td>
</tr>
<tr>
<td>Semiconductors</td>
<td>D1, D2 IN4148 (2 off), TR1 BC109C</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>ME1 250μA moving coil meter (Maplin, see text), S1 Toggle, push-button or slider type switch s.p.d.t., Pair of test prods and leads, Printed circuit board, Three MS4A solar cells or solar panel (Maplin), Wire, solder, etc.</td>
</tr>
</tbody>
</table>

Practical Electronics  August 1983
samples. The purpose of the unit is really to indicate whether or not the soil is excessively dry rather than how wet it is.

**THERMOMETER**

This thermometer covers a range of zero to one hundred degrees centigrade, and despite the simplicity of the circuit it provides accurate results that are primarily limited by the accuracy with which the meter can be read. The sensor is a silicon diode which can be located remotely if desired, and connected to the rest of the circuit by a twin lead.

The circuit is designed to be powered from a solar panel, but a supply potential of only about 1-2 volts at a current of approximately 1-2 millamps is required and the unit could be powered from three small solar cells under reasonably strong light.

**THE CIRCUIT**

A simple bridge circuit is used, and the circuit diagram of the thermometer appears in Fig. 1. One side of the bridge circuit is formed by R4 and sensor diode D2. The latter is forward biased and a potential of about 0.6 volts is therefore produced across this component, but the precise voltage produced will vary slightly from one component to another, and more importantly, it varies with temperature. A reasonably linear relationship between temperature change and voltage change is obtained, with increased temperature giving a reduction in voltage. However, the voltage change is not very great, and is likely to be only about 2 millivolts or so per degree centigrade. With a thermometer that covers a range of one hundred degrees centigrade this gives a voltage swing of about two hundred to two hundred and fifty millivolts over the full temperature span, and this is sufficient to drive a moving coil meter without the need for any amplification.

The second section of the bridge circuit is formed by R1, R2 and VR1 is adjusted so that the bridge is balanced and the meter reads zero with D2 at zero degrees centigrade. If the sensor is then raised in temperature the voltage at the negative terminal of ME1 reduces, and a forward deflection of the meter is produced. VR2 is adjusted to give the circuit the correct sensitivity so that (say) a fifty degree rise in temperature would give a reading of fifty microamps on ME1. The existing zero to one hundred scale of the meter can therefore be retained.

It is essential for the supply fed to the bridge circuit to be extremely stable indeed as a change in supply voltage of just a few tens of millivolts would give a significant change in the reading on ME1 and hopeless accuracy. Using a simple shunt regulator circuit with a couple of forward biased silicon diodes in series would not be adequate in this case, and it is necessary to use a precision, temperature compensated, voltage reference. D1 is a precision 1-2 volt shunt stabiliser, and R5 is its load resistor. D3 ensures that the input potential cannot rise to a level that would produce an excessive current through D1 and a consequent loss of regulation efficiency.

With the solar cells subjected to a strong light level, set S1 to the “check” position and make a note of the reading on the meter (this should be about 80 or 90% of full scale deflection). On any future occasions when the unit is used, if there are any doubts about the adequacy of the light level the battery check facility can be used to check the supply voltage, and the reading obtained should not be substantially lower than that obtained when making this initial trial. Note that the value of R1 will need to be altered if a meter having a full scale sensitivity other than 250µA is used, and the change in value is inversely proportional to the change in meter sensitivity (e.g. R1 should be about 1kΩ using a 1mA meter.)
If the circuit is operated from three small solar cells in series (such as MS4As) D3 can be omitted since the available supply current would be inadequate to overdrive D1. R5 should be reduced to about 56 ohms in value as well.

S1 can be used to connect ME1 across the input from the solar cells, and series resistor R3 gives ME1 a full scale sensitivity of about 4 volts. This enables a check to be made to ensure that an adequate input voltage is present.

CONSTRUCTION

The printed circuit design and wiring are shown in Figs. 2 and 3. Sensor diode D2 is shown as being mounted on the printed circuit board, but as mentioned earlier, it can be remotely located and connected to the main unit via a twin cable if desired. Even if it will eventually be mounted on the board it is a good idea to initially connect it to the board by way of a twin lead about half a metre or so in length as this will make it easier to set-up the unit ready for use.

Initially VR1 should be set with the wiper at about the middle of its track, and VR2 should be adjusted for maximum resistance (set fully anticlockwise). With D2 placed in ice cubes or iced water to reduce its temperature to zero centigrade and S1 set to the "normal" position, with power connected to the circuit VR1 should be adjusted immediately to zero the meter. D2 is then placed in warm water to increase its temperature to anything from about 50 to 100 degrees centigrade, but a thermometer must be used to measure the temperature of the water so that VR2 can be adjusted to give the appropriate reading on ME1. This procedure should then be repeated a few times to make sure VR1 and VR2 are set accurately.

With S1 placed in the 'check" position ME1 should read at least half full scale deflection, and there is inadequate voltage from the solar cells if it does not. If the unit is powered from three small solar cells a slightly lower reading of about 30% of full scale deflection is acceptable. If this method of powering the unit is adopted it is a good idea to check the reading obtained with the cells in direct and fairly strong sunlight. If a significantly lower reading is obtained at some later occasion the supply potential is inadequate.

INEBRIATION DETECTOR

This inebriation detector is really a simple reaction testing game using a row of eight light emitting diodes to give a relative indication of the operator's reaction speed. The unit is very simple to use, and about ten seconds after switch-on the first L.E.D. in the display switches on, and a push button switch must then be operated as quickly as possible. Soon after the first L.E.D. has switched on it cuts off again and the second L.E.D. lights instead, then this L.E.D. cuts off and the third L.E.D. lights up, and so on with the light appearing to move along the display. Operating the push button halts the display, and the quicker the button is operated the less far the light will have progressed along the display. Thus any degradation in reaction speed due to the consumption of alcohol can be detected.

To start a new sequence the push button is released, the circuit is reset by switching off, and a new cycle commences when the unit is switched on again. The push button must be held down until the score has been read from the display as the display will continue to operate when the button is released.

This circuit requires somewhat more power than the other five solar powered projects, but it still only requires about 4 to 9 volts at a few milliamps in order to operate reliably. It can therefore be powered from a 6 or 9 volt solar panel in reasonably strong light.

THE CIRCUIT

The circuit is comprised of two main stages: a clock oscillator and the display driver. Fig. 1 shows the full circuit diagram of the Inebriation Detector.
The clock oscillator uses an ICM7555 (IC1) and this also provides the delay between switch-on and the display starting to count. IC1 is used in what is virtually the standard 555 astable configuration, and the values used for timing components R1, R2 and C2, give an operating frequency of about 20 hertz. With an eight i.e.d. display and human reaction times normally between about 200 and 400 milliseconds, this clock frequency should be suitable, but if necessary the clock can be made to run a little faster by reducing C2 to 47n, or a little slower by increasing it to 100n.

The clock oscillator is given a switch-on delay by providing a suitable control voltage to pin 4 of the device using a simple C-R timing circuit. Operation of IC1 is blocked if pin 4 is taken to less than about 0.5 volts, and at switch-on R5 takes this terminal to the negative supply potential so that oscillation is blocked. However, as C3 charges via R3 part of the potential across C3 is fed to pin 4 of IC1 by the potential divider formed by R4 and R5. After approximately ten seconds the potential at pin 4 becomes sufficient to activate IC1 and the clock signal is produced at pin 3 of the device.

It is impossible to specify the switch-on delay time with any degree of accuracy since it varies considerably with fluctuations in the supply voltage. However, this is not really a disadvantage since it makes it impossible to predict the time when the display will start to operate and prevents contestants from obtaining low scores by having good anticipation rather than good reactions.

A CMOS 4017BE is used as the display driver, and at switch-on this is reset by the positive pulse generated by C4 and R6. Output "0" of the device then goes high while the other nine outputs are low. There is no i.e.d. connected to this output of the device (pin 3) and all eight display i.e.d.s are therefore switched off at this stage.

When the clock oscillator starts to operate, the 4017 is incremented by each clock pulse. Thus the first clock pulse causes output "1" to go high and D2 is switched on, the next clock pulse sends output "2" high and D3 switches on in place of D2, then output "3" goes high and D4 switches on, and so on. This continues until S1 is operated so that the

---

**COMPONENTS**

**Resistors**
- R1, R2: 330k (2 off)
- R3: 560k
- R4: 3M9
- R5: 1M
- R6: 100k
- R7: 3k9
All resistors 1W 5% carbon

**Capacitors**
- C1: 10µ 16V radial elect
- C2: 68n polyester
- C3: 10µ 16V tantalum
- C4: 100n polyester

**Semiconductors**
- D1: 1N4148
- D2 to D9: TIL209 3mm red i.e.d.s (8 off)
- IC1: ICM7555
- IC2: 4017BE

**Miscellaneous**
- S1: Push to make, release to break type
- S2: Miniature toggle switch s.p.d.t.
- Printed circuit board
- Solar panel (Maplin)
- Wire, solder, etc.
clock inhibit terminal of IC2 is taken high and the counting action is halted. The display then stops, and whatever i.e.d. happened to be switched on at the instant S1 was operated remains switched on so that the player’s score is shown on the display.

If S1 is operated too slowly, output ‘9’ of IC2 (pin 11) goes high, and due to the coupling through R7 it takes the clock inhibit terminal high so that the count is halted and the display does not continuously cycle through ‘0’ to ‘9’. This prevents a score from being obtained if S1 is operated too slowly.

When S2 is set to the “reset” position a short circuit is placed on the supply lines so that C1 and C4 discharge fairly rapidly, and the unit operates properly when S2 is set back to the “on” position. D1 is included so that C3 is also discharged and a new switch-on delay is produced when the unit is switched on again.

CONSTRUCTION
Construction of the unit is quite straightforward using the printed circuit design shown in Fig. 2. Note that there are three link wires on the board (Fig. 3) just above the display i.e.d.s. IC2 is a CMOS device and the usual MOS handling precautions should therefore be implemented, and IC2 should be fitted in a 16 pin d.i.l. socket. IC1 is also a CMOS component, but it has internal protection circuitry which renders MOS handling precautions unnecessary. As the ICM7555 is not the cheapest of i.c.s it is still probably worthwhile using a socket for this device.

As mentioned earlier, a solar panel is probably the best power source for this project since it would be uneconomical to buy a sufficiently large number of single cells (at least eight would be needed). The solar panel could be mounted on the case of the unit, but in use it would probably be more convenient to leave the inebriation detector and solar panel as separate units. The panels are provided complete with about one metre of twin cable, and this can be terminated in a 3.5mm jack plug with a matching power socket being mounted on the case of the inebriation detector.

If the output from the panel falls to an inadequate level either no operation at all will be obtained, or the first i.e.d. in the display might light up after the switch-on delay, but loading of the supply will produce a large voltage drop which will result in the display progressing no further. Adding a capacitor of about 680p in value across the solar panel helps to give proper results in marginal lighting conditions, but obviously this can be of no help if the light level is totally inadequate.

CONTINUITY TESTER

This very simple continuity tester produces an audio tone when a suitably low resistance is present across the test probes, and unlike some continuity tester designs it will not indicate continuity if a forward biased silicon junction is placed across the test prods. This helps to avoid confusing results when checking complex circuit boards where there can be a large number of semiconductor junctions and continuity would otherwise be indicated between virtually any two points in the circuit!

In order to keep the voltage and current requirements of the circuit to a minimum, it is based on the LM3909N low power oscillator i.e. This gives a very high level of efficiency and the unit will produce an audio tone of moderate volume from an input of only about 1.3 volts at a supply current of around 3 milliamps.

Fig. 1 shows the LM3909N in block diagram form, and as can be seen from this, the device is little more than an electronic switch. The LM3909N can be used in a variety of configurations to suit particular applications, but it is always used in what is really a simple relaxation oscillator circuit.

![Fig. 1. Basic circuit](source)

![Fig. 2. Full circuit](source)

THE CIRCUIT

The full circuit diagram of the Continuity Tester is shown in Fig. 2. In this circuit the LM3909N is used in its simplest configuration, and although this does not give quite the efficiency of some of the alternative configurations, it gives good results and excellent reliability at very low supply voltages. All that happens using this arrangement is that C2 charges via LS1 and R1 until the control voltage for the electronic switch falls below the trigger threshold, and the switch then closes so that LS1 is effectively connected across the supply rails and therefore passes a high current. It is not necessary for the solar cells to be able to provide the full current required by LS1 since it is only a short pulse of current that flows, and supply decoupling capacitor C1 can provide some of this current. During the periods when the electronic switch is in the off state the current consumption of the circuit is quite low and C1 can then recharge so that it is ready to supply another current pulse when the switch closes again. The circuit will oscillate with C1 removed, but the volume obtained is reduced drastically.

The electronic switch does not hold in the on state because once it has closed C2 discharges through R1 and
the switch until the control voltage goes above the switch-off threshold voltage. C2 then starts to charge via LS1 and R1 again, and continuous oscillation is produced.

D1 and D2 are used to limit the supply voltage to no more than about 1.4 volts. This is essential since the circuit will cease to operate if the supply voltage goes substantially above this figure.

CONSTRUCTION
Details of the Continuity Tester printed circuit board are given in Fig. 3, and construction of the unit is perfectly straightforward (Fig. 4). The unit will work using an 8 ohm impedance loudspeaker for LS1, but this would increase the current consumption of the circuit and it is better to use a component having an impedance of 40 ohms or more.

In direct sunlight two small solar cells are sufficient to power the circuit, but three cells in series or a solar panel would be a more realistic power source.

The maximum voltage across the test prods is only about 1.4 volts and the maximum current flow between them is only about four milliamps or so. Both figures are sufficiently low to give no real risk of damaging delicate components when using the unit.

TRANSISTOR CHECKER

Solar power has an obvious appeal for items of equipment that will receive only brief and intermittent use, and where the use of ordinary batteries would result in them running flat largely due to ageing rather than use. Solar cells are more expensive initially, but will go on operating year after year and have a certain novelty appeal as well.

A Transistor Checker is a good example of a piece of equipment in the category mentioned above. It is not a piece of test gear that is likely to be used every day, but on occasions a transistor checker of some kind is an essential piece of equipment. This simple design is a go/no go checker which can be used to test low, high, or medium gain devices, and an i.e.d. indicator light flashes on and off if the test device is serviceable. If the i.e.d. lights continuously the device under test has gone closed circuit, and if the i.e.d. fails to light the test device is open circuit.

The circuit requires a supply potential of 2 volts at a current of a few milliamps, and it could therefore be run from four MS4A or similar solar cells under bright conditions. However, a 6 or 9 volt solar panel would permit operation under lower light levels and would be less expensive.

THE CIRCUIT
Fig. 1 shows the circuit diagram of the Transistor Checker. The circuit is little more than an oscillator which pulses the base of the transistor under investigation with a small current, plus an i.e.d. indicator connected in the collector circuit of the transistor so that it lights up when the device is pulsed into conduction. The oscillator is based on an ICM7555 (IC1) and this has a couple of advantages over the standard 555 device in this application. One is simply that it requires a much lower supply current and will operate at a supply current of only about 50 to 100 microamps rather than the 5 to 10 milliamps required by the standard 555. Of greater importance though, the ICM7555 will operate from a supply potential of only about 2 volts which compares with
Fig. 1. Circuit diagram

A minimum figure of about 5 volts for the 555.

IC1 is used in the standard 555 astable configuration, and timing resistors R1 and R2 have been given fairly high values in order to keep the supply current drawn by this part of the circuit down to a reasonable level. Timing capacitor C2 has a value which gives an operating frequency of nearly 2 hertz. R2 has been made fairly high in value when compared to R1 so that an almost squarewave signal is produced at the output of IC1. This signal has a peak to peak value that is virtually equal to the supply voltage, and it therefore switches the test device fully on and fully off so that unreliable and ambiguous results are avoided.

The output of IC1 is connected to the base of the device under test via whichever of the three resistors (R3 to R5) is selected using S1. With R3 in circuit the test device is fed with a base current of about 0.6 milliamps or so, and a current gain of only about 5 times or more through the test transistor is sufficient to give a collector current of a few milliamps and cause the I.e.d. indicator to light up.

With R4 switched into circuit the base current is reduced by a factor of ten, and the device under test then requires a current gain of about 50 or more in order to operate the I.e.d. indicator. With R5 switched into circuit the base current is reduced by a further factor of ten, and a current gain of about 500 times or more through the test device is needed in order to operate the indicator I.e.d. This gives only a very rough assessment of the current gain provided by the device being checked, but it does avoid the situation which can occur with some simple checkers where only a single base current is used, and a high gain device seems to be fully operational, whereas it actually has a very low level of current gain.

S2 is the npn/pnp mode switch, and one pole of this connects the emitter terminal of test socket SK1 to either the positive supply rail or the negative one, as appropriate. The other pole of S2 provides complementary switching in the collector circuit of the test device. In order to enable simple npn/pnp switching to be used, two I.e.d. indicators are incorporated in the circuit. D2 is connected with the correct polarity when the unit is used in the npn mode while D1 becomes operational in the pnp mode. These I.e.d.s are different colours so that they indicate the mode in use and help to prevent the unit from being used with the mode switch
inadvertently left in the wrong position. R6 is simply a current limiting resistor.

D3 to D5 are used to stabilise the supply voltage at about 2 volts so that a reasonably consistent base current is produced by the unit, even if a solar panel (which would otherwise give a very unstable supply voltage) is used as the power source.

**CONSTRUCTION**

The printed circuit board for the Transistor Checker is shown in Fig. 2. This takes all the components apart from the solar cells and test socket SK1. The latter is a three way DIN type and most transistors can be plugged direct into one of these. A set of crocodile clip test leads must be made up so that other types can be connected to the unit.

If the two rotary switches used for S1 and S2 have printed circuit tags, they will fit onto the board without difficulty, but most component suppliers sell the type which has ordinary tags. It is possible to use this type of switch, but the ends of the tags must be cut off to leave what are effectively printed circuit pins, but do not remove any more of the tags than is absolutely essential. Push the switches right down onto the board before soldering them in place. The printed circuit board is mounted securely in the case when S1 and S2 are fitted onto the front panel, and no additional mounting of any kind is required.

The finished unit is very easy to use, but always make quite sure that S1 is set to a suitable position for the device being checked, and that S2 is set to the correct mode. Also make sure that the device under test is connected properly if D1 or D2 fail to flash on and off and the device appears to be faulty.

A simple way to check that the supply voltage is adequate is to simply place a short circuit across the emitter and collector terminals of SK1. D1 or D2 (depending on the setting of S2) should light up if the supply voltage is adequate.

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**COMPONENTS . . .**

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<tr>
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<tr>
<td>SK1</td>
<td>3 way DIN socket</td>
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SHUTTLE 6 RE-ENTRY

The precisely guided re-entry of Challenger-6 into touchdown at the Edwards Air Force Base, California, at precisely 10:53 am, was a triumph for the team of Astronauts. They were Paul J. Weitz, USAF Col. Karol J. Bodko, Donald H. Peterson and Dr. Story Musgrave. This flight has increased the confidence in the procedures for the next Shuttle at Kennedy Space Centre, Florida.

Hypsersonic and Supersonic manoeuvres carried out by the Shuttle were entirely satisfactory. They were carried out on re-entry before touchdown at Edwards Field. Confidence in the procedures for re-entry in the way of Lateral control, Stability and Reaction control were satisfactory, and so were the manoeuvres designed to check system capability and Rudder Authority.

There were three main questions to be answered about flight characteristics. These were designed to involve some thirty firings of jet-energy during descent. They were commanded instructions but were monitored by the astronauts for safety. The three hypersonic S-turns were made as is usual with re-entry. However, this time there were eight other sets of instructions to be accomplished.

The re-entry was made first at an angle of 40° as usual. The initial flight testing was made at 24,000 ft/s at an altitude of 261,000 ft. The test involved an aileron pulse followed by right-hand jet input as well as right-hand yaw jet pulse input. The crew then fired the orbital system engines for the vehicle to leave its orbit and commence its descent south of the Mauritius Islands of the Indian Ocean. The spacecraft then had a 27 second burn which brought it to 292,000 ft/s and a height of 400,000 ft, an interface required to bring it 4043 miles to Edwards Field. When the spacecraft reached a speed of 230,000 ft/s and sensed it was at 0-76 g, the first command to roll 80-85° was made. It was held at this speed until it had reached the crossrange of 377 n. miles from touchdown. At this point the attitude was corrected and Challenger's nose was pointed in Azimuth 10° to the north of the landing site.

The next test was made at 240,000 ft, and when the speed was 23,000 ft/s. This test involved yaw thrusters and was designed to check the behaviour of the ailerons and other surfaces which experience very thin air when reaching thin atmosphere. Another test was made at a height of 205,000 ft and at speeds of 18 and 15-6 mach to check the effectiveness of the ailerons and their resistance to the pressure put on them at this time. Aileron stability is very necessary when carrying heavy loads such as will be encountered with Space lab. This successful trip sure means that the re-usable vehicle is here to stay.

Many photographs were taken during this trip and some of these will be described, they are important. One of these pictures showed the astronauts climbing around the shuttle, and it was clear that they were making rather heavy weather of it. They did have some training in a water tank but it seems that this had not been sufficient. This may of course be lack of training, but this seems a little unusual. If this part of the de-briefing is released there might be some better understanding. There seems to have been trouble with the tethering lines. These did not work according to plan, though they had appeared satisfactory in the water tank. It is a little difficult for those on Earth to realise that as far as the astronauts are concerned they are free to move in any direction, it is not just a matter of up and down and side to side. It has already been depressed that the astronauts were said to be involved in an extra-vehicular exercise which would take place.

One of the pictures also showed the Earth and its clouds against the background of Space while the astronauts were working in the payload bay. All the pictures were taken with a 35 mm camera attached to the spacecraft. Another thing that was noticed by the monitoring devices: the heartbeat of Musgrave was still at 60 beats per minute whilst Peterson's had jumped to between 130 and 140, readers will remember that this happened with a previous crew. Challenger-6 was at that time in darkness and all lights were on as the 35 ft long Tracking and Data Relay satellite was raised to 59°. After the satellite had been launched the upper stage could be seen attached and inert to the disappointment of all concerned. At the moment it is not yet decided what its future fate might be.

THE RED SHIFT AS A MEASURE

At last there seems to be a real attack on the question of the Red Shift. It has been more than a decade since Chris Arp of the California Institute of Technology was displaying photographs and models of objects which have thrown doubt on the idea that Doppler shift and Red shift are always the same. Several teams have sought to refute his views and even suggested that the connecting filaments which he saw were a figment of his imagination. It so happens that Jack Sulentic of the University of Alabama has recently confirmed Chris Arp's and his team's results. This was done using some hitherto unpublished photographic plates of the galaxy NGC 4319 and the object Markarian 205. When it is confirmed it will show that at least part of the Red shift in the light from astronomical objects is not produced simply by their receding from us in the expanding Universe.

Arguments have been made before about the Red shift with regard to some very important bodies and not all astronomers demand that the Doppler effect of sound is exactly the same as Red shift. That it applies to ordinary galaxies is true—this can easily be checked by measuring the speed in different ways simultaneously or by using different methods and comparing measurements. However, there have been protagonists on both sides. It is therefore now becoming more and more important that some solution be found. As time passes new discoveries are made and more sophisticated techniques devised so it is now imperative that what we believe to be true, is proved to be true. It is significant that recently a small group of people who were interested in this subject because very long baseline interferometry (VLBI) had revealed 'faster than light' speeds in Quasars. VLBI had shown that the quasar 3C279 showed an expansion rate which, when converted by the Hubble law, gave a figure 10 times the speed of light. The astronomers at Jodrell Bank, a small group set up to look into this matter and to provide at least some ideas about the future procedure, set out to discuss it.

There are now seven known radio sources that show these superluminal characteristics. These range up to at least 10 times the speed of light in their motions. These are 3C120, BL Lac, 3C273, 3C279, 3C345, 3C179 and NRAO 140. These were revealed because of the increased technique that was due to the many VLBI arrays and the routine production of milli-arc-second-scale maps. Some indirect measurements show that the variable velocities in some cases may be due to several components. The theoreticians do not believe the results, they do not believe that real faster-than-light motions exist. This breaks Einstein's light speed limit, therefore it must be an illusion. It is true that initially it had been admitted that, seen from a certain angle, it appeared that the law was violated; indeed the law itself was disputed. This was a very serious discussion and the matter was thrashed out thoroughly. No answers were found, though many suggestions were made.

The conclusion was that during the past 12 years more questions had been raised than had been answered. What now then, stalemate? Surely not. Are mathematics confused or has something been missed? Are matters, then, to be left to others more adventurous? If one reporter is to be believed, the matter is to be left there and hope that during the next 12 years some solution will emerge. Is it then a return to the past, must Einstein be preserved right or wrong? Who mentioned Darwin . . . ?
BEFORE we can start discussing any particular aspect of robotics it is only sensible to ask the question, 'What exactly is a robot?' The word was coined in 1921 by Czech playwright Karel Capek and is derived from a Czech word meaning 'worker'. Capek's play, entitled 'RUR' (Rossum's Universal Robots), tells how a brilliant scientist named Rossum manufactures an army of mechanical 'robot' slaves to free mankind from the drudgery of work. However, after an irresponsible scientist in Rossum's laboratory gives the robots feelings, they grow to resent their lot and rebel against their creators, finally annihilating the human race.

Clearly Rossum's robots were far more sophisticated compared with those that current technology is capable of producing. The modern industrial robot is a cumbersome beast by comparison, needing many thousands of instructions to perform even a simple task, and certainly lacking both initiative and ability to oil its own springs. So what distinguishes a robot from just another piece of computer-controlled machinery? There are those who would say there is no difference, in Japan for example, any NC (numerically controlled) machine is considered for statistical purposes to be a robot. Since this is obviously not a very useful definition, we must draw a line somewhere.

Consider the difference between a digital alarm clock chip and a microprocessor. The former will undoubtedly be programmable (since the alarm would be of little use if the manufacturer had pre-set it to say, 7 a.m!) but even the most ingenious electronics engineer would have difficulty adapting that chip to control his washing machine. Although a microprocessor can easily be programmed to perform the same function as the digital alarm clock chip, everyone knows that this is by no means the limit of its capabilities.

We can usefully think of the robot then, as the 'microprocessor' of the machinery world. As with the micro, the robot's hallmark is versatility, so there is no need for its designer to try and foresee its every possible use. A robot arm for instance, given an adequate reach, speed and lift capability, should be able to turn its hand (or gripper perhaps) to anything.

WHY SENSORS?
Imagine a human brain completely divorced from its senses, unable to touch, hear, smell or see anything of its surroundings, and unaware of the positions of the limbs in its body. It is most unlikely that the brain would develop at all under these circumstances, and it is arguable that intelligence as we understand it depends entirely on the brain's ability to acquire sensory information. A computer without sensors would likewise be unprogrammable, since it would be impossible to input any code.

A robot cannot be 'intelligent' if it cannot directly acquire information about itself or its surroundings. Thus when you give a robot the ability to 'perceive' and so acquire information, you reap the immediate benefits of an artificial intelligence. These benefits are considerable: Firstly, programming can be simplified, and carried out at a higher level, and be more readily understood by the user. Secondly, the machine is able to learn about its environment during operation; and thirdly, obstacles can be avoided automatically without the need for specific programmed commands.

If a visual perception system is implemented, a robot can distinguish patterns and objects, and then act on the information. In manufacturing, for instance, a robot which picks up chocolates and automatically deposits them in the correct compartments of a box. Besides performing regular activities like these a seeing robot may intervene in abnormal situations, such as tools accidentally being dropped on to a conveyor belt, where the outcome is potentially dangerous or costly. Evidently, sensors in general and visual ones in particular are going to play a very important role in the advancement of robotics engineering.

HOW CAN ROBOTS SEE?
In human beings the seeing process is essentially a dual one: Visual information is acquired by the eye, then processed or 'understood' by the brain. Neither the eye nor
the brain can 'see' on its own—both are necessary if the visual perception system is to function. So in order for a robot to see, it must be equipped with mechanisms for acquiring and for processing images. In the area of vision, as in many fields of robotics, engineers have attempted to simulate human systems as far as possible. Visual data is normally acquired by some form of camera which transmits the visual signal to a computer for processing. Camera technology is generally agreed to be adequate for most current requirements but, as has been the case in other fields, the computer technology itself is still lagging behind.

Ideally a computer should 'understand' an image by describing it in terms similar to those a human being might employ, then use the 'knowledge' so gained in future problem-solving situations. The way to achieving this lies in the development of more powerful computers, and more importantly, the improvement of software techniques. In many industrial situations, potential robot applications have needed some form of visual feedback, and recent developments have provided solutions to a number of such problems. It is also true that many situations exist which do not demand an ideal vision system, and with which current technology can cope quite adequately. Let us now consider some of the techniques in use today.

VISION SENSORS

The simplest form of optical sensor is the photo-electric cell, the original 'electric eye'. A single photo-cell, however, is able to convey only one piece of information at a time. A robot (or computer) vision system usually requires a large amount of picture information to be supplied relatively quickly, and the solution lies in the use of some form of camera. Until quite recently the best sensor available was the TV camera tube, unfortunately rather a fragile device. Now, however, solid state 'retinas' employing charge coupled device (CCD) technology have been developed. These units are far more robust than their glass counterparts, so are more suitable for use in industrial environments. They also have the advantage that they are much easier to interface to computers.

VISION BASICS

Although computer vision systems may vary considerably in sophistication, a number of techniques are common to all of them. Before an image from a camera can be usefully processed, it has to be converted to a form which can be understood by the computer. This conversion process, known as digitisation, involves the division of the image into a grid of squares (or pixels), each of which is then stored in memory as a number (or pixel value). In a 'grey-scale' system the pixel value is called the grey-level, and is proportional to the brightness of that portion of the image represented by the pixel. In binary systems, the pixel value is either 1 or 0, corresponding to a brightness greater or less than a predetermined threshold, the stored image being basically a silhouette.

The resolution of a system is a measure of the number of pixels into which the image is digitised. Thus the higher the resolution, the more precise and detailed the stored image. However, if a very large amount of information is stored, the computing power required to process it becomes prohibitively large: a 256 x 256 pixel image contains 65536 pixels, a number equal to the total addressable memory capacity of most of today's microcomputers! A technique known as run-length encoding is often used to overcome the space problem, in which a string of numbers called a run code is set up, instead of storing every pixel. Each number corresponds to a number of adjacent pixels with the same value, together with the value itself. This allows a considerable reduction of the memory required, especially when
high resolution binary images are being processed. Let us look in detail at two vision systems representative of existing techniques.

**HIGH RESOLUTION GREY-SCALE SYSTEMS**

The most sophisticated vision systems in use today attempt to extract and process the maximum possible information from an image. The resolution of such a system is typically 100,000 or more pixels, and perhaps 256 or more grey levels are distinguished.

Comprehensive signal processing and feature extraction algorithms are used to determine the shape, size, position and orientation of an object (or a number of objects) in view. Powerful mainframe or mini-computers are used in the processing of the image, often needing several processors to achieve sufficient computing power. By storing information about an object such as the relative positions of features like corners and holes, complex networks of tubes and pipes or contoured metal castings can be consistently recognised. Powerful contrast enhancement techniques enable information invisible to the human eye, such as hairline cracks in printed circuit board tracks, to be detected.

Using systems such as these in conjunction with robots it is possible to automate processes in which the type and orientation of parts to be manipulated is outside the control of the programmer. Here the robot uses its 'eye' to direct it in its task. However, even high-resolution systems have their limitations. Three-dimensional and mobile vision technology is still in its infancy, and it is not normally possible to compensate for the effects of variable lighting conditions. The high level of performance indicated above is generally attainable only in clear environments, using a fixed camera position and carefully controlled lighting. The advantages of high resolution systems lie in their increased information-handling capacity. These are offset though, by drawbacks such as considerable bulk, slow operation and high cost (typically over £20,000).

**LOW RESOLUTION BINARY SYSTEMS**

An alternative approach is gaining favour in some areas of robotics applications. This minimises processing overheads, cost and complexity by using very low resolution (VLR) binary (i.e. silhouette) vision systems. These use typically only one or two thousand pixels of digitisation, and a limited number of feature extraction functions. They are able to process visual information at speeds comparable to that at which an efficient robot arm might move. In other words, direct real-time visual feedback loops can be established. The recognition-ability of such systems is usually limited to a small set of criteria. These might include area, perimeter, the number of 'holes' in an image, and so on. Nonetheless, since the camera is compact enough to be mounted on the end of the robot arm itself, areas of interest can be magnified simply by moving it nearer to the object. Calculating the position of the centre of gravity, provides a basis for location and orientation algorithms which are often fast and precise enough for the arm to follow a moving object. Unimation Ltd recently demonstrated this ability using a PUMA robot arm fitted with a 32 x 32 pixel camera. The robot followed a plastic toy building brick as it was moved across a surface, picking it up correctly when it remained stationary for longer than about four seconds.

VLR systems are of greatest use in situations where the identity of an object has been pre-determined, and where high-speed operation is important. Because VLR systems are simple and relatively inexpensive (typically under £1,000), they are popular among hobbyists and educational establishments. Though less sophisticated than their high-resolution counterparts, they employ many of the same techniques.

**THE COLVIS VLR VISION SYSTEM**

An example of VLR technology is the COLVIS vision system, manufactured in the UK by Colne Robotics Co Ltd. This system employs a 32 x 32 pixel, binary solid-state camera using a dedicated Z80-based micro-

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**Diagram Description:**

A typical configuration of the COLVIS high-speed system: Commands may be entered either with the light pen or via the user I/O channel. The host computer interrogates the system for visual information which it then uses to control the robot.
computer. It can be used either on its own, or under the control of any micro or mini-computer fitted with an 8-bit bi-directional port. In stand-alone mode the system can perform simple vision-based control functions, and is programmed via a TV monitor and light pen. When under computer control, the system can be interrogated for either raw or processed vision data which is then transmitted back to the 'host' computer. In this way, a computer controlling a robot arm can be supplied with vision information on demand, and at no cost to its own processing time.

The system is supplied with software enabling it to determine the position, orientation and identity of objects in its field of view. The commands available to the user are in three groups:

(i) Data acquisition
(ii) Image processing (including feature extraction)
(iii) Learning/recognition

Eight picture stores are provided, and the camera image can be read into any one of these, one at a time. Each picture store has an associated area of memory in which any of the following parameters can be updated on command:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre of gravity:</td>
<td>Position, orientation</td>
</tr>
<tr>
<td>Direction of longest dia:</td>
<td>Orientation</td>
</tr>
<tr>
<td>Direction of shortest dia:</td>
<td>Orientation</td>
</tr>
<tr>
<td>Area:</td>
<td>Recognition</td>
</tr>
<tr>
<td>Perimeter:</td>
<td>Recognition</td>
</tr>
<tr>
<td>Number of holes:</td>
<td>Recognition</td>
</tr>
<tr>
<td>Perimeter²/Area</td>
<td>Recognition</td>
</tr>
<tr>
<td>(compactness):</td>
<td>Recognition</td>
</tr>
<tr>
<td>Longest diameter:</td>
<td>Recognition</td>
</tr>
<tr>
<td>Shortest diameter:</td>
<td>Recognition</td>
</tr>
</tbody>
</table>

Measures are taken to ensure that the system always operates at its fastest possible speed. A comprehensive range of learning functions has been implemented, enabling the system to be taught to identify objects on the basis of some or all of the recognition parameters listed above. A 'Learn' command is given, together with a name for the object to be learnt. The system then calculates, and records the required recognition parameters in a data structure which incorporates a set of tolerances associated with each parameter. These tolerances are automatically initialised to a useful set of values, but for each learnt object the user can adjust them individually, in both the positive and negative axis. Learnt objects can be deleted or re-learnt; they can be saved on cassette tape or loaded from it. When the 'Recognise' command is given, the list of learnt objects is scanned, and those parameters in use are compared with ones calculated from the camera image. If the new parameters all fall within the specified tolerance for a learnt object, the system notifies the user (or host computer) that it has recognised that particular object. Up to 64 different kind of objects can be learnt at any one time. In normal use an operator would teach the system a new object, adjusting tolerances and changing the criteria (i.e. parameters used) for recognition, until optimum performance was achieved, before handing back control to the host computer.

Additional commands enable the system to pre-process picture information before parameters are calculated. These include picture inversion, exposure control, choice of light or dark background and several noise-reducing functions which strip or fill-in isolated pixels. A macro construction facility enables strings of commands to be stored in memory and executed as single instructions. The contents of any two frame stores may be displayed simultaneously on the monitor screen, together with their associated parameter lists. When under computer control, all parameter, learning and frame store information can be transmitted on request to the master system.

In Fig. 1, the VDU shows an object (coded BLNK) which the system has learnt and identified: In the top right of the screen the parameter requirements are shown and are represented by the picture in the square. The list of parameters closest to those learnt, is shown in the lower part of the display, and has been identified as TRUE; the other possibilities being rejected as FALSE.

The COLVIS system is simple to use and fast-operating, making it ideal for educational purposes, though undoubtedly it will find its way into a number of industrial situations as well. An important aspect, particularly for educational establishments, is the low cost of this system; around £400.

**LOOKING AT THE FUTURE**

There is considerable scope at present for improving visual perception techniques. The vision system of the future will be able to process picture information far more efficiently than its relatively primitive predecessors, using extremely sophisticated high-level programming languages developed solely for such a purpose. We can expect computers themselves to be hundreds, perhaps thousands of times faster and more powerful. If technology within this field continues to advance at its present rate, some seemingly far-fetched predictions will rapidly become probabilities rather than remote fantasies. We can foresee vision systems installed overlooking large and complicated scenes—factory floors or perhaps crowded city centres. There, they will survey the area for abnormal events, capable of detecting fires, accidents and maybe even crimes! We must remain alert to the value and importance of robot vision, a field whose enormous potential is still to be explored and exploited.
You must have heard of the House of Floggit, to my mind one of the most interesting department stores in South London. Family-owned, it first opened its doors towards the end of the 19th century and, until recently, remained an undying echo of the Victorian era of retail trading when the customer was king.

Floggit's merchandise was, and still is, of superb quality. Its standards of service impeccable. The lady assistants wore modest frocks that suppressed any gender-indicating undulations. The gentlemen were dressed in formal suits, the jackets of which were never discarded, even on the most sweltering day. And such frivolities as the use of forenames and remarks of a jokey nature were OUT.

Accounting and stock control systems were equally traditional. Cash was handled with genteeel disdain. The customer's payment—he wasn't up to much if he didn't have an account—would be placed in a kind of torpedo tube and shot off to the counting house by an overhead railway. If change was involved, it would be returned by the same means. All this gave the impression that so far as the management was concerned, the handing over of the money was no more than a slightly indecent incident.

In those pre-VDU days a basement-based covey of brown-coated retainers, all with unnaturally-tapered index fingers, carried out a digital stock count at the end of each day, recording their findings in copperplate handwriting on a series of lists. The store was open six days a week and no matter how late the hour, no one was allowed to leave their post so long as there was a customer about.

On the basis of the report which eventually landed on his desk, Arnold decided to sink an odd million or so quid in a computer-based system which would do away with that absurd overhead railway, pep up accounting and stock-control and provide a constant flow of management information.

One day a team of young experts wearing Imperial College ties arrived to set up the computer. The staff didn't take much notice at first. All they knew was that a load of layabouts were mucking about in the basement.

But the course of events was soon brought home to them when one day one of the layabouts marched into Perfumery and dumped an electronic cash register on the counter. Miss Sniff, the buyer, 30 years with the firm, ignored it completely to begin with and continued to have fun with her overhead railway.

The next sinister happening was a summons from above for all senior buyers. It was there that Arnold unveiled his grand plan and then handed the group over to Mr. Teachem, the training officer, for an intensive course of instruction in the modern miracle which was to transform their lives.

It was a frightening contraption so far as the conservative senior staff was concerned. It had more buttons than a cardinal's cassock and a habit of bleeping and popping whenever anyone laid a finger on it.

That first training session is not a happy occasion to record. Miss Silk of Haberdashery announced her intention to seek early retirement. Miss Swish of Ladies Fashions went all hysterical and had to be sedated with a swig of mint tea from the canteen. Mr. Spark (Major Domestic Appliances) eased his feelings by giving the thing a sly kick.

One cannot blame any of those present for their attitude when you consider the circumstances. Here they were, loyal servants who had grown grey in service, brought up in a world of dignified and calm, if stick-in-the-mud, working methods, being asked to become user-friendly with something which, in their opinion, belonged to another planet.

Arnold Floggit had not done things by halves and had gone all-out for sophistication. The cash register—which was not a cash register at all, but a thing called a terminal—was a multi-function beast. It could record both cash and credit transactions, log the date and time of each sale, with the identity number of the assistant concerned, and provide accurate, highly-detailed and easily-accessible data on stock movements.

"I bet," said Mr. Crepe (Footwear) with dry cynicism, "it would boil an egg if you asked it nicely."

The day that the new system came into active public service had, for the younger members of the staff, a touch of carnival. Weaned on digital watches, up-market calculators and even home computers, they found little difficulty in adapting themselves to the revolution. Indeed, some of them regarded the occasion as the start of an era of liberation from the outmoded and sometimes despotic Floggit regime. Hopes were encouraged by a few, including fashion-conscious little Wendy Penn (Stationery), that they could soon start turning up for work in flashy tops instead of bust-flattening blouses. Young Tom Channel (Radio and TV) prophesied that soon he'd be wearing cords and bimbo jacket.

The over-40s were not so happy. The complicated procedures needed a strong mental digestion. An ordinary cash transaction, for example, involved the pressing of some 13 buttons, all in the correct order without, alas, a comforting cancel facility for the correction of cock-ups. Credit sales were even more complex. Barclaycard and Access, popular and convenient as they are, brought fresh terrors, as did the handling of cheques. And when some clever dick decided he wanted a refund, the effect on the hard-pressed salesperson was frightful to behold.

It will come as no surprise to you that all this sophisticated technology had adverse repercussions on customer-relations. The chap who'd just popped in for a set of batteries for his tranny on the way to the betting shop instinctively resented having to stand for 15 minutes witnessing a dazzling display of terminal trickery instead of merely slapping his money on the counter and pushing off.

In those departments where the older generation presided long queues were the order of the day. There was much muttering of "things aren't like this at Comet". The caravanserai trade, accustomed for generations to serve and sedate, switched to Harrods where they could hope for service almost as efficient as that accorded to the Queen. Turnover dipped, morale sagged and the star called Floggit began to dim in the retail firmament.

Arnold Floggit, dedicated technologist as he was, began to wonder whether or not he hadn't dropped one. A realistic fellow, he reasoned that by equipping his goose with a golden facility he may well have retarded her ability to lay golden eggs. And it was with a sigh of resignation and a fondly wistful to his not inconsiderable investment that he did a half-turnabout. One way or another they had to be rid of things.

Out went the computer and its attendant terminals. Back went the overhead railway and the brown-coated stock counters. All hopes of dress reform faded into the middle distance. The older generation had their happiness restored.

There is an obvious moral to this story. You will recall that in a previous issue of PE I enjoined the Church to adopt electronic techniques in the name of greater efficiency.

Perhaps at the same time I should have pondered on the problems of such retail houses as the House of Floggit and exhorted leaders like whiz-kid Arnold to pause before hurling themselves headlong into the electronics age.

Mind you, it's only a matter of time before Floggists, like other concerns, will have to succumb. In the meantime I shall take a middle-aged satisfaction in guessing at the mysteries of the formal frock, watching my money whizzing between counting house and counter by overhead railway and sympathising with youngsters in their heavy serge.
all in your
SEPTEMBER
issue!

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PRACTICAL ELECTRONICS
SEPTEMBER ISSUE ON SALE FRIDAY, AUGUST 5
Most modern logic and microprocessor circuitry take power from a single supply rail; either +5V for TTL and microprocessor-based systems, or higher voltages for some CMOS circuitry. The incorporation of any other supply rails within such a system can be a considerable nuisance, adding complexity, size, and cost to the final project. A frequent requirement is for a low current negative supply, used to provide power to a small amount of analogue circuitry within the logic system. Digital to analogue, and analogue to digital converters are examples of circuitry which require this negative rail; likewise CMOS circuitry. The incorporation of any power requirements are so small that it seems to be an "overkill" to have to provide a complete negative supply system, whether derived from the mains supply or from extra batteries. The ICL 7660 is designed to help solve this problem. It is an 8 pin CMOS I.C. which converts a positive supply into a negative supply voltage. Hence, any nominal positive supply of +1.5V to +10V is converted to a negative supply of -1.5V to -10V, with sufficient drive current for most applications (typically up to 40mA for a +5V input).

**Basic Circuit**

Fig. 2 shows the circuit design principle on which the ICL 7660 is based. Under the control of an internal 10kHz oscillator and switch control logic, four MOS power switches are used to charge up, and transfer charge between, C1 and C2. These capacitors are external to the I.C., since they must be relatively large; 10 μF is typical. The sequence is as follows: S1 and S2 turn on, while S3 and S4 remain off. As a result, C1 is charged up to the positive supply voltage. Then, S1 and S2 turn off, while S3 and S4 turn on. The positive end of C1 is now taken from the positive supply down to 0V. The negative end of C1, which was previously at 0V, then becomes forced negative; for a positive supply of +5V, the negative end of C1 is taken to -5V. The charge on C1 transfers to C2, the reservoir capacitor, which then supplies current into the load. S3 and S4 turn off, S1 and S2 turn on, C1 charges up again, and the whole cycle repeats continuously.

**Using the Chip**

The pin-out of the ICL 7660 is shown in Fig. 1, complete with its specifications. There are several important points to note about the load. S3 and S4 turn off, S1 and S2 turn on, C1 charges up again, and the whole cycle repeats continuously.

**Table**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>Min. Value</th>
<th>Typically</th>
<th>Max. Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>All spec’s measured at +5V supply</td>
<td>1.5</td>
<td>5</td>
<td>10.5</td>
<td>V</td>
</tr>
<tr>
<td>Quiescent current</td>
<td>No load on negative output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>-20</td>
<td></td>
<td>+70</td>
<td>300</td>
<td>°C</td>
</tr>
<tr>
<td>Power dissipation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mW</td>
</tr>
<tr>
<td>Oscillator frequency</td>
<td>20mA load current</td>
<td>10</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Output resistance</td>
<td>Positive supply = 2V, 3mA load current</td>
<td>55</td>
<td>150</td>
<td>300</td>
<td>Ω</td>
</tr>
<tr>
<td>Output voltage (as percentage of positive supply)</td>
<td>No load on negative output</td>
<td>-97</td>
<td>-99.9</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Output ripple, pk/pk</td>
<td>5mA load current</td>
<td>0.1</td>
<td>0.2</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Output ripple, pk/pk</td>
<td>20mA load current</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

**Voltage Converter (ICL 7660)**

---

**Notes**

Finally, for supplies of +6.5V or more, or use at high frequencies, a diode must be added in series with the output. Fig. 3 shows the basic voltage converter circuit, and D1 is the extra series diode if required. For the lowest forward voltage drop a germanium diode is the best choice; an OA47 is specified, but any similar diode will do. A 1N4148 or similar will work satisfactorily, but will drop slightly more voltage. Take care with the polarity of D1; the feed from pin 5 of the I.C. is negative, not a positive one!

Because the negative supply is generated by the charging up and discharging of capacitors, it is far from being a perfect voltage source. As would be expected, the output voltage becomes less (i.e. nearer to 0V) as more current is drawn. In practice, the relationship between the output voltage and the current drawn is linear; the effect is the same as...
**Fig. 2 Principle of i.c. operation**

Putting a resistor in series with a perfect voltage source. The value of this effective output resistance is dependent on the supply voltage, with 55 ohms being typical for a 5V supply, and 150 ohms for a 2V supply.

The graph of output voltage versus output current for a +5V supply is shown in Fig. 4. For most op-amps, A-D converters, D-A converters, etc., the current drawn is small, and the slight variations in negative supply voltage have no significant effect, but this characteristic of the i.c. should be borne in mind when designing appropriate circuitry.

**IMPROVING PERFORMANCE**

Figs. 5, 6 and 7 show ways of improving the output characteristics of the ICL 7660. In this circuit the output voltage is twice the input voltage, less the two forward diode drops. This can provide up to approximately 16V, since the voltage doubling is performed only by C1, C2, D1 and D2. The +10.5V supply limit on the i.c. is not exceeded, since D2 prevents the high voltage ever feeding back into the i.c. Note that C2 can’t be a 16V type for all supply voltages, so use a 25V type instead.

**EXTERNAL CLOCK**

Finally, the oscillator frequency of the ICL 7660 can be changed, if required, by feeding an external clock into pin 7. When fed from CMOS logic, a 1k series resistor should be provided, while for TTL a 4k7 pull-up resistor to the positive supply is needed. If an external clock is to be used, note that the conversion frequency is half the applied clock frequency, due to an internal divide-by-two circuit. The internal oscillator can be lowered in frequency by adding a capacitor (typically 33 to 330pF) between pin 7 and the positive supply. If the frequency is lowered, C1 and C2 should be increased proportionally to maintain the performance.

**Fig. 3 Basic voltage converter circuit.**

D1 is not necessary for supplies >6.5V. Include it if high temperatures are anticipated.

**Fig. 4 Graph of output voltage versus output current for positive supply**

**Fig. 5 Parallel connection if i.c.s**

Fig. 6 shows a way of using the i.c. to provide a positive to positive voltage conversion! This circuit the output voltage is twice the input voltage, less the two forward diode drops. This can provide up to approximately 16V.

**Fig. 6 Positive voltage converter circuit**

19V, since the voltage doubling is performed only by C1, C2, D1 and D2. The +10.5V voltage limit on the i.c. is not exceeded, since D2 prevents the high voltage ever feeding back into the i.c. Note that C2 can’t be a 16V type for all supply voltages, so use a 25V type instead.

**Fig. 7 shows three devices connected in series to provide a larger negative supply voltage.** Up to ten i.c.s can be connected in this manner, within the limits of a maximum negative voltage of -10V. However, in this configuration, the output resistances sum.
APPLICATIONS CIRCUIT

Fig. 8 shows a simple application of this i.c. The circuit provides a logic system with a d.c. coupled analogue output, which is variable in level and symmetrical about 0V, rather than between 0V and the positive supply voltage. IC1 is the voltage converter used in a standard configuration to provide the negative supply to IC2, a high slew rate (i.e. high speed) op-amp. It is all powered from the logic system's own power rails, which are unlikely to be below 3.5V, so pin 6 of IC1 should be of low open circuit. D1 can be replaced by a wire link for supplies of less than 6.5V. IC2 is used as an inverting amplifier, so precede this circuit with an inverting logic gate if polarity is important. The gain is variable between $x\, 0.1$ and $x\, 2$, an inverting amplifier, so precede this circuit with supplies of less than 6.5V. IC2 is used as an inverting amplifier, so precede this circuit with supplies of less than 6.5V.

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This circuit is a fairly simple, but hopefully effective, demonstration of the way in which voltage conversion can provide a low power alternative supply rail in a larger system. Bear in mind the intrinsic limitations of the device, and it can prove to be an extremely useful circuit element. The ICL 7660 is readily available from a number of suppliers, such as Technomatic, Maplin, and Waford Electronics.

Note: in Semiconductor Circuits (June 1983): In Fig. 1 pin 8 should be positive supply.
Practical Electronics August 1983

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- BBC 34 Dual 40K Drives: 575.00

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- BBC 23 10 Pin DIN Plug: 0.66
- BBC 24 5 Pin DIN Plug: 0.66
- BBC 25 6 Pin DIN Plug: 0.66
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- BBC 28 Data Cable in 10 feet sections: 0.99
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- SBSB1tree of Knowledge: 8.69
- SBSB Peak 400 Interface Manual: 8.69
- SBSB1 Algebraic Manipulation Pack: 8.69
- SBSB8 Creative Graphics: Cassette: 8.69
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- SBSB50 Graphics and Charts: 7.60
- SBSB60 Display Manual: 7.60
- SBSB103 FOURTH: 7.60

Price only, for current delivery on Acornsoft Products before ordering.

**BBC MICRO COMPONENTS**

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**VOLTAGE REGULATORS**

**DATA SHEETS**

**Wide borderline "view"**

**SPECIAL OFFER**

**Spectrum 32K Upgrade Kit**

**MEMORIES**

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**REGULATORS**

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**DATA BOOKS**

**Wide borderline "view"**

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**ADDRESS:**

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**MIDWICH COMPUTER COMPANY LIMITED**

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TELEPHONE (0389) 683125
**TV SOUND TUNER**

**BUILT AND TESTED**

In the cut throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by chopping this out?" in the domestic TV set, one of the first caustics seems to be the price. Quality small speakers and no tone controls are common and all this is quite real ad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact and independent TV tuner that connects direct to your Hi-Fi is a must for quality reception. The unit is main operated.

This TV SOUND TUNER offers full UHF coverage with 5 pre-selected tuning controls. It can also be used in conjunction with your video recorder. Dimensions: 114H x 43 x 34. E.T.I. kit version of above without chassis, case and hardware. £21.95 plus £5.00 p&p.

**PRACTICAL ELECTRONICS**

**STEREO CASSETTE RECORDER KIT**

COMPLETE WITH CASE

ONLY £31.00 plus £2.75 p&p.

- **NOISE REDUCTION SYSTEM**: Automatic PCN.
- **AUTO STOP**: Tape counter.
- **SWITCHABLE E.Q.**: Independent level controls.
- **TWIN V.U. METER**: VFM / VVF.
- **HUM FILTER**: 0.1%. Record/LP/Back I.C.
- **ELECTRONIC SWITCHING**: FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES.

Kit includes tape transport mechanism, ready punched and backed printed circuit board and all electronic parts, i.e. transistors, capacitors, hardwire, top cover, printed scale and mains transformer. You supply solder & hookup wire. Fitted in April P.E. reprint 50p. Free with kit.

**STEREO TUNER KIT**

This easy to build 2 band stereo kit. FM tuner kit is designed in conjunction with P.E. Dudley '81. For ease of construction and alignment it incorporates stereo Multi-val modules and an I.C. IF System.

**FEATURES**: VHF MHz, LW Bands, internal muting and AFC on VHF. Tuning meter. Two back printed PCBs. Ready made chassis and scale. Aerial: J/M fitting for indoor use or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 100 x 2" x 2" approx. Complete with diagram and instructions.

**SPECIAL OFFER!** £13.95 +£2.50 p&p

Self assembly simulated wood cabinet sleeve to suit tuner only. Finish size 114 x 85 x 10 x 34. £3.50 plus £1.50 p&p.

125W HIGH POWER AMP MODULES

The power amp kit is a module for high power applications. It will handle up to 80 watts RMS into 8 ohm. It is suitable for Hi-Fi or Disco use and comprises a 125W Amplifier, 125W Power Amplifier, and an I.C. Power Amplifier. The unit is protected for domestic systems. The unit is protected for high PRF signal attack. The power amp kit is a module for high power amplification. It incorporates three Mallard modules and an I.C. Power Amplifier. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95.

- **REFERENCES**: Stereo/mono mains power supply for use in conjunction with generously rated components, public address systems and even high PRF signal attack. The power amp kit is a module for high power amplification. It incorporates three Mallard modules and an I.C. Power Amplifier. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95.

**ACCESSORIES**: Stereo/mono mains power supply for use in conjunction with generously rated components, public address systems and even high PRF signal attack. The power amp kit is a module for high power amplification. It incorporates three Mallard modules and an I.C. Power Amplifier. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95. For ease of construction and alignment with P.E. (July '81) for £11.95.

**AUDAX 8" SQUARE 8 OHM TO 7KHZ. IMPEDANCE 8 OHMS.**

**SPEAKER BARGAINS**

- **2 WAY 10 WATT SPEAKER KIT**
  - **BASS/WIDFM RANG**
  - **3" tweeter. Complete with screw wire, crossover and cabinets**
  - **BASS/WIDFM RANG**
  - **3" tweeter. Complete with screw wire, crossover and cabinets**

**SUPERKITS! NOW WITH NEW CHOICE OF CASES**

**DECK**

- **SUPERKITS! NOW WITH NEW CHOICE OF CASES**

**SUPERKITS! NOW WITH NEW CHOICE OF CASES**

**SPECIAL OFFER!** £13.95 +£2.50 p&p

Self assembly simulated wood cabinet sleeve to suit tuner only. Finish size 114 x 85 x 8 x 34. £3.50 plus £1.50 p&p.

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Go-Ahead

The recommendations of the Alvey Committee that some £300 million should be invested in a cooperative research programme on advanced information technology have been endorsed by the Government. The taxpayers' contribution via the Department of Education and Science, the Ministry of Defence and the Department of Industry will cover half the cost with the remainder coming from industry. Hard-cash involvement by industry should ensure that research will be down-to-earth with marketable end-products both in software and hardware.

The Department of Industry will run the programme through a five-member directorate under Brian Oakley, seconded from his post as head of the Science and Engineering Research Council, and the directorate will report to a supervisory board of industrialists headed by Sir Robert Telford who is chairman of Marconi.

The Cabling of Britain programme has also got the go-ahead with the publication of the Government White Paper. It will be recalled that when first mooted the idea was universally applauded. Since that early flush of enthusiasm potential investors and manufacturers have had second thoughts. The flop of TV-am and generally reduced viewing figures suggest that a possible 30 channels of cable TV will not be a licence to print money. Those days are gone. None-the-less, if cabling goes ahead as it inevitably will there will be a steady living as a reward for success.

Predictably the Opposition wanted monopoly powers granted to British Telecom and complained that the whole idea was divisive in that some poor people may not be able to afford the service. But, of course, there is nothing to prevent BT competing in the market and BT's chairman, Sir George Jefferson, positively welcomed the go-ahead and appointed Donald Wray as supremo of BT's spearhead thrust into the whole area of broadband local networks including interactive services. The argument on divisiveness is plainly silly. Few of us can afford to motor in a Rolls-Royce but that is no reason why luxury cars shouldn't be built for those who can. The provisional indication of a £5 per week subscription is hardly likely to deter keen viewers.

Industry will benefit almost immediately. Racal-Oak have announced a £3 million initial contract from British Telecom for the supply of decoding equipment which ensures that viewers can access only those programmes and services to which they have subscribed.

Inmos

Since my last comment on Inmos the company has revealed at a press conference the latest state of play. For newcomers, Inmos was born in 1978 during Labour's last administration using as midwife the National Enterprise Board who were to finance the company with £50 million in two installments of £25 million. The objective was to build up an all-British VLSI chip capacity at the same time creating 4,000 new jobs in the UK. The business target was set at £150 million of profitable turnover by 1984.

Inmos started trading in 1981 and in that year (to December 31) achieved £2.1 million turnover with a trading loss of £1.3 million. Last year sales accelerated to £13.7 million and the loss rose to £20.4 million. This year turnover is running at some £20 million, whether profitably or not is as yet unclear.

Total new jobs created in the UK are 275, expected to increase to 575 during the coming year. Current forecast is that no more than 1,000 jobs will be available at the Newport, Gwent, factory and a second factory, scheduled in the original plans, is not shelved but certainly far in the future.

All is not gloom. The Transputer, described as a single-chip micro-computer, should hit the market at the end of next year although not contributing profit until 1985. Meantime the memory products can reasonably expect to be generating profits as the capacity for high volume production at Newport is steadily increased.

Back-Up

No manufacturer can succeed without adequate after-sales service. But good engineers are in short supply, transport costs are high and hotels and meals don't get any cheaper. But even more important than cost is speed and quality of service on which the whole reputation of a company may well depend.

Engineering for reliability, testability and maintainability has made great advances in electronics manufacturing and overall reliability has greatly improved through LSI and other modern techniques. Against this there is the ever-increasing complexity of equipment and systems. At the end of the day things can and do go wrong and service engineers continue to be needed.

With high costs and a shortage of skilled people is there a better way of organising service visits, particularly those occasioned by panic? Digital Equipment has found an answer not by putting more men on the road but taking their most skilled engineers off the road completely.

Not for them the Quixotic quest of traffic jams or living out of a suitcase. Instead, 16 of the best are housed in air-conditioned comfort at the company's Basingstoke customer service centre, offering a 24hr service.

The key to successful service is diagnosis and it is in this key role that the Basingstoke experts excel. Once the fault has been pin-pointed or, at worst, p.c.b. level, rectification is a simple matter and can be completed by a less skilled travelling engineer.

The operation depends on a data communications network over which the Basingstoke diagnosticians can access the faulty DEC minicomputer and, backed up by a large mainframe computer, perform powerful test routines even though the remote faulty mini may be hundreds of miles away. The European network is continually extended as every new DEC mini delivered is supplied with the necessary modem and software to complete the remote testing link.

So now the experts, instead of making one or at most two service calls a day, can service many more just by staying put.

Upturn

It is now clear that the current upturn in activity started last year with an increase in consumer spending. It is heartening to report that consumer electronics is back in business after so long in the doldrums. TV sales were a record last year and this year looks even better. Home computers are a brisk and expanding market and it is a pity that over two million VTRs sold in the UK none were manufactured here.

Capital equipment sales remain buoyant with the defence sector aided by the replacement programme following the Falklands campaign. The Electronic Engineering Association reported an eight percent increase in output in the past year at £2,125 million. Direct exports totalled £740 milllion but is probably about £1,000 million after taking account of equipment fitted in, for example, aircraft or other systems sold as a complete package.

Some sectors have fared better than others. Marine electronics has slipped back as a direct reflection of the world slump in shipping. The UK market for military tactical radio has slackened now that the British army has been re-equipped but exports are still doing well. Avionics remains in the superstar class and won Marconi Avionics two Queen's Awards this year, one each in technology and exports. Latest Marconi scoop is a £25 million order from the Royal Australian Air Force for airborne anti-submarine systems. The company has also teamed with Honeywell in military application of ring laser gyroscopes for inertial navigation.

The EEA reports a drop in employment in the capital goods sector of three percent to 98,000, the result of modernisation in manufacturing and assembly techniques. A chief constraint to rapid expansion is the shortage of engineers, a perennial problem.
IT IS evident by looking at recent projects in this magazine, that digital electronics in general, and microprocessors in particular, are playing an ever-increasing role in amateur projects. Many hobbyists are designing their own, building from kits, or just using home computers. There comes a time when it is necessary to test new designs, debug built projects, or fault-find digital circuitry. The most useful piece of test equipment for this is a logic analyser. However, due to the price of commercially available equipment, such a luxury is normally out of reach of the amateur.

The logic analyser to be described was designed to overcome this problem. The unit is used with an oscilloscope (when the 'scope display option is fitted), a piece of test equipment more easily affordable to the hobbyist. With a guaranteed maximum working frequency of 5MHz (the prototype worked to 7-9MHz), the analyser can cope with nearly all microprocessor systems found in the home today. Even systems working at a faster clock frequency can be tested by running the system (while testing) at a lower clock frequency. Comparison of the logic analyser’s specifications (see Table 1.1) with those of commercially available units shows that the facilities offered compare favourably, for a much smaller outlay.

The analyser was designed to be as modular as possible. This allows the power of the analyser to be increased as and when it is needed, and is affordable. Five options can be fitted to the basic unit. Only one option is required to have a useful instrument. All the options are plug-in, and therefore have retrofit capability, and can be fitted in virtually any order.

Since the majority of microprocessors run with a clock frequency less than 5MHz, and it was a design requirement to be able to test 5MHz systems, the use of a µP was ruled out. However, even using Schottky TTL, some clever use had to be made of available i.c.s, in order to achieve the design requirement. For this reason, it may still be of interest to readers who do not intend building the unit to read the paragraphs on the circuit operation description.

**WHAT IS A LOGIC ANALYSER?**

An oscilloscope can display two (four on expensive models) traces of real-time information. When testing digital circuits, it is useful to be able to see the timing relationship between various signals, or alternatively, if looking for example at a data bus, to be able to look at the sequential data being put out on the bus. A logic analyser enables one to do this. Synchronously with the clock of the system under test, it captures and stores a number (depending on the memory size) of bytes, each byte being 8, 16 or 32 bits wide, depending on the design. The analyser then subsequently displays the timing diagram of the captured data on a CRT display. In order to make the analyser more useful, a number of facilities are usually incorporated. As mentioned, the analyser can be driven synchronously with an external clock. When using the external clock, the negative or positive edge can be selected, and clock qualifiers are provided. These can be switch-selected such that a logical 1, 0 or X (don’t care) makes the input valid, so that external signals can control when the analyser stores information. There are usually three methods of triggering an analyser to start (or stop) storing data. A word recogniser can be used to compare the incoming data with a previously set up bank of switches (one switch for each input, allowing a 1, 0 or X to be selected) when the data is equal to the present word, the analyser is triggered. An external input, with the rising or falling edge selectable, is also provided for triggering, or manual trigger is possible with a switch. To further enhance the triggering capability, the user can select how the analyser must store the data with respect to the trigger. The trigger can be used to stop storing data (for a 1K byte memory, the analyser will store 1024 bytes before the trigger occurs), called post trigger, start storing data on the trigger (store 1024 bytes after the trigger), called pre trigger, or store 512 bytes before and 512 bytes after the trigger, called centre trigger. A more detailed explanation of the uses and working of these facilities will be given below. Since it is normally impossible to display all the bytes of data stored simultaneously (the display would be unreadable) only a portion of the memory is displayed, and the user can scan up and down the memory. Expand facilities can also be provided, so that although less bytes are displayed, more display resolution is achieved. The more expensive analysers provide cursors which can be moved across the display. Some also provide the capability to store two sets of data in two separate memories, and then compare the memories for differences.

This logic analyser includes most of these facilities. Eight input lines and a 1K x 8 memory allow 1K bytes of 8 bit
## SPECIFICATION

### TABLE 1.1. Specifications, modes and facilities

<table>
<thead>
<tr>
<th>DATA IN:</th>
<th>NO. OF INPUT LINES:</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INPUT LOAD:</td>
<td>1 LSTTL LOAD EACH</td>
</tr>
<tr>
<td></td>
<td>DATA MUST BE VALID AT THE RISING (FALLING) EDGE OF THE INPUT CLOCK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DATA HOLD TIME:</td>
<td>60ns</td>
</tr>
<tr>
<td></td>
<td>(i.e. DATA must be valid for at least 60ns after the rising (falling) edge of the clock occurs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STORAGE DEPTH:</td>
<td>1024 BYTES</td>
</tr>
<tr>
<td></td>
<td>OPTIONAL:</td>
<td>CMOS HI-Z INPUTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLOCK:</th>
<th>EXT IN</th>
<th>MAX 5MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Synchronous)</td>
<td>RISING (FALLING) EDGE SELECTABLE CLOCK MUST BE HIGH (LOW) FOR 50ns MIN</td>
</tr>
<tr>
<td></td>
<td>INPUT LOAD:</td>
<td>1 LSTTL</td>
</tr>
<tr>
<td></td>
<td>MIN MARK OR SPACE:</td>
<td>60ns</td>
</tr>
<tr>
<td></td>
<td>INTERNAL: (Optional)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Asynchronous)</td>
<td>5MHz CRYSTAL CONTROLLED</td>
</tr>
<tr>
<td></td>
<td>5MHz, 1MHz, 100kHz SELECTABLE FOR ASYNCHRONOUS OPERATION</td>
<td></td>
</tr>
</tbody>
</table>

When SYNCH clock is selected, 5MHz is available for synchronisation or as a clock drive at CLOCK OUT. When either 5MHz, 1MHz, or 100kHz asynchronous clock is selected, then the selected frequency is available at CLOCK OUT.

<table>
<thead>
<tr>
<th>CLOCK OUT:</th>
<th>SEE OPTIONAL INTERNAL CLOCK ABOVE</th>
</tr>
</thead>
</table>

| CLOCK QUALIFIERS: | NUMBER: 3 POS OR NEG LEVEL SENSITIVE |
|                  | Any or all may be chosen as negative, positive or don't care. |
|                  | LEVELS MUST BE VALID A MINIMUM OF 2ns BEFORE THE CLOCK EDGE. |
|                  | NOTE: The qualifiers are level sensitive, and must be valid for the duration of the sample. |

| ARMING: | THE UNIT IS MANUALLY ARMED, AND CAN BE RESET AT ANY TIME. |
|        | NOTE: To ensure that all old data is overwritten by the new data when POST or CENTRE trigger is selected, the unit must be armed at least 1024 fins before the trigger occurs. |

| TRIGGERING: | WORD RECOGNISER: SELECT INPUT WORD ON SWITCHES, INCLUDING DON'T CARES. |
|            | EXT TRIG: RISING OR FALLING EDGE SELECTABLE TRIGGER IS EDGE SENSITIVE TRIGGER MUST OCCUR WITHIN 70ns OF THE RISING (FALLING) EDGE OF THE CLOCK |
|            | MANUAL TRIGGER TRIGGER SELECT: MANUAL SW TCH PRE TRIGGER, POST TRIGGER OR CENTRE TRIGGER SELECTABLE. |

| DISPLAY MODES: | HEX DATA DISPLAY (OPTION 2) 2 DIGIT HEX DISPLAY OF DATA BYTE. ANY DATA BYTE WITH RESPECT TO THE TRIGGER WORD CAN BE DISPLAYED BY THE UP/DOWN SWITCH. THERE IS A DECIMAL DISPLAY OF THE ADDRESS OF THE DATA WORD BEING DISPLAYED |
|               | SCOPE DISPLAY (OPTION 1) DISPLAYS 8 BITS BY 34, 32 or 16 BYTES. THE START BYTE IS SELECTED BY THE UP/DOWN SWITCH AND THE DECIMAL DISPLAY SHOWS THE ADDRESS OF THE START BYTE. BOTH OPTIONS MAY BE FITTED SIMULTANEOUSLY. IF THE SCOPE OPTION IS USED, A FURTHER OPTION MAY BE ADDED. THIS OPTION HIGHLIGHTS THE TRIGGER WORD WHEN IT IS DISPLAYED ON THE SCOPE. |
data words to be stored. The analyser has an external clock input (up to 5MHz), with the clock edge switch selectable. Three clock qualifiers are provided, and each can be selected for a 1, 0 or X. With the clock option fitted, the analyser can also run asynchronously at three selectable frequencies—5MHz, 1MHz and 100kHz. The selected clock frequency is buffered and is brought out to the front panel, so that the circuit under test can be driven by the analyser's clock. The three modes of triggering discussed above are provided: external (edge selectable), manual, and word recogniser. A bank of 8 switches is provided for this, and each input line can individually be set for a 1, 0 or X. The analyser allows the selection of pre, centre and post triggering as defined above. Two data display options are possible, one of which must be fitted to make the unit useful, although both can be fitted if desired. The one option displays 64 bytes by 8 bits (8 traces) of timing diagrams on a normal oscilloscope display (the oscilloscope must be a dual trace one with X-Y capability). The display can be expanded so that only 32 or 16 bytes are displayed. The display can also be scanned up and down the memory. The other option allows the Hex value of the data to be displayed on two 7-segment displays. For both options, a 4-digit display indicates the address of the data byte with respect to the trigger point for either the data being displayed in Hex for the Hex display option, or the first byte of the set of 16, 32 or 64 bytes being displayed by the scope option. When both options are installed, the Hex data corresponds to the first (left-most) byte being displayed on the scope. A further option available which can only be used in conjunction with the scope display option, uses the Z-MOD input of the oscilloscope to brighten up the trigger byte (the byte at which the analyser was triggered) when that byte is being displayed on the oscilloscope.

Finally, the basic analyser accepts TTL compatible inputs, however the last option available will allow the testing of CMOS or other circuitry, at user defined supply rails.

SPECIFICATIONS

A complete list of specifications is given in Table 1.1, and these are self-explanatory. Perhaps the only extra explanation required is that of ARMing. Normally the analyser is in the display mode, displaying previously captured data. To get the analyser ready to capture new data, the unit must be ARMed. This is done manually with a switch, and when it occurs, the ARM i.e.d. lights, the data being displayed becomes invalid, and the analyser awaits the trigger. During this time, the analyser is storing data, so that when a trigger arrives, the TRIG i.e.d. lights, and both remain on until the data has been stored. At this point, the i.e.d.s extinguish, and the analyser automatically reverts to displaying the new data. At any stage, the ARM/RESET switch can be used to reset the analyser from the ARMed state to the display state.

CIRCUIT DESCRIPTION

Before considering how the circuit works, it is necessary to keep two factors in mind. The first is that with a 5MHz clock, only 200ns is available to do the following: increment the RAM address, check for a valid trigger, generate the Write pulse to the RAM, and then be ready to repeat the sequence. A look at the circuit diagram shows that signals have to pass through quite a few i.c.s, and the propagation delays through each begin to add up. For this reason, one has to firstly be careful that the total worst case time to complete a cycle does not exceed 200ns, and secondly that the Enable, Latch, Data, and Clock pulses are generated in the correct time slots and sequence, to ensure reliable operation. With the aid of the timing diagram shown in Fig. 1.1, we will be looking at how correct timing was achieved.
The second factor concerns data skew. For example, consider the EXT. TRIG. input where either positive or negative edge triggering is possible. A simple way to achieve selection is shown in Fig. 1.2. The problem with this circuit is that:

1. When negative edge is selected, the input sees only one gate input, and when positive edge triggered, the input sees two gates.
2. Because of the extra inverter, the propagation delay for negative edge triggering is longer than that for positive edge triggering.

To overcome this, the circuit of Fig. 1.3 is used. This circuit has one further advantage, that the input signal itself is not physically switched—the switching is done by a d.c. level applied to the EX-OR gate. This second factor also applies to the clock and qualifiers’ inputs, as well as to the word recogniser. In these two cases a different method was used to overcome the problem.

Refer to Figs. 1.4, 1.5 and 1.6 for the block diagram, front panel circuitry, and main board circuitry respectively. Assume that the unit is on, and has been reset. We now want to store data, so we must ARM the analyser using switch S16. This sets the master flip-flop consisting of IC28c & d L (low) on STORE, and H (high) on STORE become valid, with the following effect: IC1's outputs become valid (no longer in Tri-State). IC15 gates data from the data bus to the RAM, the RAM is put in the WRITE mode, IC27b and IC31 are enabled. Depending on the setting of S14, IC31 selects either the SYNC CLOCK, or one of the three asynchronous clock frequencies from the CLOCK OPTION, if it is fitted. Since the inputs to the i.c. are paralleled to both halves of the i.c., the same selected clock appears at both outputs (except in the case of SYNC CLOCK selection, where the internal 5MHz clock appears at output 2Y). Thus the internal clock frequencies are buffered and made available at SK7 on the front panel. The output of Y1 is called the STORE CK. Normal gates were considered for the selection of STORE CK, but calculations of propagation delays proved that using IC31 would be faster, with the advantage of a smaller total chip count. Assume now that the SYNCH CLOCK has been selected. However, before continuing with the STORE CK, let us see how the SYNCH CLOCK was derived. Since the clock qualifiers must act on the input clock, some sort of gating must be incorporated. We also want to be able to select positive or negative clock edge, and the qualifier level. At the same time we must be careful of data skew. To solve the problem, all four inputs are buffered with a single LS TTL gate (IC5) each. This allows the lowest possible load to be applied to the circuit under test. The clock and qualifier inputs are fed to one set of inputs of a 4-bit magnitude comparator, IC4. The i.c. gives an output on pin 6 only when all the bits in one set of inputs correspond to the bits in the second set of inputs. Consider selecting positive edge for the CLOCK, positive level for CQ1, negative level for CQ2, and don't care for CQ3. For CQ1 positive, B2 input is low, and thus S2a is switched such that A2 is low. Similarly, for CQ2, B3 will be high, and with S3a in the position shown, R20 will hold A3 high. In the don't care case, S4 is switched such that R25 and R21 pull B4 and A4 high respectively. So when the correct inputs are applied to the qualifiers, the respective B inputs will be equal to the A inputs. For positive clock edge S1a wiper is at OV, i.e. A1 is low, when the clock goes high, B1 will become low (due to the inverter) and because these inputs as well as the qualifier inputs are now equal, IC4 pin 6 goes high. When the clock falls, A1 is not equal to B1, so pin 6 goes low, and
thus follows the input clock. If a qualifier became invalid, the
clock would stop, and that if negative clock edge is selected,
the output at pin 6 would be an inverted version of the input
clock. By the use of only one i.c., all the clock functions have
been implemented, propagation delay has been kept to a
minimum, and data skew has been avoided, as all inputs to
the i.c. have similar propagation delays through the i.c.

Now to come back to the STORE CK. IC24b has been dis-
abled by L on STORE, and its output is high. The STORE CK
passes through IC36c, and is applied to the RAM address
counters clocks (ICs 17–19). Pin 1 of IC23a is low, and there-
fore pin 3 is high, with the result that the LD inputs of the
RAM counters are high. Therefore the counters are being
clocked, and the RAM is being addressed in time with the in-
put clock. Now every time IC31 pin 7 (STORE CK) goes
high, the output of IC30a (LE) goes low, latching the data
into IC1. There are two further requirements of the STORE
CK. Firstly a WRITE pulse with a minimum width of 40ns
must be generated to store the data in the RAM, but only
when the address and the data are valid. Secondly, the input
latch, IC1, must remain latched for just long enough so that
the memory stores valid data. The circuit works like this.
When the analyser is ARMED, H on STORE goes high, and
this sets the Q1 and Q2 outputs of IC34 (via the CLR inputs)
to low. The output of IC29d is thus low, and because pin 12
of IC31 is still low, LE is high. When the STORE CK goes
high, LE goes low, and the input data is latched. One cannot
rely on the STORE CK to hold LE low, because for a 1:1
mark-space ratio 5MHz clock, the high level is only valid for
100ns which, as we will see, is too short. So what happens
is that the STORE CK clocks the first D-TYPE, and Q1 goes
high. IC29d output thus goes high, and now regardless of
whether the STORE CK falls away or not, LE remains low.
Q1 of IC35 goes low after the propagation delays of IC32b
and IC35, and remains low for approximately 43ns, which
is long enough to write the data into RAM. On the rising edge
of Q1 (IC35), Q2 of IC34 is clocked high, IC29d goes low,
and if the STORE CK has become low, LE once again
becomes high. If STORE CK is not yet low, LE will remain
low until this occurs. When the next STORE CK comes, the
sequence is repeated. With this little bit of circuitry then, in-
put data is latched, held long enough to be stored, the store
pulse (WE) is produced, and the latch is disabled once again.

At this stage we have the input clock clocking the RAM,
and input data being stored in the RAM. The counters IC17
to IC19 are cycling through a count of 1023. Now we must
consider the trigger circuitry. The type of trigger is selected
by S19, and IC25a, b & d. Manual trigger is simple: IC26
produces a pulse, IC25b goes low, IC27a goes high and
IC27b goes low. EXT works similarly, with IC29c and S18
allowing the rising or falling edge to be selected. For this
case S19 enables IC25a.

WORD RECOGNISER

The word recogniser works in a similar fashion to the
clock and its qualifiers, in that the incoming data is com-
pared to data set up on switches S6 to S13. ICs 2 and 3 do
the comparison, and produce a high level output when the
data sets are equal. This output is gated via IC24a through
IC25d to IC27a, if the word recogniser trigger has been
selected. The requirement for gating the output is that a
false trigger may occur while the latch outputs are settling,
or input data is changing. To avoid this, LE, suitably inverted
(by IC25c) and delayed (IC24d) to allow for latch setting
time, only enables IC24a when the data at the output of IC1
is valid. IC28a & b sets. The flip-flop is capacitively coupled, and this
allows pin 5 to go high even if IC27b stays low so that the
flip-flop can be reset when necessary (this ensures that
triggering is only edge sensitive for all the triggering modes).
IC28a goes low, lighting the TRIG I.e.d. The flip-flop con-
sisting of IC30c & d is set by IC28b via C7, which again
allows the second flip-flop to reset before the first one does.
The flip-flop triggers the monostable IC32, which provides a
positive and negative pulse. The positive pulse is used to
reset the second flip-flop, and also for the Z-MOD option,
to be described in a future part. The reason for the second flip-
flop being necessary, as will shortly be explained, is that the
first flip-flop can be reset immediately after being set. Thus
the time for which the flip-flop is set is virtually that of the
propagation delays of two STTL gates, being approximately
10ns. Since a 74121 requires a minimum input pulse of
50ns, this lengthened pulse is provided by the second flip-
flop. The negative pulse produced by IC32 (ADL) firstly loads
the address that was on the address bus into ICs 20–22, so
that the address at which the analyser was triggered, is
stored. ADL also loads the preset binary number 0, 511 or
1023, depending on S5 into the counters ICs 7–9. IC10 and
IC11, two EPROMS, decode the binary number into BCD,
and the number is displayed on displays 1–4. Thus the dis-
play is preset with a number depending on which TRIG
POSition is selected — 0 for POST, 511 for CENTRE, or
1023 for PRE trigger. With IC28b output low, counters
IC37–39 are preset to zero, and when POST goes high, the
counters and IC24c are enabled. This allows STORE CK to
clock ICs 37–39. Again, depending on position of S5, either
POST, or QA or QB is switched to IC30b. If PRE trigger is
selected, QB is connected, allowing the counter to count to
1023 before a pulse is produced which resets the main flip-
flop. The count of 1023 allows the memory to be filled with
1K of data from when the trigger occurs. In other words,
the analyser was triggered to start storing data, and this is thus
called PRE-trigger. If CENTRE trigger is selected, the coun-
ters count to 511 before resetting the main flip-flop. Here
the memory is only filled with 512 bytes of data after the
trigger and thus contains 512 bytes of stored data before the
trigger occurred. Hence the name centre trigger.

POST TRIGGER

Finally for POST trigger, it is required that the analyser
stops storing immediately, so POST signal is connected
directly to the reset. As can now be seen, when POST is
selected, IC28b causes itself to be reset via the switch and
IC30b; and for this reason IC30 c & d are required as ex-
plained above. Once the main flip-flop and IC28 a & b have
been reset, the ARM and TRIG I.e.d.s extinguish, IC1
becomes Tristate, IC15 gates RAM data to the data bus, the
RAM goes into its read mode, IC31 (and thus the STORE
CK) is disabled, and ICs 17–19 have their LD input taken
low by IC23a, so that the trigger address loaded into ICs
20–22 now passes through ICs 17–19. This means that the
data stored when the analyser was triggered is on the data
bus, and the data corresponds to the trigger position being
displayed on the address display. If POST trigger had been
selected, 0 would be displayed, showing that the data byte
on the bus is the first data byte stored, i.e. the trigger data
byte. For CENTRE trigger, 511 would be displayed, implying
that the trigger data byte is in the middle of the RAM, and
similarly, for PRE trigger, 1023 will be displayed, indicating
that the trigger byte was the last byte stored. Before dis-
cussing briefly how the data is displayed (the display options
will be described in Part 3), let us now look at the timing
diagram, Fig. 1.1.
SYSTEM TIMING

We will take the rising edge of the input clock as reference. Using maximum and minimum propagation delays as given in the Texas Instruments TTL Data Book, STORE CK will go high a maximum of 42ns later and a minimum of 25ns, due to the delays through IC5, IC4 and IC31. Taking into account the delay through IC30a, LE goes low 5ns later. Also, 44.5ns after STORE CK goes high, the address on the data bus becomes valid (delays are due to IC36c and the counters IC17-19). Now if IC33b is not in circuit, the address is valid 5ns later. Also, 44.5ns after STORE CK goes high, the address is valid. This means that the time taken between the rising edge of the input clock and the point at which a word recogniser trigger stops the STORE CK, is 157.5ns. This last calculation ensures that the analyser is reset within 200ns, i.e. before the next clock edge arrives.

and then 24.5ns later (due to IC34, IC29d and IC30a) LE goes high again (assuming of course that the STORE CK is already low). This would then be a worst case total of 182ns after the input clock edge, which allows 18ns spare before the next clock edge arrives. As is specified, the data input must be valid at the rising edge of the input clock, and becomes valid at the output of IC1 10ns later due to the delay through IC1. The comparators take 28ns for the comparison, and including the delay of IC1, the A = B output is valid 38ns after the rising clock edge. Now including the delay of IC25c, LE applied to IC24a (without IC24d) would take a minimum of 29 + 3 = 32ns, which would mean that IC24a could be enabled 6ns too early. Thus the delay of IC24d is included to ensure that the A = B signal is valid before IC24a is enabled. IC24a adds 7.5ns and then the trigger path adds a further 78.5ns before the master flip-flop is reset. This means that the time taken between the rising edge of the input clock and the point at which a word recogniser trigger stops the STORE CK, is 157.5ns. This last calculation ensures that the analyser is reset within 200ns, i.e. before the next clock edge arrives.

COMPONENTS...

Resistors

- R1–R25, R34, R35, R40, R68, R70, 10k (30 off)
- R30, R32, R69, 100k (3 off)
- R31, R33, 27k (2 off)
- R42–R62, 470 (21 off)
- R41, 270
- R71, 220
- R76, 2k 1% \( \frac{1}{2} \)W

All resistors are 5% \( \frac{1}{2} \)W unless otherwise stated.

Capacitors

- C1, C2, 2µF/16V tant. (2 off)
- C3, C4, C9–C26, 100n/16V tant. (18 off)
- C5, C6, 1µF/16V tant. (2 off)
- C8, 30µF ceramic (2 off)
- C28, C30, C32, 1µ/35V tant. (3 off)
- C27, C29, C31, 10µF/35V tant. (3 off)
- C33, 4700µ/25V elect. (2 off)
- C34, C35, 2200µ/25V elect.

Transistors & Diodes

- TR1, 8C108
- REC1, 100V p.i.v. 5A
- REC2, 100V p.i.v. 1A
- D1, D2, D3, 3mm red i.e.d. (3 off)

Integrated Circuits

- IC1, 74LS373
- IC2, IC3, IC4, 74S85 (3 off)
- IC5, 74LS04
- IC6, IC7-9, IC20-22, 74LS193 (6 off)
- IC10, IC11, 2716 (2 off)
- IC12–14, 74LS47 (3 off)
- IC15, 74LS245
- IC16, MK4801A–B5
- IC17–19, IC37–39, 74LS191 (6 off)
- IC23, 74LS00
- IC24, IC33, 74S08 (2 off)

IC25, IC28, 74S00 (2 off)
IC26, IC32, IC35, 74121 (3 off)
IC27, 74S20
IC29, 74S86
IC30, 74S02
IC31, 74S153
IC34, 74S74
IC36, 74S32
IC40, 7912CT
IC41, 7812CT
IC42, LM323K

Switches

- S1, S18, S21, DPDT min. toggle (3 off)
- S2–4, S6–13, DPDT (with centre off) min. toggle (11 off)
- S5, S19, S20*, 4P3W rotary (3 off)
- S14, 3P4W rotary
- S15, DPDT momentary action
- S16, S17, DPDT momentary action (with centre off) (2 off)

Miscellaneous

- T1, Transformer 9V @ 3A
- T2, 150mA
- SK101*, Red banana socket
- SK102*, Black banana socket
- SK103*, Green banana socket
- SK7, BNC female chassis mount
- SK4, SK5, 16 pin i.c. socket (2 off)
- SK3, 14 pin i.c. socket
- SK1, SK2, SK6, SK8, Double-sided wire-wrap p.c.b. edge connector. See text (4 off)
- 14 pin wire-wrap sockets for displays (6 off)

Sockets for i.c.s: See text

Sockets for i.c.s: See text

Heat sinks, nuts & bolts, stand-off pillars.

Cap: 440mm x 110m x 200mm deep.

Soldercon i.c. socket strips (see text)

16-way ribbon cable

Ribbon cable headers to fit 16-pin i.c. sockets (4 off)

Fuse and fuseholder (chassis mount 500mA)

Coloured "Easy-Hooks"

X1–X4 0.3" i.e.d. 7-seg. display (Maplin common anode type)

X5–X6 0.3" i.e.d. 7-seg. display (FND357)

*These items are used with the display options. Since they are relatively cheap, it is recommended that they are fitted to ease retro-fitting of these options. Refer to text.
Fig. 1.5. Front panel circuitry
The clock modifiers must be valid before the trigger word appears, to get the analyser triggered. Once triggered, the modifiers can then be used to select data to be stored, i.e. to start and stop storage as required. The reason for this requirement is that the trigger pulse is gated through by IC24a, which is enabled by LE, which is in turn derived from the STORE CK. So if the modifiers are invalid there is no SYNC CLOCK, which means no STORE CK. Hence the trigger word will never get through. Once IC28b and IC28a have been set, it does not matter if no more pulses come through, therefore the modifiers can be used.

All unused inputs of the probe (including unused modifiers and EXT input) should be tied high or low, especially when operating at higher frequencies. Floating gate inputs can affect other inputs of the same i.c., and although no problems were experienced with the prototype, this is good practice.

**DATA DISPLAY**

Assuming no scope option, the input to IC23d (LD) is low, and the output of IC23a is therefore low. As already explained, the address on the outputs of ICs 20–22 are therefore passed through ICs 17–19, and the data corresponding to that address is on the data bus. Because LD is low, the latch on the Hex display option is disabled (not latched) and the data on the data bus is displayed. If S17 is now activated, one of the halves of IC6 oscillates, and the latch is pulsed low, reloading ICs 17–19. LD is also being held high, so the LD inputs of ICs 17–19 are invalid. However, every 64, 32 or 16 clock pulses, LD is pulsed low, reloading ICs 17–19 with the base address stored in ICs 20–22. Also, the Hex display option gets the pulse, so the latch on the option latches in the data only when the base address (from ICs 20–22) is valid. Now similarly, when S17 is operated, the base address in ICs 20–22 change, and so the starting point from which the scope displays its 64, 32 or 16 bytes is changed. In this way, the whole memory can be scanned up and down in segments of 64, 32 or 16 bytes.

**POWER SUPPLY**

The power supply is conventional, using 3-terminal regulators. Although the ±12V has not yet been made use of, it is used for the CMOS input option, and the scope display option. The transformer supplying the +5V must have a rating of at least 2A, as the total current consumption of the complete unit exceeds 1A.

**COMPONENTS**

Full constructional details of the basic unit will be given in the next issue; however, a comment on the components is necessary. The Schottky TTL must not be replaced by LS TTL, otherwise the 5MHz specification will not be achieved. Double-sided p.c.b.s have had to be used, but do not have to be through-hole plated. Since it is not wise to solder i.c.s direct to the p.c.b., it is recommended that Soldercon i.c. socket strips are used. These allow soldering on both sides of the p.c.b. and are cost effective. The alternative is to use wire-wrap sockets, to allow the sockets to stand proud of the p.c.b., so that the pins can be soldered both sides where necessary. The prototype was built using Soldercon strips, and these worked well, while providing a neat solution.

---

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<table>
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<td>(encased in ABS plastic)</td>
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TAROIDALS

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INFRA-RED HELMET LINK

Motor cyclists and their pillion passengers have a problem with communication, largely because British law (very reasonably) compels them to wear crash helmets. The obvious solution is a radio link. But if the legal CB wavelengths are used the link is likely to be useless, especially in city areas, because these frequencies are now so cluttered and blitzed by illegal high-powered transmitters, that normal use is impractical.

David Thompson of London W8 and Nicholas Hobson of SW3 have filed a British patent application (2 103 043) on an alternative approach. They suggest using an infra-red transmitter and receiver system built into the crash helmets. This seems a sensible approach, because the distance between rider and passenger is small, and their front-back positioning is fixed. The system can be modified, however, for sideways use with a side car.

Fig.1 shows two helmets, each with microphone 3 and headphones 4 inside. L.e.d. 5 serves as an infra-red emitter and photo diode 6 as a receiver, on the front, rear and/or side of the helmet as necessary.

Inside each helmet there is an infra-red transceiver, shown schematically in Fig. 2. Speech picked up by microphone 14 is amplified at 15 and split into two paths. One path triggers threshold switch 16 and the other controls AGC circuit 17. The controlled signal is limited at 18 and band-pass filtered at 19 to around 300–330Hz. The processed signal is then fed to one input of Pulse Width Modulator 20, while the other input receives a triangle carrier generated by oscillator 21 at around 20kHz. The pulse width modulated output is converted to Pulse Position Modulation by circuit 22. The inventors say PPM allows average transmitted power to be greatly reduced.

DOUBLE-CARRIER STEREO TV

There is currently a move in Germany to protect the native TV manufacturers from foreign competition, by the use of a patented stereo sound system. For the last sixteen years Europe has been able to limit the number and type of colour sets made in the Far East and in Europe, by clever use of the Telefunken patents on the PAL signal coding system. But now the PAL patents are running out and in Germany IGR (Interessengemeinschaft fur Rundfunkschutzrechte GmbH) is hoping to do the same with a folio of patents on the double-carrier system now being used to transmit stereo sound with some TV programmes in West Germany. This is one very good reason why the Germans adopted a very different approach to that used in Japan.

In that country the two channels of sound are multiplexed on a single carrier, whereas in Germany they are transmitted on two separate carriers. Unfortunately the German patents on stereo TV sound are likely to prove far weaker than the PAL patents, for the simple reason that there is nothing new in twin carrier transmission. IGR’s only hope is to patent details of the system.

European patent application 0 069 864 is an example of what looks increasingly like a doomed attempt at fending off foreign competition. The patent application, in the name of IGR, has been filed in all the major European countries, including Britain. This is an expensive tactic but the application covers only a trivial circuit detail. Even if IGR can persuade the European Patent Office that such a simple idea is new, and worthy of a patent, it is hard to see how it can be used to ward off the Japanese competition.

Copies of Patents can be obtained from: the Patents Office Sales, St. Mary Cray, Orpington, Kent. Price £1.60 each.

Practical Electronics August 1983
To most hobbyists the function or even existence of a Deglitcher is somewhat obscure. However, with the increasing interest generated in these pages over recent years concerning microprocessor interfacing, particularly in digital to analogue conversion, a number of experimenters may well have been 'glitched' without being fully aware of their situation, the results being curious logic spikes and consequently distortion of the desired output.

THE GLITCH DEFINED

A glitch is a transient spike which occurs at the output of any DAC (digital to analogue converter) when the input code is changed. All DACs suffer from glitching. The transients are due to the finite, variable times taken for digital signals to drive analogue switches. These variations are caused by small imperfections introduced to the integrated circuit during fabrication, hence stored charge, or gate to drain capacity, is inconsistent. The resultant effect is that both digital and analogue switches turn on and off at different rates at different times. Consequently a series of states is experienced when the input, and hence the output, is changed.

This behaviour is most pronounced when small changes occur about the most significant bit (MSB). To illustrate this point consider the incrementing of data from $127_{10}$ to $128_{10}$; in binary form this corresponds to a transfer of $01111111_{2}$ to $10000000_{2}$; in other words a complete change of state is required for each logic input. If this is analysed further the DAC must switch the MSB on and switch off the other lesser seven bits in order to synthesise the corresponding analogue voltage. However these switches of logic level do not occur simultaneously and thus for a small space of time there are many possible input values. The two worst cases are $1111111_{1}$ (the MSB switches on while the lesser bits are still on) and $0000000_{0}$ (the lesser bits turn off prior to the MSB turning on). Both of these cases are shown in Fig. 1.

DEGLITCHING

The immediate concern is the various methods of glitch elimination. The first point to make is that complete deglitching is only possible by over-damping the system. In most cases this is possible but wholly undesirable due to the sluggish response. However the principle of damping is a useful one and is commonplace in comparatively slower systems.

In its simplest form a capacitor strapped across the DAC's output acts as a reservoir for smoothing purposes. The choice of capacitance depends on a compromise between response time and glitch amplitude. Unfortunately these two parameters work against each other and hence alternative methods are necessary for higher speeds (Fig. 2).

One such method is to load all the logic bits into a storage register before updating the DAC. In this way the skew time of the digital drive circuitry is reduced simply by ensuring...
that all the data bits are input at the same time. However the output stages are still prone to fabrication problems as mentioned earlier. Another problem with the storage register system is that significant propagation delay times are added to the signal processing and this hinders fast operation.

This leads to the third, and most efficient, method of reducing glitches: a Deglitcher. In making this statement it must be noted that glitches cannot be eliminated, only reduced. A Deglitcher is a switched feedback element, and as such a device it must be included in the feedback loop of an operational amplifier used at the output stage of the DAC. They are essentially analogue devices with some clock functions, closely related to sample and hold amplifiers. The principle of a Deglitcher circuit is to isolate a DAC glitch and substitute its own small glitch. This latter glitch comes from charge dumping on the Deglitcher hold capacitor during transitions from sample to hold and hold to sample. Since this is independent of the DAC, changes in the digital input codes will have no bearing on the glitch size. Therefore the glitch is small and constant.

Implementation of a Deglitcher is shown in the block diagram of a DAC system in Fig. 3. The timing of the circuit is given in Fig. 4. Here, when the external storage registers are full a pulse, ‘Strobe In’, is applied to the Deglitcher. The rising edge of this pulse places the Deglitcher into its hold mode and then triggers an internal mode control gate pulse. At a small but specified time after the ‘Strobe In’ pulse has been received, a ‘Strobe Out’ pulse is generated. This allows data to be transmitted from the storage registers to update the DAC. After the DAC has assumed its new data level the falling edge of the Deglitcher mode control switches the mode from hold to sample and hence reconnects the DAC output to the amplifier, which quickly assumes its new value. Obviously a sufficiently fast op-amp must be used.

Minimising glitches in this manner results in an essentially linear analogue representation of a digital input. This is extremely important in applications such as cathode ray tube display driving where large high speed transients are integrated over a number of microseconds thus affecting accuracy, lengthening system settling time and creating distortion.

**PRACTICAL SYSTEM**

Such a system is realised in Fig. 5. In this particular example the DAC is an 8 bit device, but it could be of any resolution. The particular Deglitcher is the Teledyne Philbrick 4902 which is a high reliability hybrid module. This device requires an f.e.t. op-amp and hence an LF 351 is used. The Deglitcher has three externally controllable variables. The ‘Jump Trim’ determines the voltage of the hold signal and the ‘EOS Trim’ is the offset voltage compensation for the device.

Other features of the circuit are the clamped output of the DAC using two Schottky diodes, the debounce of the strobe input and the feedback resistor Rf. The diodes prevent damage due to over voltage, and glitches, by supplying a low resistance path to ground. The debounce network consists of low value components in order to attain a reasonably fast, clean edge for the Deglitcher to trigger from; situations such as these always call for a compromise between speed and effectiveness. The feedback resistor Rf is one of the major components in the circuit. During the sample mode the constant glitch is generated. The amplitude of the glitch is a function of the DAC output current and the feedback resistor. Hence, during the sample mode Vg = -IRf. The output becomes that of Fig. 6. Pin 11 is the strobe o/p which enables the data latches to update their registers.

Typical applications where this sort of circuit is employed are CRT display systems, fast process controllers, camp generators, automatic test equipment and symbol recognition devices.
Increasing RAM to 3K

Sir—The available user-RAM on the PE Microcontroller is 1K bytes. More complex control programs become restricted due to lack of user-RAM. The circuit described increases this memory by 2K bytes whilst retaining:

a) battery backup facility
b) "DISBUG" monitor facilities

c) the minimum of p.c.b. modifications, and at very low cost.

The RAM chip used is the Hitachi HM6116LP-3. Being pin compatible with the 2516 EPROM, it will plug into the spare 24-pin socket (for IC26) on the Microcontroller. As with the DISBUG EPROM (IC3) the use of an additional low profile socket is required with pins 18, 20, 21 and 24 being bent out before insertion, allowing access for modifications. The p.c.b. wiring of address and data lines are compatible. Modifications are however required for the control signals—p.c.b. modifications being:

1) cut track between IC24 pin 4 and IC25 pin 1
2) cut track to IC7 pin 3 (near IC7) and join the now isolated track to IC7 pin 4
3) carefully lift IC7 pin 1 (to allow access to this pin only, for wiring)

Additional wiring required is as shown on the circuit diagram. The 74L500 chip (IC27) can be sited above 1C10 (spare socket) on the Microcontroller or on adjacent Veroboard. All wiring connections can be made on top of the p.c.b. wire as follows (6116 chip removed):

1) 74L500 interconnections, power supply, ground
2) IC25 pin 6 to IC26 pin 21
3) Join IC26 pins 18 and 20, wire to IC7 pin 3
4) IC27 pins 12, 13 to IC6 pins 13, 14 respectively
5) IC27 pin 2 to BUS 02
6) IC27 pin 4 to IC6 pin 15
7) IC27 pin 6 to IC24 pin 4
8) IC27 pin 3 to IC7 pin 1 (i.e. pin only)
9) IC26 pin 24 to VRAM
10) Connect 3K3 resistor from IC7 pin 1 to +Vcc

IC6 (address decoder) output Y1 is enabled for a valid memory address between 0000 and 03FF, generating a chip select for the 1K RAM (IC8, 9). The additional 2K RAM is located at addresses 0400 to 0BFF, utilising the outputs Y2 and Y3 of IC6. If either of these outputs is true, IC27 pin 11 goes high. This enables IC27 pin 1, which is phased with BUS 02 clock, to generate chip select to IC26, provided the +5 volt power supply rail is held.

The Microcontroller uses a clock stretching input to IC1 (clock generator) whenever any address in RAM is assessed. For compatibility of software timing this is used in the modified circuit. IC27 gates a preset to IC24 (dual D flip-flop) whenever any of IC6 outputs Y1, Y2 or Y3 are true. This enables the clock and D inputs to generate: i) memory ready to IC1 pin 6; ii) enable to the other flip-flop (IC24).

This second flip-flop (IC24) generating the "write enable" signal to IC25 pin 5, enabling this gate to provide a read or write signal to all of the RAMs.

Memory standby/supply power is taken from the supply (VRAM) and Use of the HM 6116 LP RAM device ensures low power consumption. This device has a standby power of 20 microwatts (typical), ensuring the Microcontroller will still retain memory data for many months, when not used—a prime requirement.

The memory map shows the user locations of RAM. It must be remembered to avoid the area of DISBUG RAM when combining the existing 1K RAM and the additional 2K RAM in any software routine.

Before making any modifications to the Microcontroller p.c.b. it is essential the wiring of IC25 is examined. The gates used within this package may differ from the circuit diagram supplied with the Microcontroller. Modification details refer to IC25 pin/gates as on my Microcontroller p.c.b. Use a low-profile 24-pin d.i.l. socket for IC26.

S. Marke, Towcester.

Table 1. Memory map

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<th>KEYBOARD P.I.A.</th>
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<th>USER P.I.A.</th>
<th>USER P.I.A.</th>
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<td>1800 -&gt; 1803</td>
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<td>1400 -&gt; 1403</td>
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<td></td>
<td>1000 -&gt; 1003</td>
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<td></td>
<td>0BFF</td>
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<td>07FF</td>
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<td></td>
<td>0400</td>
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<td></td>
<td>0000</td>
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</tr>
</tbody>
</table>

Figure 1. Circuit diagram (with added 2K memory and Chip Select and Write Enable)
SIR

The adjacent MIC subroutines effectively quadruples the screen resolution of the UK101 with no hardware mods. It does this by dividing each character slot on the screen into 4 (see below).

The routines decide which quarter to light, which quarters are already lit, and then displays the appropriate "chunky" graphics block in the slot. This gives a resolution of 92 x 62 on my system.

The routines supplied allow either very fast point or line drawing in white or black (plot or unplot). They may be called from BASIC with USR(1) or in MIC programs by JSR XXXX.

To use the routines as supplied:
- POKE $F0 with X0-co-ordinate
- POKE $F1 with Y0-co-ordinate
- POKE $F2 with X1-co-ordinate
- POKE $F4 with Y1-co-ordinate
- POKE $F2 - 00 for black (unplot) not 00 for white (plot)

THEN JSR $1E81 to plot the point (X0, Y0)

OR

JSR $1F33 to plot the line (X0, Y0) to (X1, Y1) at the same resolution.

Both drawing routines are very fast and although not quite the 279 x 192 of an Apple II they do give a creditable performance on the graphics programs written for the Apple. Other 6502 systems can use the same routines if they have chunky graphics available (e.g. Tangerine). The codes for the graphics blocks for that system are then put in place of BLOCKS at $1EA1 of the routines and then everything else will work.

Steven Lomas, Bath.

Sir—The adjacent MIC subroutines effectively quadruples the screen resolution of the UK101 with no hardware mods.

This is the binary for each of the quarter pixels.

This is the data giving the "chunky" graphics characters which fill in appropriate quarters of the block, according to which of the "pixels" (quarters) are lit.

LDA #SCD
STA VDU
LDA #SCD (must be consecutive)
STA VDUHY
GET the double X co-ordinate and divide by 2
LDA XX
LSR A
store actual X co-ordinate multiply up again save it
STA XP
ASL A
QUART as a pointer to the table
STA TEMP
SEC
QUART = XX - INT (XX)

QUART = (YY - INT(YY))'2

To find which quarter of the block is referred to...
- use
LDA YY
LSR A
save it
and now
LDA Y0
QUART XX INT (XX)
to find which quarter of the block is referred to.

If ZZ = 0 then "unplot"
If ZZ ≠ 0 then plot switch off pixel
save pointer plot it
PLOT
JMP PLOT

.to which of the "pixels" (quarters) are lit.

LDA #SCD
STA VDU
LDA #SCD
STA VDUHY
SAVE the double X co-ordinate

LDA XX
LSR A
store actual X co-ordinate multiply up again save it

STA XP
ASL A
QUART as a pointer to the table

STA TEMP
SEC
QUART = XX - INT (XX)

QUART = (YY - INT(YY))'2

(i.e.) which quarter?

01, 02, 04 08
01 02
04 08
actual Y pointer
load VDU address (low) add a line
LDA Y0
ADC #540
STA VDU

LDA (VDU), Y
INC VDUHY
load the character on the screen already identify the block.

if not equal then jump over this which saves the pointer

if not done go back add pixel to CHAR

save pointer plot it
pLOT

add pixel to CHAR

and save it in QUART

and with what’s there already. Is it lit?
if here then pixel required is lit

ZZ is switch —

If ZZ = 0 then "unplot"
If ZZ ≠ 0 then plot switch off pixel
save pointer plot it
PLOT
JMP PLOT

JMP PLOT

add pixel to CHAR

to switch pixel on

save pointer and plot it.

add pixel to CHAR

to switch pixel on

save pointer
microcontroller clock

many people have noticed that the microcontroller clock is not accurate and typically loses 10 to 20 seconds every 24 hours. David Whitfield, a co-author of the project, has investigated this problem and encountered difficulty in tracing a missing second every 5 to 10 minutes. In the end, he used a BBC micro programmed as a data rate logic analyzer to monitor the 1 Hz clock and compare it with the internal clock on the BBC machine. This, in conjunction with the test program published in the December copy of PE, showed the following:

1. The 1 Hz clock does not "swallow" whole seconds due to the circuitry associated with IC2. This would have been a convenient solution.
2. The accuracy of the Microcontroller's 1 Hz clock is better than that of the BBC micro system clock over a long period. This is probably due to the higher interrupt load on the BBC's CPU and its dependence on the system clock over a long period. This is better than that of the BBC micro's clock.
3. The internal DISBUG clock does lose count at a long term rate of around 1 Hz. TOCK, however, is updated whenever an interrupt occurs. Since there is only one interrupt set up by DISBUG (the 1 Hz clock), the results from TOCK and TICK should be the same. If anything, TOCK might be expected to gain on TICK due to the effects of spurious noise-induced interrupts; TICK does a check on the PLA status to avoid this problem. The test program, when run from 0000, and compared with a "real" clock, allows the two counts to be displayed simultaneously. The full TOCK count is shown in the address area of the display, while only the two least significant digits of TOCK are shown in the data area. After a few hours of running, watching and comparing, it is evident that TOCK loses counts, but that TICK does not appear to gain any.
4. Further tests show that the problem is that the 1 Hz interrupt is sometimes not reflected in the control register of PIA IC12. As to why this might be so, David is still investigating. In the meantime, he has developed a short "fix" to allow TOCK to be used in place of TICK; just use 03C1/2 in place of 03E2/3. The "fix" should be included in the initialization code of any program (remembering to set the address accordingly), just before the main loop. DISBUG will initialise TOCK in the same way as TICK, setting it to 0000 at power-up or restart.

Table 1. Software fix for the real time clock: setting up 'TOCK'. Include this code at the start of a user program which wants to use TOCK, which is located at 03C1/2, instead of TICK (which is located at 03E2/3).

LDX #ALTINT: LDX 03 03
JSR 0000: B6
JSR 0001: BD
JSR 0002: F8
JSR 0003: F8
JSR 0004: C1

If an addition to the IRQ interrupt handler is already made by the programmer, omit the first patch (since the program must already contain an equivalent), and add the first 3 instructions only of the last patch to the new interrupt handler. The reason is that only one additional handler may be defined.

LDX #ALTINT CE

STX IRQSRA FF 03

Include this code IN ADDITION to that above at any convenient position in RAM which is unused (suggestion is to locate it at location 03E0).

ALTINT: LDX TOCK FE 03 C1

INX 08
STX TOCK FF 03 C1

RTI 3B

Table 2. Real time clock test program

<table>
<thead>
<tr>
<th>Address</th>
<th>Label</th>
<th>Instruction</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>START</td>
<td>LDX #ALTINT</td>
<td>CE 03</td>
</tr>
<tr>
<td>0003</td>
<td>STX</td>
<td>IRQSRA</td>
<td>FF 03</td>
</tr>
<tr>
<td>0006</td>
<td>LDX #0000</td>
<td>CE 00</td>
<td></td>
</tr>
<tr>
<td>0009</td>
<td>STX T1</td>
<td>FF 03</td>
<td>E2</td>
</tr>
<tr>
<td>000C</td>
<td>STX TOCK</td>
<td>FF 03</td>
<td></td>
</tr>
<tr>
<td>000F</td>
<td>LDA #15</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>0011</td>
<td>JSR PROMPT</td>
<td>BD 08</td>
<td></td>
</tr>
<tr>
<td>0014</td>
<td>AGAIN:</td>
<td>LDX #ADDDIS</td>
<td>CE 03</td>
</tr>
<tr>
<td>0026</td>
<td>LDA A (TOCK + 1)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>0017</td>
<td>LDA A (TOCK + 1)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003F</td>
<td>JR T1</td>
<td>B6 07</td>
<td>F7</td>
</tr>
<tr>
<td>0029</td>
<td>LDA A (TOCK)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>0016</td>
<td>LDA A (TOCK + 1)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003A</td>
<td>LDA A (TOCK)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>002C</td>
<td>LDA A (TOCK + 1)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003B</td>
<td>LDA A (TOCK - 1)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003D</td>
<td>LDA A (TOCK)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003E</td>
<td>LDA A (TOCK)</td>
<td>B6 03</td>
<td></td>
</tr>
<tr>
<td>003F</td>
<td>LDA A (TOCK)</td>
<td>B6 03</td>
<td></td>
</tr>
</tbody>
</table>

This table shows the results of testing the real time clock.


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**COMBO**

As the electric guitar is the mainstay of the group, it ought to be dealt with before other instruments. Yamaha has introduced new instruments recently, many of them featuring 'through-neck' design: in this case the neck extends right through the body of the instrument to its heel, giving more uniform transmission of string vibration to the pick-up. The SG series and SF series have solid bodies with humbucking coils. The SC series use a single coil. SA series guitars are semi-acoustic with single coil/humbucking and have exceptional tonal ability. AE series are acoustic and provide that warm and intimate sound for contemporary jazz. Among these, the hard-rock musician would probably choose the SF series for its extensive distortion control and powerful Alnico-5 pick up magnets.

The new BB series of electric basses has been developed with the aid of leading players. They offer full, balanced response with plenty of punch and definition. A range of effectors that can be fitted in-line include phasing, chorus, flanger, octaver, distortion, tone booster, compressor, parametric EQ, limiter, noise gate and noise selector. When the intubed guitar controls are also taken into account, performers have ample scope for modifying waveforms from the pickup.

**KEYBOARDS**

Among Yamaha's pianos, one of the most interesting is Digital Keyboard GS1. This 88-key model looks like a small baby grand and features touch-responsiveness: up to 16 notes may be played simultaneously, 16 voices are available and it will read magnetic cards for voicing, vibrato may be applied and piano-type pedals control this, damper and tremolo are also featured. GS2 is a smaller, 73-key version with a similar specification.

Models CP-80 and CP-70B are 88 and 73-key acoustic pianos with amplification, the latter model being portable despite the metal frame carrying the strings. Both instruments allow the player to control timbre over three distinct parts of the keyboard compass, with variable tremolo depth and speed.

CP35 and CP25 are 73 and 61-key digital pianos with 16 note capacity in two pitches, decay, tremolo, flanger, filter and equaliser controls. The CP25 keyboard may be split, when each section then allows 8-note capacity.

A useful keyboard to use at home is the CP11. This is also digital (10 note polyphonic) but the keyboard can be split and 6 notes are then reserved for the chord section. Eight rhythm patterns are provided and these control the auto-accompaniment. The available tones are Piano 1, Piano 2 and Harpsichord. Sustain operates normally but the EG control allows decay only after the playing key has been released—producing organ-like tones. Tremolo is fitted and the instrument has an internal 5W speaker.

Yamaha's Symphonic Ensembles are best described as very comprehensive portable organs: they have one/two manuals with organ tone, solo synth, poly synth and string chorus etc. Optional 13 note pedalboards may be attached. This SK series is ideally suited to a skilled keyboard player in a group.

Synthesizers from Yamaha range from CS70K—a polyphonic programmable instrument with 61 keys and 12 VCOs—to the CS-5, a 3-octave monophonic keyboard with a single VCO.

**PRODUCER SERIES**

This idea from Yamaha should be very welcome to any neighbour of a practising pop enthusiast! The sound capabilities of stage and recording equipment have been compressed into a small and affordable system that can be used without disturbance to others. It is based on three units—M10, MM10 and MA10.

MA10 is a headphone amplifier which will drive two sets of MH10 stereo phones and has a Monitor Out facility to feed other MA10s or a power amplifier. The input jack accepts signals from guitar or keyboard and input connections can also be made through Monitor In and Aux.

MM10 is a stereo Mic/Line mixer, each of the four channels having individual pan pots and level controls. CS01 is a 2½-octave monophonic synthesiser with VCO, VCF, VCA and EG (Envelope Generator): a Breath Controller allows alteration of the VCO and VCF characteristics, leaving both hands free to use the keyboard and sliders. All three units run from mains adaptors providing 9—12 v.d.c. (Type PA-1).

By interconnecting these units, a group of instrumentalists/vocalists can hear the combined stereo output through headphones with total realism and clarity. Interconnections require some thought, though Yamaha can offer suggestions in this respect. The Producer Series should be a boon to practising musicians and neighbours alike as one word that appears to be synonymous with combo music is decibels!

**AMPLIFIERS**

These are comprehensive and fall into three categories. The JX series cover outputs from 20W to 50W into 8 . . . at 3% THD and have integral controls. G and B Mk II series handle from 50W to 100W into 8 . . . at 1% THD. Alternatively, stackable amplifiers can be supplied using G100il amplifier head or B10011 with one of the S Series speaker enclosures in conjunction: outputs up to 240W are available by this method. Different amplifiers are used for guitar and bass (indicated by codes G and B) because of the differences in tonal spectrum. New preamplifiers PG1 and PB1 (for bass) have recently been introduced.

Mixing consoles from Yamaha will accept up to 32 inputs, depending on the model concerned, with faders, equaliser, echo panpots and talkback. Analogue Delay Units E1010 and E1005, Graphic Equaliser Q1027, frequency Dividing Networks F1040 and F1030 are other items to interest groups. General speaker systems, individual drivers and horns are supplied for those that prefer to assemble to their own specification.

**PERCUSSION**

The company is well known for its orchestral instruments, including its System Drums. The YD-9000RA system includes two bass drums, snare drum, seven mounted toms, hi-hat and seven mounted cymbals of various sizes—surely enough for any

---

**Strictly**

by K. Lenton-Smith

**GLENN MILLER**

Students of light music will be familiar with the problem that faced Glenn Miller 45 years ago. He was searching for a particular sound that would set his band apart from others—and inadvertently found his answer through a mishap to his lead trumpet. The player concerned had split his lip and the trumpet part had to be taken by the clarinet (both instruments being pitched in Bb, the same music could be used).

In fact, Miller re-arranged his parts to suit this event and the resulting blend of soli saxes and clarinet produced a sound unmistakable today.

I feel sure that modern combo groups have that same problem—how to sound different from the rest. In the Miller era, pure musicianship was the only method: if the main supply failed, only the announcer's microphone was affected. Today, complete failure of the electronics would mean the instrument has fallen as a direct result. Combo groups look carefully at the equipment they buy and how to make the most of it. In this article we will look at what the world's largest manufacturer, Yamaha, has to offer.

---

Practical Electronics August 1983
INMOS

Sir—Re the little note about INMOS in the April Industry Notebook.

Some of the things that Nexus says about INMOS may very well be true but don't forget that the company was messed around by the present government for political reasons. They were forced to set up their factory in a place they didn't want and their second investment payment of some £50 million was delayed for several months whilst the government tried to wriggle out of the original contract.

In fact the original INMOS investment was made by the NEB and any loss to the taxpayer must be taken from the NEB books and not INMOS. Your view—sorry the view of Nexus that if a product is worthwhile then private capital will automatically be attracted to it is naive. How does he explain the problem Ferranti had when they wanted money for their ULA project. Not one merchant bank would look at them. In the end they went to the NEB and asked Tony Benn for £7 million. Obviously the NEB could smell success better.

In fact the original INMOS investment was made by the NEB and any loss to the taxpayer must be taken from the NEB books and not INMOS. Your view—sorry the view of Nexus that if a product is worthwhile then private capital will automatically be attracted to it is naive. How does he explain the problem Ferranti had when they wanted money for their ULA project. Not one merchant bank would look at them. In the end they went to the NEB and asked Tony Benn for £7 million. Obviously the NEB could smell success better than the banks. Later Thatcher sold those Ferranti shares on the open market for £54 million to the very people who refused the original investment. Could we possibly offset the losses that INMOS are making with the profits made on the Ferranti deal? Nexus should be criticising the government for killing off the NEB when it was doing a good job helping small business men (and large), creating jobs and making a profit as well. Does Nexus imagine that the Japanese stand back and let private enterprise do everything—their government hands out plenty of money for their banks to invest in industrial research and development—and where would the American electronics industry be without those big defence contracts?

And anyway what is £100 million? It represents just 4 or 5 weeks subsidy to the EEC agricultural fund for food that could be bought cheaper on the world market and is either destroyed or sold off cheaply to the Russians. Or it represents 3 months for the defence of those barren rocks in the South Atlantic, and that after an initial investment of some £2000 million.

The remarks about C&W were equally silly. C&W were making handsome profits during the whole time they were owned by the taxpayer. Selling them off was a political not economic decision.

Please keep us informed about what is happening in the industrial world with a more balanced view of the political and economic problems that have to be faced by governments and industries.

If any of the statements I have made in this letter are inaccurate then it is partly your fault for not keeping me better informed. I do not wish to offend but if I need puerile political views then I would subscribe to the Telegraph or the Mail—they do it so much better than your magazine.

John Hunt
UNDP
Rangoon
Burma.

Nexus comments:-

Inmos cannot be compared directly with Ferranti. The respective investments were different in kind, in quantity, in time and made for quite different reasons. It remains true that a worthwhile product or service attracts private capital. Indeed, as Mr Hunt points out, Ferranti had no difficulty in attracting £54 million once it became worthwhile. Similarly, Cable & Wireless, modestly profitable, was heavily oversubscribed when brought to the market. C&W's performance and profit can only now be fairly described as 'handsome'. The problem, as I am sure Mr Hunt would agree, is spotting the winners and although he may think £100 million is peanuts, by ordinary investment standards it is a large gamble on an outsider only just beginning, after four years, to show any form. The NEB's betting record has been no better than the average punter.

POSITIVE FEEDBACK

Sir—In response to your recent encouragement to readers to provide some feedback I am putting pen to paper.

I have subscribed regularly to your magazine for many years, am aged 32 and my interest in electronics is through hobby only. I often buy the odd issue of your competitors' magazines to see what's available and find I prefer your magazine for the following reasons:

The projects are presented clearly, are detailed and complete.

The content on the whole is what I want.

The style avoids the chatty slightly flip-flop style evident in at least one competitor.

Now some criticisms:-

Why terminate "Semiconductor Update", I certainly appreciated the feature.

I'm afraid this new feature 'Vernon Trent' just leaves me cold. I buy your magazine for information, not the sort of article common in the daily press.

My PE Micro-controller does not keep good time. The internal clock in the monitor loses approximately 1 second every 300 seconds or so. Is the crystal at fault or is there a bug in the monitor? I know I can allow for this in my own software but I may be short of space for this. I enclose s.a.e.

Colin A. Kerr
Edinburgh.

Thank you for all your comments; we are always pleased to receive them. The only other comments we have had regarding VT have been in favour—more views welcome! Regarding Semiconductor Update this was replaced by Semiconductor Circuits, which not only introduces a new chip each month but provides data plus a working circuit and layout. We have also added Silicon News Corner to News and Market Place, thus providing information on a range of new chips as they are announced. Our intention was to cover this area more fully and show how to use the chips that are now available.

Your query on the Micro-controller is answered in Microprompt.
TRANSMISOR ANALYSER

This unit was designed and built to help with the sorting out of large bags of untested transistors. It indicates whether the transistor under test is:

1) Functional/non-functional
2) npn/pnp
3) Germanium/silicon.

IC1 and associated components form a conventional astable multivibrator, the output of which drives the collector and base (through R4) of TR1, the transistor under test, alternately positive and negative with respect to ground. If the transistor is of the npn type, negative pulses will drive it into conduction so lighting indicator D1; if it is npn D2 will be lit (a faulty transistor will either light both lights or neither).

Simultaneously, the base voltage of the transistor (which will be varying between ground and Vbe) is fed to window detector IC2/3 and associated components, which gives a high output in the range ±4V. A high output will light D8 indicating a germanium transistor whilst a low output will light D7 indicating a silicon transistor.

D3-D6 can be any medium power diodes whilst the output is more legible if different colour diodes are used for D1 and D2, and for D3 and D4.

S. D. Draper,
Sudbrooke,
Lincoln.

ELECTRONIC DIE

This circuit is for an electronic die. When the 'spin' button (S1) is pressed then released the l.e.d. display shows a random number between 1 and 6, arranged in the standard die format.

The 555 (IC1) is in the astable mode running at 1kHz. When S1 is pressed pulses are fed into the 4017 (IC2) decade counter, this sends a pulse out of each of the nine outputs in turn. The sixth pin is connected to the reset pin (15) so that it counts up to 6 then resets. When S1 is released the counter will stop at one output and current will flow through the OR gates of the 4075 (IC3) and light up the l.e.d.s at a number between 1 and 6. While S1 is depressed all the l.e.d.s will appear to light up at once as the unit flashes through its cycle.

Stephen Ives,
Burnham-on-Crouch,
Essex.
CAR
LIGHTS-ON
WARNING

The circuit in Fig. 1 has been fitted to the author's car for over a year and works well. It is an audible alarm which sounds when the door is opened with the lights on. An extra feature of this simple design is a time limit so that the alarm does not continue to sound if the door is left open with the lights on. This could be the case at a petrol station or when dropping off a passenger.

The alarm needs only two connections to the car electrics (Fig. 2). The first is to the feed for the panel lights and the second is to the wire which runs from the door courtesy-light switch to the light itself. The whole circuit, including the speaker, was mounted on Veroboard behind the dashboard.

The key to the design is D1. This detects the closure of the necessary switches and feeds current to the alarm. The alarm itself is an NE555 timer i.e. connected as an astable oscillator, running at audio frequency. The output from this component is sufficient to directly drive the speaker.

The time limit is provided by the combination of C1 and R4, connected to the reset pin of the timer. When the alarm initially sounds, C1 is discharged and gates the timer into oscillation. As C1 charges, the voltage at pin 4 becomes more negative and eventually turns off the sound. In fact, the result is not an abruptly ending tone, owing to a feature of the internal design of the NE555. The pitch of the oscillation is low for about three seconds, then quite high for three seconds—before it stops.

D. J. Greaves, Cambridge.

MICRO
MULTIPLEXED
DISPLAY

The circuit shown (Fig. 1) is driven from a 6802 evaluation unit and can operate up to eighteen displays although only six are used in this application.

HARDWARE: The hex display requires four data lines, therefore the 8 bits on the PIA output lines (P80–P87) can supply data to two displays at any instance.

The PIA CB2 port is programmed to produce a strobe pulse on each 'write' operation and this is used via the 7493 and 7442 to generate three 'blanking' signals in sequence which multiplex two displays per occasion.

Decimal 3 output from the 7442 is used to reset the 7493 following generation of the blanking pulses.

Before transmitting data to the display, it is necessary to ensure that the 7493 is in the 'ready' position. This is achieved by means of the 74LS132 (IC9). When the reset switch (S1) is depressed then the oscillator formed by IC9 is enabled via TR2 and the 7493 is clocked until output 3 (Pin 4) on the 7442 is low. The reset circuit 'locks up' at this point and the 'ready' i.e.d. is energised via TR1. The display is now ready to accept data from the 6802.

SOFTWARE: The 6821 PIA is initiated with 'B' side as outputs and CB2 producing a strobe pulse on each write operation. Address 0030 is used as a scan counter and is loaded with 04 (pin ). The first data byte is obtained from address 0040 and after sending to the display, the next byte is read from 004 etc. When three bytes have been transmitted to the display the programme jumps back to re-load the scan counter, and thus the cycle is repeated. As mentioned earlier, it is possible to expand the system to cater for 18...
displays this being limited only by the 0-9 outputs on the 7442 i.c. Also, further development work is possible on the 'reset' circuitry along the lines of a software solution.

R.G. Caldwell,
N. Ireland.

Fig. 1

ROGER 'BLEEP' BLEEP'

Unlike most published designs which only bleep at the end of transmission, this design bleeps both at the beginning and the end of transmission.

When the push to talk button (PTT) is pressed, flip-flop one (IC1a and b) controls bleep one via D1 and R3. Flip-flop two (IC1c and d) controls bleep two via D2 and R3 when the button is released.

The 555 tone generator (IC2) is switched on and off by pin 4 through TR1. D5, C4 and R5 control the carrier delay via Darlington transistors TR2, TR3 and the relay (RLA1). The length of each bleep and carrier delay can be adjusted by altering the value of the electrolytics C2, C3 and C4.

A single bleep only at the end of transmission can be achieved by omitting D1, and the tone can be varied by altering the value of R6.

J. L. Colwill,
North Devon.
**STEAM WHISTLE**

This circuit produces a sound similar to that of a steam locomotive whistle. TR1 and TR2 form a multivibrator, the frequency of which is set by VR3. This is the "toot" part of the whistle. TR4 amplifies white noise generated across the reverse biased transistor TR3. White noise and "toot" are mixed by IC1, the ratio of each being set by VR2. The output from IC1 is fed to a simple amplifier based around the TBA 810 device.

Positive 12V could be fed to the circuit by a push switch near the controller or by the model train itself by means of reeds or microswitch devices.

David John, Alvaston, Derby.

**NI-CAD BATTERY CHARGER**

The circuit shown is for a constant current Ni-Cad battery charger. It features a timed charge rate followed by a trickle charge for an indefinite period. At switch on the output of the ZN 1034 timer goes low bringing on the relay. This in turn passes a constant current from a 7805 voltage regulator to charge the batteries. After a delay of up to 12 hours, as set by the potentiometer, the output goes high switching off the relay. The cells now pass only the quiescent current of the circuit which is approximately 12 mA.

Up to six cells may be charged in series and an I.E.D is included to indicate when the batteries are on full charge.

P. Thompson, Glasgow.

**HIGH Z INPUT FOR VOLTOMETER**

The op amp is connected as a unity-gain voltage follower. The voltage to be measured is applied between the non-inverting terminal and 0V. In this mode the input impedance can be very high—many tens of megohms maybe—but the output of the op amp is of very low impedance and will easily drive an ordinary meter. The nulling preset should be adjusted so that, with the input shorted, there is exactly nil voltage between output and the 0V line, as measured with the most sensitive range of a meter. The current drawn from the supply is minimal, and if two little 9V batteries are used, voltages up to about 8V may be measured. If only one battery is used, the junction between two 1k resistors across the supply will provide the 0V point, allowing measurement of voltages up to about 4.5V. To avoid any interference or hum pick-up, the input must be screened to 0V, and the whole ought to be in a metal case grounded to 0V.

Make input and output connections before switching power on; if pin 3 is left floating pin 6 will quickly drift into saturation and perhaps damage the sensitive range of a good meter.

S. A. R. Guest, Truro.
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### MEMORIES

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### INTERFACE

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### OPTOELECTRONICS

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<tr>
<td>12V 100mA</td>
<td>1500p</td>
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- Search Filter
- Damp Meter
- Four Simple Projects.

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- D/X5R Audio Processor
- Sweep Oscillator
- CMOS Crystal Calibrator

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- Over 26W/channel into 8Ω at 1kHz both channels driven.
- Frequency response 20Hz to 40kHz ±1dB
- Low distortion, low noise and high reliability power MOSFET output stage.
- Extraordinarily easy to build. Almost everything fits on main pc board, cutting interwiring to just 7 wires (plus toroidal transformer and mains lead terminations).
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