Low-price robots from POWERTRAN

- hydraulically powered
- microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry. With prices from as low as £425, even the home enthusiast can aspire to his or her own robot.

Each robot in the Genesis' range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to 6 independent axes are capable of simultaneous operation with positional control being provided by means of a closed-loop feedback system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.

The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing.

All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project.

For under £100, Helbot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors coupled to its shell return data about its environment to the computer enabling evasive or exploratory action to be calculated.

The robot connects directly to an I/O port or, via the interface board, to the expansion bus of a ZX81 or other microcomputer.

HEBOT II
Weight 1.8kg complete kit with assembly instructions. £85
Interface board kit £10

MICROGRASP
A real programmable robot for under £200! Micrograsp has an articulated arm, jointed at shoulder, elbow and wrist positions. The entire arm revolves about its base and there is a motor driven gripper. All five axes are motor driven and serve controlled, giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP
Weight 8.7kg, lifting capacity 100g Universal computer interface board kit £48.50
Robot kit with power supply £145.00
23 way edge connector £2.50
AX81 peripheral/RAM pack £3.00

GENESIS S101
Weight 2.0kg, lifting capacity 5kg
5-axis model (kit form) £475
5-axis complete system £737
5-axis complete system (ready built) £1,450

GENESIS P101
Weight 3.4kg, lifting capacity 2kg
6-axis model (kit form) £675
6-axis complete system (kit form) £945
6-axis complete system (ready built) £1,650

GENESIS P102
Weight 3.6kg, lifting capacity 2kg
6-axis system (kit form) £1,175.00
6-axis system (ready built) £1,950.00
Powertran Cortex microcomputer self-assembly kit £295.00
ready-built £395.00
CONSTRUCTIONAL PROJECTS

RELAXOMETER by Ralph Lovelock
Learn to relax with this visual feedback aid ................................. 18

LOGIC TUTOR by M. Tooley BA and D. Whitfield MA MSc CEng MIEE
'Breadboarding' system for our new series ................................. 26

DIGITAL PANEL METER
Featuring the ICL7219 this module can be the heart of a sophisticated auto ranging multimeter ................................. 34

LOGIC ANALYSER Part 3 by D. Mandelzweig MSc Eng
Readout options: Scope, hex display or both? ................................. 52

EXPANDING THE VIC 20 by Sam Withey
First of a series incorporating RAM, ROM, Robotics I/O and DAC/ADC boards ................................. 64

GENERAL FEATURES

VERNON TRENT AT LARGE .................................................. 33

SEMICONDUCTOR CIRCUITS by Tom Gaskell BA(Hons)
Overvoltage protector (MC 3423) .............................................. 39

INTRODUCTION TO DIGITAL ELECTRONICS M. Tooley BA and D. Whitfield MA MSc CEng MIEE
The start of our O and A level course ........................................ 42

ELECTRONICS IN PHOTOGRAPHY by Clifford Stokes AIIP, ARPS, FRSA
Printing processes explained .................................................... 60

NEWS AND COMMENT

EDITORIAL .............................................................................. 15

NEWS AND MARKET PLACE
The latest news and products ...................................................... 16

BAZAAR .............................................................................. 22, 38, 41
Free readers' advertisements

INDUSTRY NOTEBOOK by Nexus .............................................. 25
News and views on the electronic industry

NEW SYMBOLS ..................................................................... 41
Our logic explained

SPACEWATCH by Frank W. Hyde .............................................. 51
Extra-terrestrial activities chronicled

ELECTRONIC HOBBIES FAIR ............................................. 59

SPECIAL OFFER—CASSETTES ............................................. 63

SPECIAL SUPPLEMENT

MICRO-FILE by R. W. Coles .................................................. 71
Filesheet 11 8748

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, OCTOBER 7th, 1983
(for details of contents see page 11/6 Micro-file)

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OPTO

LEDs including Opts

TL208 Red 3mm

TL216 Green 5mm

TL209 Yellow 3mm

5V 780 40p 70Kp

12V 780 40p 70Kp

24V 780 40p 70Kp

V 780 40p 70Kp

B SERIES

BTL08 5mm

BTL09 3mm

BTL09 5mm

BTL09 3mm

V 780 40p 70Kp

B SERIES

BTL10 5mm

BTL11 3mm

BTL11 5mm

BTL11 3mm

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

B SERIES

BTL12 5mm

BTL13 3mm

BTL13 5mm

BTL13 3mm

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

B SERIES

BTL14 5mm

BTL15 3mm

BTL15 5mm

BTL15 3mm

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

V 780 40p 70Kp

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V 780 40p 70Kp
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 TV 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.

PRACTICAL ELECTRONICS

STEREO CASSETTE RECORDER KIT COMPLETE WITH CASE

ONLY £31.00 plus £2.75 p&p.

- NOISE REDUCTION SYSTEM
- AUTO STOP
- TAPE COUNTER
- SWITCHABLE E.Q.
- INDEPENDENT LEVEL CONTROLS
- TWIN V.U. METER
- WOW & FLUTTER 0.1%
- RECORD/REPLAY I.C. WITH ELECTRONIC SWITCHING
- FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES

Kit includes tape transport mechanism, ready punched and backed with printed quality circuit board and all electronic parts. It can be used in conjunction with your video recorder. Dimensions: 11 1/8" x 8 3/4". (£1.50 postage and packing).

STEREO CASSETTE DECK

Stereo cassette tape deck transport with electronics. Manufacturer’s surplus—brand new and operational—sold without warranty.

£119.55 plus £5.25 p&p.

Just requires mains transformer and output sockets and a volume control to complete. Supplied with full connection details.

125W HIGH POWER AMP MODULES

The power amp kit is a module for high power applications—disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe to use in open circuit conditions. A low safety margin exists by use of generously rated components, resulting in a high powered rugged unit. The PCB board is back printed, armed and ready to drill for ease of construction and alignment. A large safety margin exists by use of generously rated components, resulting in a high powered rugged unit.

SPECIFICATIONS:

Max. output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loads: 4 - 16 ohm. Frequency response measured @ 50 watts: 25 Hz - 20 kHz. Sensitivity for 100 watts 100 mV. Dimensions: 205x90 and 190x36mm.

£10.50 plus £2.50 p&p.

For despatch. R.T.C. Limited reserve the right to discontinue this kit without notice. VAT is not included and will be added to all mail orders. R.T.C. reserves the right to alter design. 

AUDAX 8"

HIGH QUALITY 40 WATTS RMS BASE/MIDRANGE

Ideal for either Hi-Fi or Disco use this speaker features an aluminium voice coil a heavy 70mm diameter magnet. Frequency range: 20Hz - 20kHz. Impedance: 8 ohm. Dimensions: 8" x 4 1/2" x 3 1/2". £5.50 plus £1.50 p&p.

£8.95 + £2.00 Postage.

£24.95 + £2.00 Postage.

STEREO TUNER KIT

This easy to build 3 band stereo AM/FM tuner is designed in conjunction with the Ministry of Defence. For ease of construction and alignment incorporates three throuhh module and an I.C. F.M. System.

FEATURES: VHF, V.M., L.H Bands, interstation muting and AFC on V.F.M. Tuning meter. Two back printed PCB’s. Ready made chassis and case. Aerial: AM- 300 ohms. FM- 300 ohms. Stabilised power supply with ‘C’ fuse mains transformer. All components supplied are to P.E. strict specification. Front scale is 10/"0.3”/MV approx. Complete with diagram and instructions.


STEREO CASSETTE DECK

Stereo cassette tape deck transport with electronics. Manufacturer’s surplus—brand new and operational—sold without warranty.

£119.55 plus £5.25 p&p.

Just requires mains transformer and output sockets and a volume control to complete. Supplied with full connection details.

SPEAKER BARGAINS

2 WAY 10 WATT SPEAKER KIT


£8.95 + £2.00 Postage.

ALL CALLERS TO: 323 EDGWARE ROAD, LONDON W2. Telephone: 01-723 8322. 9 minutes walk from Edgware Road Tube Station. Now open 6 days a week 9 - 6. Prices include VAT.
**AT-80**

**Electronic Car Security System**
- Arms doors, boot, bonnet and has security loop to protect fog/spot lamps, radio/tape, CB equipment
- Programmable personal code entry system
- Armed and disarmed from outside vehicle using a special magnetic key fob against a windsheen sensor pad adhered to the inside of the screen
- Fits all 12V neg earth vehicles
- Over 250 components to assemble

**SX1000**

**Electronic Ignition**
- Inductive Discharge
- Extended coil energy storage circuit
- Contact breaker driven
- Three position changeover switch
- Over 65 components to assemble
- Patented clip-to-coil fitting
- Fits all 12V neg earth vehicles

**SX2000**

**Electronic Ignition**
- The brand leading system on the market today
- Unique Reactive Discharge
- Combined Inductive and Capacitive Discharge
- Contact breaker driven
- Three position changeover switch
- Over 130 components to assemble
- Patented clip-to-coil fitting
- Fits all 12V neg earth vehicles

**TX1002**

**Electronic Ignition**
- Contactless or contact triggered
- Extended coil energy storage circuit
- Inductive Discharge
- Three position changeover switch
- Distributor triggerhead adaptors included
- Die cast weatherproof case
- Clip-to-coil or remote mounting facility
- Fits majority of 4 and 6 cyl. 12V neg. earth vehicles
- Over 145 components to assemble

**TX2002**

**Electronic Ignition**
- The ultimate system
- Switchable contactless
- Three position switch with Auxiliary back-up inductive circuit
- Reactive Discharge
- Combined capacitive and inductive
- Extended coil energy storage circuit
- Magnetic contactless distributor trigger head
- Distributor triggerhead adaptors included
- Can also be triggered by existing contact breakers
- Die cast waterproof case with clip-to-coil fitting
- Fits majority of 4 and 6 cylinder 12V neg. earth vehicles
- Over 150 components to assemble

SPARKRITE products and designs are fully covered by one or more World Patents.

**SPECIAL OFFER**

"FREE" MAGIDICE KIT WITH ALL ORDERS OVER £4500

**MAGIDICE Electronic Dice**
- Roll an electric but quiet fun dice
- Total random selection
- Triggered by waving of hand
- Bingles and flashes during a 4 second tumble sequence
- Photon emitted for 10 seconds
- Auto display of last throw 3 seconds in 5
- Swimming and ON switch on base
- Directly from the plug-in non battery
- Over 100 components to assemble

SPARKRITE 82 Bath Street, Walsall, W. Midlands WS1 30E England.

<table>
<thead>
<tr>
<th></th>
<th>Kit Ref.</th>
<th>Name</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

NAME

ADDRESS

ENCLOSE CHEQUE(S)/POSTAL ORDERS FOR

KIT REF

CHEQUE NO

PHONE YOUR ORDER WITH

SEND ONLY SAE IF BROCHURE IS REQUIRED

Prices incl. VAT, postage & packing

PE 10.83

CUT OUT THE COUPON NOW!
Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc. I LP are one of the few 'All British' electronics companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries — including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I. L. Potts — Chairman

WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with I LP'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 I LP are recognised as world leaders.

BIPOLAR MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power Watts</th>
<th>Load Impedance</th>
<th>I.M.D. 1% 1KHz</th>
<th>Supply Voltage</th>
<th>Size mm</th>
<th>WT grams</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY60</td>
<td>16</td>
<td>4.8</td>
<td>0.01% &lt;0.005%</td>
<td>T.H.D. 1% 60Hz</td>
<td>15</td>
<td>78 x 40</td>
<td>£8.10</td>
</tr>
<tr>
<td>HY61</td>
<td>30</td>
<td>4.8</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>HY610</td>
<td>30</td>
<td>4.8</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>HY124</td>
<td>60</td>
<td>4</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>HY128</td>
<td>60</td>
<td>4</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>HY246</td>
<td>120</td>
<td>8</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>HY266</td>
<td>180</td>
<td>8</td>
<td>0.01% &lt;0.004%</td>
<td>T.H.D. 1% 60Hz</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
</tbody>
</table>

Most amplifiers modules can be driven by the PSU driving the main power amp. A separate PSU is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations.

Mounting Boards

For ease of construction we recommend for PSU modules HY6 - HY12 £1.05 (inc. VAT) and for the HY6 for modules HY6 - HY78 £1.29 (inc. VAT)

POWER SUPPLY UNITS (incorporating our own spiral transformer)

<table>
<thead>
<tr>
<th>Model Number</th>
<th>For Use With</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU 2x1</td>
<td>1 or 2 HY30</td>
<td>£11.93</td>
</tr>
<tr>
<td>PSU 4x1</td>
<td>1 or 2 HY30</td>
<td>£11.93</td>
</tr>
<tr>
<td>PSU 4x2</td>
<td>1 or HY12/16</td>
<td>£11.93</td>
</tr>
<tr>
<td>PSU 5x1</td>
<td>1 or HY12/16</td>
<td>£11.93</td>
</tr>
<tr>
<td>PSU 5x1</td>
<td>1 or HY244</td>
<td>£11.93</td>
</tr>
</tbody>
</table>

MOSFET MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power Watts</th>
<th>Load Impedance</th>
<th>I.M.D. 1% 1KHz</th>
<th>Supply Voltage</th>
<th>Size mm</th>
<th>WT grams</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS 128</td>
<td>60</td>
<td>4</td>
<td>&lt;0.005% &lt;0.006%</td>
<td>10% 15% 50%</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>MOS 246</td>
<td>120</td>
<td>8</td>
<td>&lt;0.005% &lt;0.006%</td>
<td>10% 15% 50%</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
<tr>
<td>MOS 526</td>
<td>180</td>
<td>8</td>
<td>&lt;0.005% &lt;0.006%</td>
<td>10% 15% 50%</td>
<td>10</td>
<td>78 x 40</td>
<td>£11.50</td>
</tr>
</tbody>
</table>

Protection: Full load time. Slow Rate. 150V. Rater res. S/N ratio: 50dB.
Frequency response 1-300KHz, input sensitivity 500mV rms.
Input impedance: 100K ohm. Damping factor: 100Hz - 4KHz.

'NEW' to I LP In Car Entertainments

C15 Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction.

Mounts anywhere in car.

Automatic switch on.

Output power maximum 220v peak into 4 ohms.

Frequency response 1-300KHz. Input sensitivity: 500mV rms.

Input impedance: 100K ohms.

'NEW to I LP' In Car Entertainments: C15

Stereo version of C15

Size 95 x 40 x 80. Weight 206 grams.

Price £17.19 (inc. VAT)

Practical Electronics October 1983
TТОRIOIOAls

The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., price. Our large standard range is complemented by our SPECIAL weight, lower radiated field and, thanks to I.L.P., price. Industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thanks to I.L.P., price.

**NEW PRODUCTS**

**HR614**
- Any 12 volt d.c. equipment required for many hobby or professional applications.
- Heat sink and are fully short circuit protected making them suitable for home or bench running of CB, car stereos or any 12 volt d.c. equipment required for many hobby or professional applications.

**TECHNICAL SPECIFICATIONS**

**MODULE**

<table>
<thead>
<tr>
<th>Type</th>
<th>Series Secondary</th>
<th>Rms Current</th>
<th>Price</th>
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<tbody>
<tr>
<td>HR314</td>
<td>15.10</td>
<td>4.00</td>
<td>£5.12</td>
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<tr>
<td>HR614</td>
<td>25.20</td>
<td>4.00</td>
<td>£7.42</td>
</tr>
<tr>
<td>300 VA</td>
<td>40.20</td>
<td>4.00</td>
<td>£10.88</td>
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**TECHNICAL SPECIFICATIONS**

**MODULE**

<table>
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<tr>
<th>Type</th>
<th>Series Secondary</th>
<th>Rms Current</th>
<th>Price</th>
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<td>25.20</td>
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</tr>
<tr>
<td>300 VA</td>
<td>40.20</td>
<td>4.00</td>
<td>£10.88</td>
</tr>
</tbody>
</table>

**IMPORTANT Regulation - Full load is quoted as FULL LOAD Please add regulation figure to secondary equivalent and are available with 110V, 220V or 240V primaries coded as follows:**

<table>
<thead>
<tr>
<th>PRIMARY VOLTAGE</th>
<th>SECONDARY VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>110V</td>
<td>220V</td>
</tr>
<tr>
<td>220V</td>
<td>240V</td>
</tr>
</tbody>
</table>

**Orders despatched within 7 days of receipt for single or small quantity orders.**

**21 days manufacture for urgent deliveries.**

**#5 year no quibble guarantee.**

**For 110V primary insert U in place of X in type number**

**For 220V primary European insert I in place of X in type number**

**For 240V primary UK insert 2 in place of X in type number.**

**Also available at Electrovalue, Maplin.**

**For mail order please make your crossed cheques or postal orders payable to ILP Electronics Ltd. Barclaycard/Access welcome. Trade orders standard terms.**
Try the new prototyping method of building and testing circuits with the British-made Verobloc kit. It consists of:

1. Verobloc. 2. A pad of design sheets for planning the circuits. 3. A component mounting panel for the larger components, i.e. switches, etc.

You can expand the circuit area by simply interlocking two or more Veroblocs and, of course, with normal usage, they can be used time and time again without damaging contacts or component leads. The glass nylon material is virtually unbreakable and able to withstand temperatures from -60°C to +120°C.

So take advantage of our special price of £5 per kit (including VAT) by completing the coupon below, or telephone 04215 62829 (24 hours). This offer closes December 31st, 1983.

We are exhibiting at the following exhibition, so why not come along and see the products for yourself.

- Personal Computer World, The Barbican, September 28-October 2. Stand No. 159.

Our new catalogue containing over 150 new products is available from mid-October.
**HOME LIGHTING KITS**

Three kits that are designed to HS & DSA regulations. Full instructions & data & designed to replace a standard wall light. 50W replacement.

**T6500** Remote Control £14.30 50W Capacity: 50W

**MRL** Transmitter for above £4.20 30W Capacity: 30W

**TS5000** Touchdimmer £7.00 15W Capacity: 15W

**T6500** Extender for 3 kits £2.50 15W Capacity: 30W

**L0500** Rotary Dimmer £3.50 15W Capacity: 30W

---

**ELECTRONIC LOCK KIT XK101**

This kit contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to complete a lock. As with all kits, key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-printed plug. Size: 7 x 6 x 3cms Supply 5V to 15V d.c. at 450mA Output: 700mA max

---

**COMPONENTS**

A wide range of components is available in our range of kits and accessories. To find out more, call or visit our website.

---

**NEW!**

OPEN-SESAME

The X113 is a general purpose infra-red transmitter. Incorporating a sensitive infrared detector and two infrared transmitter outputs. Designed primarily for controlling movement photocells and two auxiliary outputs for drive garage lights at a range of up to 200 ft. The unit also has numerous applications in the home for switching lights. To clothing ewaters, etc. Ideal for aged or disabled use.

Order as XK102 £15.50

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**MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER**

Now you can run your central heating, lighting, etc. system and timer. The program is designed to control four mains outputs independently, switching on and off at pre-set times over a 7-day period, e.g. to control your central heating (including different switching times for weekends). Next connects to your programmable timer and a buffer input for the buffer to complete your timer system and use and run in.

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Rechargeable and mains powered unit. Includes tunnel connector, contact lens for universal plugs and 9V battery. Size: 7 x 3 x 5cms .

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**DISCO LIGHTING KITS**

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This value for money kit features a 4-way 3amp channel. Easy to assemble and easy to use lighting system for the home. Includes 4-way line driver, 4 fibre optics, 10 fibre connectors, 4 polyester diffuser caps, 4 fibre optic diffusers, 4 fibre optic size: 7 x 5 x 5cms.

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**HOME CONTROL CENTRE**

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**COMPONENTS**

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**HOME ELECTRONICS**

High-quality components for all your needs. A wide range of electronic products is available, including computers, microprocessors, memories, and other electronic components.

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**ELECTRONIC LOCK KIT XK101**

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**DIGITAL ULTRASONIC DETECTOR**

**US 5063**

- 3 levels of discrimination against false alarms
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- Adjustable range up to 30ft
- Built-in delay
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This ultrasonic module uses digital signal processing to provide the highest level of clarity for those who experience potential false alarm conditions. The module has an audible and visual alarm lamp, with a selectable entrance delay, plus many more outstanding features. This advanced new module is available at only £13.95 + V.A.T.

**ULTRASONIC MODULE**

**US 4012**

- Adjustable range from 6 to 25ft.
- This popular low cost digital ultrasonic module is already used in a wide range of applications, horn outstanding features

This module provides the highest level of clarity for those who experience potential false alarm conditions. The module has an audible and visual alarm lamp. The unit is supplied with the necessary mounting pillars and screws etc. Ultrasonic module type US 4012 of US 4011 only £17.59 + VAT.

**ALARM CONTROL UNIT**

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The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation, or simply consulting a single magnetic switch on the front door.

- Built-in electronic switches 2 double speakers
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- Suitable for large areas of glass-charging facility
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- Anti-tamper and panic facility
- Standardised voltage output
- 2 operating modes - all alarm anti-tamper and panic facility
- Screw connections for easy installation
- Provides stabilised 12V output at 85mA arid PS 4012

This attractive case is designed to house the unit. For ease of setting up, the unit is supplied with the necessary mounting pillars and screws etc. ULTRASONIC MODULE type US 4012 of US 4011 only £17.59 + VAT.

**SIREN & POWER SUPPLY MODULE**

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A compact, high quality one power supply module which is capable of providing sound levels of 110dB's at 2 metres when used with a horn speaker. In addition, this module has a stable 12V output voltage 10.4V. A switch present in the power supply module to the unit is used in conjunction with the US 4012 to form a complete alarm system.

**POWER SUPPLY & RELAY UNIT**

**PS 4012**

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NEW STYLE

FOR some time the editorial staff of *PE* have been discussing the pros and cons of our logic circuit symbols. The symbols were based on BS3939 of 1969 and were accepted practice for many years. While we are aware that for some time our symbols have not conformed to any of the various “standards” (BS having been revised many years ago), we have been reluctant to change until one system of identification became accepted. Our main problem being that we neither liked nor found many working examples of the later BS specification symbols.

Early this year when our *Introduction to Digital Electronics* series was being planned, it became obvious that if this series was to be readily accepted in education and of maximum benefit to hobbyists and students alike, the symbols used should conform to those generally accepted. Further investigation led to further confusion as the systems used in many schools and colleges and recommended by some examining boards do not conform to any other standard.

What we have found is virtual universal acceptance of the so called American Mil. Spec. for logic symbols in industry, and that this system is used in many educational establishments. This standard is also now used by virtually every other electronics publication.

It does seem rather silly that some UK educational establishments and examining boards use a system that is individual but then so did *PE* until now. No doubt they have suffered from the same problems as us.

From now on *PE* will use what is known as the Mil. Spec. standard for logic symbols. However, trying to get hold of a “Mil. Spec.” proved difficult but, aided by the local library, we discovered the correct title is ANSI Y32 14–1973/IEEE Std 91–1973, the letters representing American National Standards Institute and The Institute of Electrical and Electronics Engineers. This standard is a revision of ANSI/IEEE of 1962 and MIL-STD-806B, MIL-STD-00806C (Ships) hence the Mil. Spec. title.

Both the ANSI/IEEE and BS documents refer to IEC (International Electrotechnical Commission) Publication 117-15, BS, claiming their symbols are identical to IEC and ANSI saying theirs are “substantially compatible”. Investigation reveals that the American Standard gives two alternative symbols, one is a box which is virtually the same as IEC and BS, while the other is called the Distinctive-Shape Symbol and this is the one that has become universally adopted. So what is in use is probably not what was intended by IEC but it does seem to be easier to follow on a circuit diagram and more logical!

The industry has shown that it will not adhere to a system just because it is set as a standard, it also has to be representative of the needs of the users. Perhaps IEC and BS should now amend their symbols and fall in line with the users!

Comparisons of the old and new *PE* styles are shown elsewhere in this issue and Part 2 of *Introduction to Digital Electronics* will show comparisons of the Mil. Spec. “distinctive shapes” with BS boxes.
New Computer Range

The latest home computer to enter the micro market is the MTX 500 from Memotech. The standard machine will have 32K of user RAM with a further 16K dedicated to video RAM. Also to be launched is a 64K user RAM version—the MTX 512. They will cost £275 and £315 respectively.

The 'all purpose computer' is the selling angle and indeed extra attention has been paid to the differing uses of the micro. As can be seen the keyboard is of the QWERTY type with a separate 12 key numeric cursor control and editing pad and an 8 key user definable function keypad. The unit is housed in an anodised aluminium case angled towards the user and is ergonomically high scoring.

Whether your needs are for personal programming, games playing, scientific or process control, educational or business use the machine is already capable or is easily adaptable to most applications boast the manufacturers. The 16K ROM contains several languages and routines. Standard languages being MTX BASIC, LOGO and NODDY, ROM routines include and ASSEMBLER/DISASSEMBLER with screen display of Z80 CPU registers, which can be manipulated from the keyboard. Other interesting features include an Add-on 80 column video board as opposed to the 40 column norm. twin RS232 interface ports and ultimate expansion to 512K.

With a programming speed of 2400 baud the quality of the cassette player used in conjunction with this machine will play an important role in accurate data transferal. Games, Educational and Business software will also be available produced in the main by Continental Software Ltd.

IBM Breakthrough

IBM scientists have hit the news again; this time with a microscopy breakthrough at their Zurich Research Laboratory. An effect known as vacuum tunnelling has been successfully exploited to study surface topography down to atomic level—vertical differentiations of as little as 0.1 Angstroms, and horizontal differentiations of as little as 6 Angstroms apart, have never before been observed.

The tunnelling technique actually detects the electron clouds surrounding surface atoms, and as such, qualitatively reflects the atomic surface structure. In vacuum conditions a probe scans the specimen raster fashion, so that a 3-D facsimile is gradually built up. An electric current between the probe and surface is used to detect surface deviations. So sensitive is this technique that a distance the diameter of one atom changes the tunnel current by a factor of 1000.

The photograph shows an enlarged model of a silicon surface constructed from STM data. Two rhomboid-shaped unit cells are clearly visible. The individual "bumps", which are as little as 6 Angstroms apart, have never before been observed.

Mic on a Chip

A new technology pioneered by Honeywell has led to the creation of the "mic on a chip"—a completely solid state microphone! Zinc oxide on a single silicon substrate offers a chip-sized microphone with significant advantages over the ceramic alternative; it responds to frequencies as low as 0.1Hz, as opposed to 20Hz. Honeywell's microphone is devoid of mechanically linked parts, and consequently far more reliable and robust. It is smaller and lighter too. The mic consumes a mere 40mW which makes it ideal for battery powered field work, and it is sensitive to as little as one microbar of pressure.

The New Steam Age

For those nostalgic of the ignifluous hearded, ablescens breathed labourer of the permanent way, in short, the steam locomotive the news that living steam is to return to the railways of North America might come as a pleasant shock. But not the clanking, brass bell and smokestack machine. Instead, a loco "heavily disguised" as a diesel unit with pistons on its wheels, manufactured by American Coal Enterprises, will beat through American suburbs where electrification infrastructure costs are prohibitive.

With a microprocessor for a fireman, efficiency of the locomotive is lifted from the 5 per cent of its ancestors, to 15 per cent. Whilst diesel may be 30 per cent efficient, this fuel costs four times as much as coal, and with a micro on the footplate to ensure minimum pollution in terms of gases and ash, the New Jersey company feels it has sparked off a good idea for the future. Production is expected to start soon.

COMPUTER BRIDGE

The Sistema BG1 Bridge Game is a simple computer, with control keys and display, designed so that one person can play Bridge, using the computer to play the roles of the other three persons.

The computer will deal new cards each time and you can choose between two levels of difficulty. It allows you to be dummy, declarer or defence. Between the hands, result of contract and vulnerability are displayed as well as below the line scores.

In each game you are able to bid and play your hand against the computer. During the auction, you make your own decisions as to what to bid, but the decisions of the other three players are made by the computer. The BG1 Bridge game is expected to retail at under £30.
Five UK banks are to link together their 2,500 cash dispensers for shared customer use, by 1983. Bank of Scotland, Lloyds, Williams & Glyn's, Barclays and the Royal Bank of Scotland will be providing this common on-line facility to a total of 15 million customers.

Researchers at Battelle-Columbus have developed a low-cost, energy efficient method for coating plastics with metal. The technique is known as "in-mould" plating because unlike conventional deposition, the plastic component emerges from the mould with its metal coating. Processing costs are cut by over 30%, and the technique may well herald an era of lightweight production parts for automobiles, business equipment and plumbing fixtures.

W. H. Smith have opened three specialist computer shops at their branches in Birmingham, Bristol and Croydon. If these first efforts realise their predicted sales figures a national network will follow next year. The first special offer will be Mattel's new micro 'Aquarius' well before its official UK launch.

Socialist France has installed data links between its treasury and its border posts. Computer warrants enable emigration police to identify and jail immediately anyone who, upon trying to leave the country, owes money to the exchequer. Having fed the traveller's passport through a scanner terminal, the officer on duty is empowered to detain any offender until he/she pays up and wipes out the debt. In a matter of weeks of operation, hundreds of citizens had settled in cash rather than lose their connection.

Maplin Electronics has introduced its Computer Aided Shopping by Telphone (CASHTEL) service, which allows owners of home computers with RS232 and modem facilities (CCITT 300 Baud) to link directly into its stock control computer. The user must have a customer number, and hold one of the major credit cards to be able to place an order, and may check that the components he/she requires are in stock. Maplin's computer is a DEC PDP11/70 with 2 Mbytes of MOS memory and 200 Mbytes of on-line disc. It is accessed by dialling 0702 552941.

LITESOLD

Litesold have just introduced a mains-voltage soldering iron.

The ECO incorporates an electronic temperature control circuit mounted inside the handle, which operates in response to a thermistor fitted inside the bit-mount. Power to the 50 watt heating element is controlled by a triac operated by a zero-voltage switching i.c., to minimise spiking and RFI, and the iron is fully earthed so that it may safely be used on sensitive equipment and components.

A special feature of the design is that the low-voltage supply necessary for the control circuit is obtained by means (for which a patent is pending) which do not involve the fitting of a dropper resistor in or near the handle. This problem has previously prevented a mains iron of this type being made to run with a sufficiently cool handle.

Access is provided to the temperature control potentiometer, and settings may be varied from approximately 280 to 400°C. Standard settings is 370°C. The iron costs £28 + VAT and postage from Light Soldering Developments Ltd, 97/99 Gloucester Road, Croydon, Surrey, CRO 2DN. (01-689 0574).

FLASHBACK

Would you give a week's pay for a calculator with only the most basic of functions? The answer is yes if you bought one ten years ago. Before such technology was available to the general public, those in the know could purchase the Sinclair Cambridge for a staggering £43.95. The average weekly wage at that time was around £36 and the electronics world was celebrating the Silver Jubilee of the transistor. Such was the state of technology in 1973.

Nowadays the purchasing power of our weekly pay packet could run to three computers, ZX81's of course. With the microprocessor bandwagon well and truly rolling who knows what goodies will be around for our 1993 pay days?

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.

Mullard Electronic humidity sensor (type 2322 691 90001) that operates between 10-90% relative humidity. Is a metallised film, capacitive cell. Worst case accuracy is ±5%.

AMS/PM receiver TEA5570. Suitable for hifi, car radio and portable. S.w. to 30MHz.

High speed 8K PROM, type 82S181B in 8-pin d.i.l. package. Designed for battery back-up using only one ni-cad cell. Data transferred serially via I2C bus.

High speed 8K PROM, type 825181B (1024 x 8) and 825185B (2048 x 4). Both 45ns access. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

Selenium 10kV rms opto-isolator HIL10 in 16-pin d.i.l. package.

Claimed to be the world's smallest (match head sized) reflective opto switch, type SFH900. Very high dark/light ratio sensor. Emitter capable of 1-5A, 10µs pulse.

35 dot intelligent display, DLO 7135 series. 96 chars, ASCII format, µP compatible. Red, yellow, or green. Row/column addressing simplified by integral memory/decode/drive chip. Chars 0-68 in. high, with 75° viewing angle.

Mostek The MK3801 Z80 STI contains a USART for serial communication, and reduces Z80 system chip-count. This multifunction device contains two binary, two full function timers, and eight general purpose bi-directional lines. 16 out of 24 internal registers are directly addressable. Pronto Electronic Systems Ltd., 466 Cranbrook Road, Gants Hill, Ilford, Essex IG2 6LE.
ANYONE who has watched a very young baby acquiring manual skills such as reaching out and grasping a desired object, will have realised the complexity of the process. The hand first closes short of the object, then beyond it, then to one side of it, but once success has been attained, all further attempts are effortless and automatic. To the infant there is no comprehension of the physiological process, but the mind desires a certain end, the eyes feed back to it the results of trial and error, and the child 'learns' to use its body to perform the task.

Such knowledge continues with us into adult life, and without any conscious awareness of the individual electrical impulses which actuate the muscles, we can automatically learn, through feedback of the results of trials, from the five senses, from emotional reactions in the mind, and from the pleasure of attaining the desired end.

Much of the control and operation of bodily functions are exercised without conscious awareness. By fitting a suitable transducer to the body which will feed back to the mind through the senses an indication of state from moment to moment, the operation of such autonomic control is brought to the level of consciousness. This process has been named 'biofeedback', and through it it has been found possible to learn to raise or lower body temperature, blood pressure, rate of heart beat, and the operating mode of the mind itself.

One of the earliest applications of this process was in the American lie detector, which informed the questioner rather than the subject, of an emotional state. All well-equipped hospitals today employ many involved electronic machines to inform the doctor and nurses of the operational state of many bodily functions. This article is concerned with the development of the lie detector to respond to much more subtle states of mind, and feed back to the subject himself so that he may learn to control states beyond the level of consciousness. Such methods are being used currently in therapy of a number of psychosomatic conditions including cancer.

RELAXATION

It is common knowledge that worry, anxiety, sorrow, and emotional stress can all give rise to acute nervous tension. Some of our younger generation have sought relief from the pressures of Western civilisation by learning to relax under the guidance of Eastern religions. A regular entry into deep relaxation often accompanied by concentration on a fixed theme or phrase, as in transcendental meditation, can bring relief from such troubles, often allowing the operation of bodily functions below the level of consciousness to return to normal, and thus allow the natural responses of the body to meet and destroy any undesirable invasion.

Such relaxation is often accompanied by a brain wave known as 'alpha rhythm', and there has been an attempt in America to sell to the general public a cheap version of equipment to feed back to the patient the results of such electrical pulses by sound or sight, using biofeedback to learn control of the process. While such machines are in
SKIN CONDUCTIVITY

These machines are often misnamed 'skin resistance meters', but such a designation is not true, because the relationship between applied voltage and resulting current is not linear, nor does the nature of conductivity variation with emotion remain similar over a wide range of voltage applied. In the normal process of living, the skin is being constantly abraded and replaced by new growth; on the surface is the debris of wear, beneath this is a complex outer layer, and beneath that the inner materials associated with the electrochemical organisation of life. It is in the outer layer of skin proper that the conductivity used occurs, while the surface debris offers an obstacle to measurement by injecting a high resistance limiting the effective area of electrode contact.

The conductance of the skin is not resistive because it is the result of electro-chemical transfer of charge through the walls of adjacent cells, and for the purpose of monitoring, relaxation research has indicated that potentials greater than 2V applied across electrodes will give anomalous results. The older method of obtaining a large effective area of conductivity was to use cheaply available components to obtain a smooth logarithmic variation of gain in the amplifier over a range of ten thousand and fifty thousand ohms, and such conductance was readily measured in a range of voltages below 2V. With dry electrodes however, such as those described here, the effective resistance can rise to several megohms, and it was this limitation which was only overcome at a reasonable price when cheap versions of very high input resistance operational amplifiers became available. The instrument described here will allow an untrained person to adjust and monitor the conductance across the electrodes between five thousand ohms and fifty million ohms, a range of ten thousand to one, and involving the monitoring of changes in current of a few pica -amps.

In use, a needle moves across the scale of an instrument. With the electrodes applied to the skin, a knob is turned to increase the reading until it is approximately mid-scale. Any increase in nervous tension will cause the reading to increase, while a state of relaxation will cause it to fall back towards zero, the further the fall, the deeper the state. Apart from the difficulties of measurement in this range, a further difficulty was to use cheaply available components to obtain a smooth logarithmic variation of gain in the amplifier over such a wide range, without backlash or drift, such that an untrained person could easily operate it. Very early in the development it became obvious that the greatest operating cost was likely to be the destruction of sensitive meters from accidental overload, and in designing a meter protection circuit a means was found of obtaining a very desirable modification of input/output law over the working range.

CIRCUIT OPERATION

The meter protection circuit is shown in Fig. 2. The output of the amplifier is a voltage proportional to the current into the electrodes, and this is fed into the meter circuit. Since the purpose of the instrument is to 'teach' relaxation, there is no need for the reading to be a linear measure of conductance, but it is desirable that it shall have a large change, while a state of relaxation will cause it to fall back towards zero, the further the fall, the deeper the state. Apart from the difficulties of measurement in this range, a further difficulty was to use cheaply available components to obtain a smooth logarithmic variation of gain in the amplifier over such a wide range, without backlash or drift, such that an untrained person could easily operate it. Very early in the development it became obvious that the greatest operating cost was likely to be the destruction of sensitive meters from accidental overload, and in designing a meter protection circuit a means was found of obtaining a very desirable modification of input/output law over the working range.
towards relaxation to be clearly visible to the user, and thus encourage him to make further progress. The overall response of the circuit is shown in Fig. 5. D7 suppresses the zero, and D8 compresses the maximum reading, thus giving the expanded deflection around mid-scale which is desirable. In addition to this function, D7 masks the effects of TR2 to 0.07V which will leave it cut off in the absence of additional current through D5. If the battery voltage falls to such a level that D5 ceases to conduct, the voltage on the base of TR3 will fall to 0.17, it will also be cut off, its collector will rise to 6V, applying 5.3V through D1 to the fail line; although there may be up to nine more amplifiers connected to this line, each will have a diode in the same location, which will prevent them from shutting this voltage to zero, and the switch unit will light the alarm lamp. Until the battery voltage falls to too low a value to cause current to flow through D5, that additional current through R2 will rise until TR2 conducts, when feedback from R1 to TR1 will maintain a voltage just sufficient to cause around 0.5mA to flow through D5, and TR3 will conduct.

The amplifier section of the unit consists of a dual operational amplifier having input impedances around 1500 megohms and designed for single ended operation from 4–36V. The dual logarithmic potentiometer of 1M resistance is loaded so that the overall response of the amplifier to rotation of the control is very nearly logarithmic, and the response of a typical machine is shown in Fig. 6. A current of 0.93mA flows through D2, D3, D4, giving a ground line to the amplifier of 1.8V above the zero voltage input to it. This same current through R6, R7, R8, places a voltage across the potentiometer between 0.3 and 2.8V above the ground line. This is the voltage which should be applied across the electrodes, but their impedance is so low that the desired logarithmic control would not occur, and the first of the two operational amplifiers is used as a unity gain buffer of high input and low output impedances so that the required voltage is applied to the test terminals.

The amplifier circuit is shown in Fig. 3. The voltage regulator section is designed to accept the output from the 9V battery at the collector of TR1 and deliver at the emitter a drive potential constant for varying load at a value between 5.5 and 6.5V. A value of 6V will cause a current of 0.104mA to flow through R4, R3 and R2, raising the base of TR2 to 0.07V which will leave it cut off in the absence of additional current through D5. If the battery voltage falls to such a level that D5 ceases to conduct, the voltage on the base of TR3 will fall to 0.17, it will also be cut off, its collector will rise to 6V, applying 5.3V through D1 to the fail line; although there may be up to nine more amplifiers connected to this line, each will have a diode in the same location, which will prevent them from shutting this voltage to zero, and the switch unit will light the alarm lamp. Until the battery voltage falls to too low a value to cause current to flow through D5, that additional current through R2 will rise until TR2 conducts, when feedback from R1 to TR1 will maintain a voltage just sufficient to cause around 0.5mA to flow through D5, and TR3 will conduct.

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The current flowing through the test terminals flows also through R10 and VR1b. The voltage developed across them is applied to the input of the second op amp. For very low values of skin resistance, not only is a lower voltage applied to limit current flow to the requisite low levels for significant response to tension, but the input resistance in the path of test negative to ground is also very low to prevent a masking of test variation by a significantly high resistance in series with the skin conductance. As the voltage is increased to give a test current which is low enough to register tension, but is also high enough to operate the amplifier above the 'noise' level when skin conductance is low, the value of the second potentiometer resistance is also increased for the same reason, and the combination of the two gives the overall logarithmic response which is shown in Fig. 6 and which also keeps the second op amp operating satisfactorily over the design range.

As far as the operator is concerned these various adjustments of condition are automatically performed and in turning the control knob from zero towards full scale, he sees a smooth increase of meter reading until it is half scale, at which point he leaves it there, and watches the needle for indication of relaxation or of tension.

PERSONAL USE

The instrument is basically of assistance in learning to relax. Most people think initially that if an effort of 'will' is made, and the mind concentrated on a firm intention of relaxing, that they succeed, and that the harder the mind is stressed in achieving the end, the deeper will be the relaxation. In practice, nothing could be more effective in preventing it; the very stress of concentration leads to tension, the very antithesis of the desired end.

COMPONENTS

<table>
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<th>Resistors</th>
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<tr>
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<td>560k</td>
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<td>R16</td>
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All resistors 0.4W metal film ±1% tolerance

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<td>D1–D4</td>
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<td>D5</td>
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<td>CA3240E</td>
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<td>D6</td>
<td>Red l.c.d.</td>
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<tr>
<td>D7–D8</td>
<td>1N4148 (2 off)</td>
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<tr>
<td>ME1</td>
<td>50μA meter</td>
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<tr>
<td>S1</td>
<td>Double pole indicating push button switch (RS 339–443)</td>
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Biofeedback is only one of many methods which have been used to train in relaxation, but it is probably the easiest, and certainly the most universally applicable, since it is the only one which is not tied to any one area, but applicable alike to mystical, spiritual, religious, and medical assistance.

When commencing to use it, a number of sessions are normally needed before it becomes possible to rapidly relax. The difficulty or ease of learning depends in large measure on one's prior disposition and experience, and if one does not become discouraged, and gives the routine a fair trial, eventual success is certain. Many attitudes are currently adopted in relaxation, varying between standing on one's head, sitting cross-legged on the floor, lying on the floor, and sitting in a chair. A straight-backed chair is the easiest, and most effective to use, where the feet, when sitting upright, can rest comfortably on the floor.

The electrodes are attached to fingers or to the palm according to type, the unit switched on, and the meter adjusted to half-scale reading. The mind is gently diverted from surrounding objects and present interests, by slowly reviewing the body members, from feet, up legs, thighs, trunk, hands, arms, shoulders, gently relaxing all muscular tension in turn and leaving it in this state as attention is turned to the next. The breathing rate is dropped to about two-thirds of normal, but making each breath deep, slowly in, then completely expelling from the bowl upwards. Finally, the mind is detached from all the surroundings, and thought centred on a single matter (mental picture, or single syllable sound without rational meaning) and the needle idly watched with the full confidence that it is slowly going to drop towards zero.

The unit can be successfully used in private, in one's own home, but it is usually easier and more effective when done regularly in a group, from three up to six, all sitting around a table on which the machines rest. The location should be quiet, with no probability of external interruption, and duration from twenty to fifty minutes. It will be found that even if it takes a time to enter relaxation, to remain there for at least ten minutes will bring a feeling of great rest, and a peace which will remain for the remainder of the day. Even when able to relax with ease, relaxation should be practised regularly, at least weekly, if possible more frequently, even perhaps daily. It will become possible with practice, to relax without a machine, but it is advisable to monitor occasionally with one to make certain that one is still relaxing; in any case the reassurance of seeing its existence will bolster confidence in its use.

Finally, it should be noted that it is a complete mistake to think that sleep is a condition of deep relaxation. During a prolonged period of sleep, the brain experiences periods of intense activity in dreaming, with rapid eye-movements and other muscular activity. It is often found by patients that after a period of many minutes of noting the needle on zero, they have dropped off to sleep, and on waking have found the needle at full scale.

WANTED Kodak Carousel projector type SAV 2000. Mr. B. R. Smith, 126 Eastbourne Rd., Southport, Merseyside LPR 4EA Tel: 06316.

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PE VDU board £12 o.n.o. Elector 16K DRAM £15 o.n.o. Microtan 85 £25, SCMP/1 model £18 each d.i.Uplug in relays 75p/C, MM5303 unused £5. G. Williams, 85 Salthouse Rd., Barrow-in-Furness, Cumbria LA13 9TN. Tel: 022929152.

FOR SALE, 7 TM52516 PROMs, 8 2114 RAM chips, 3 MPU's. Offers for lot. Will split. Tel: Chesterfield 825185.

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ATOM 13x + 16K Utility 4A p.s. manuals leads etc., books, over £60 software Acorn tested £199. Mr. C. D. Bittlestone, 1 Beechcroft Ave., Dere Park, Brandon, Co. Durham DH7 8BT. Tel: Durham (09062) 50125.

STEREOVIEWER control car cost £70 reluctant sale price £30. Tel: 01 504 0565. D. Snowdon, 124 Walpole Rd., South Woodford, London E18 2LL.

UK101 Cegyn 32 x 48 16K 1/2 300/800 green screen v.d.u. Manuals. Software various. £260 o.n.o. Tel: (0734) 501656, (0734) 22410. P. R. Border.

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October 1983
This view adds weight to the rumour that Lord Weinstock has his eye on Inmos as a possible acquisition.

Another high-flyer is Sir Ernest Harrison heading up the Racal Group which, ten years ago, would not rate much in the top 100 and is now in 15th spot. Racal boosted pre-tax profit to £114 million from £103 million last year but the City remains unimpressed, downgrading Racal from its former ‘glamour’ status. Those with the foresight to invest £1,000 in Racal shares when the company went public in 1961 and left them with dividends intact would find themselves today with a return of over £500,000. Well, you can’t grow at that rate for ever and there are good reasons for the slow-down.

Defence electronics in the Middle East is one of Racal’s most profitable markets. The cut-back in oil prices in OPEC countries didn’t help there. The data communications business in the USA ran into a price-cutting war and this didn’t help, either. Then there was the problem of Decca, recently acquired, and needing turning round to profit. Borrowings soared to finance the Decca deal but these have now been paid off. So all-in-all the Racal Group looks set for further advances.

The three-year re-structuring of Decca and its integration into the Racal Group has now been virtually completed. Central to this task was David Elsbury, an old Racal hand and one of the earliest high flyers who has now retired to become as Deputy Chief Executive, second only to Sir Ernest in the hierarchy. Elsbury also has special responsibility for the Data Communications Group recently relinquished by D. Leighton Davies who has taken early retirement but remains a consultant to the company. A new promotion is that of Barton J. Clarke to chairman of Racal Radar Defence Systems Ltd. Clarke joined Decca in 1957 and in recent years succeeded in building up the company’s electronics warfare business to world status. Now, within Racal, this EW group employs 1,800 people exporting to 30 countries.

The larger the company the harder it becomes to get dramatic growth in percentage terms. Thus Ferranti, almost a midget beside GEC, romped home with 31 percent increase in pre-tax profits to £31.5 million. Ferranti again showed the sharpest advance, 49 percent up on the previous year. Order books for the current year are 20 percent up compared with a year ago.

STC, now British controlled (ITT retaining only a minority share), is also flying high as, indeed, are Flessey and Thorn-EMI.

**Change**

But to keep going means changing with the times, ditching old unprofitable lines, introducing new products at keener prices. So it was that GEC’s telecommunications factory at Hartlepool which once employed 6,000 people is now reduced to a few hundred. Hardship for those displaced but it needn’t be for ever. Remember Corby, ‘crucified’ by closure of British Steel with 6,000 people ‘thrown on the scrap heap’ three years ago? With government incentives, over 200 new firms have emerged not counting the great Wonderworld leisure complex yet to come with £200 million pounds investment and another 3,000 jobs. Corby hasn’t yet solved its unemployment problem but has accepted the challenge of computing off steel in favour of a diversity of new products. What should have been a Labour stronghold, fuelled on disquiet, Corby with a vision of a new future ahead voted Conservative. But change is not all for the good. RS Components, for example, relocating at Corby means a loss of jobs in London.

**Fruit Machines**

Small computers named after fruits continue to proliferate but I should imagine that Lemon or even worse, Raspberry, models will not appear. We all know that the cost of computing is on a downward curve but it is still a surprise to learn that if aircraft fares had fallen at the same rate as computing power over the last 40 years you could fly the Atlantic for a penny! The comparison is based on the original Eniac at a then estimated cost of £10 million. The humblest micro will do more or less the same job today for a handful of notes.

The hardware may fall in cost but the software may not. It is conceivable that, like the Gillette safety razor once given free with a packet of blades, so the computer will come free with the software. But not yet. ACT, unveiling its new Apricot model at a basic £1,500, is decidedly up-market compared with, say, Sinclair, but even in this bracket there is an active price war. Apricot claimed to have the price edge through lower overheads, and might comfortably drop further when production speeds up to 4,000 machines a month early next year.

It is bad enough with genuine competition. The real trouble comes with illegally produced look-alikes, the cheap copies made in Hong Kong, Taiwan, Singapore, even, it is said, in Japan itself. Apple is the principal target, one machine being labelled Apollo (near enough to confuse) with other look-alikes with machine looks and wildly sub-titled Apple-compatible. One such is reported as being marketed in North America as the ‘Orange’. And how about software? Will computer software go the same pirating way as video tapes? There seems no reason why not while there is tainted money to be made. No, I’m not advocating the practice, just observing what could go wrong. The very prospect is terrifying the whole legitimate industry.

A possible countermeasure is the recent adoption by Japanese manufacturers of a common standard for both hardware and software for personal computers. Thus, any low-priced home computer will take any software. This could reduce prices to a level where it is not worthwhile for the copycats. On the other hand it sharpens up the existing price war to the point where only the strongest can survive. Looks like a re-run of the pocket calculator struggle. Perhaps we should forget the agogies of the manufacturers and concentrate on the benefit to the consumer.
THE PE Logic Tutor has been designed specifically for use with the series, 'Introduction to Digital Electronics' which commences in this issue of PE. The Logic Tutor provides the user with 'hands-on' experience of digital circuits and numerous practical investigations have been included in the text. Furthermore, although primarily designed as a learning aid, the Logic Tutor can be used as a 'breadboarding' system in its own right. It is thus eminently suitable for those readers engaged in the design and development of logic circuits. Indeed, it is envisaged that the newcomer will continue to find numerous applications for the Logic Tutor when the series has been completed.

LEARNING AIDS

There are, essentially, two distinct approaches to the problem of providing an effective digital logic learning aid. The first involves a fixed arrangement of logic gates wired permanently to a board with terminals to facilitate links between gates. Such an arrangement is ideal for a beginner but tends to be somewhat inflexible and often fails to reflect the "real-life" characteristics of integrated logic devices. The second approach involves the use of a "breadboard" area into which a wide variety of TTL and CMOS logic integrated circuits may be inserted. Such an arrangement is usually based upon a proprietary breadboarding system and is often lacking in such additional facilities as logic level generators of various types, a means of logic state indication, clocks and a power supply. Some, or all, of these items have to be provided by the user at additional cost and inconvenience.

The PE Logic Tutor combines both approaches; retaining the simplicity of the first method with the flexibility of the second. It is, therefore, adaptable and versatile, and furthermore is completely self-contained, requiring only a power source to be fully operational.

CIRCUIT DESCRIPTION

Logic State Indicators

The circuit diagram of the four logic state indicators is shown in Fig. 1. Each logic state indicator consists of a single npn silicon transistor operated in common emitter mode as a saturated switch. The I.e.d. connected in the collector of the transistor becomes illuminated whenever the transistor is in its conducting ('on') state. R1 and R2 set the input switching threshold and are arranged so that a logic '1' input state is recognised whenever the input voltage exceeds approximately 1.4V. The maximum input current drawn from the circuit under investigation is limited by R1 to below 1mA. Under the saturated condition in which TR1 is operated, R3 determines the 'on' state collector current and thus can be used to adjust the brightness of the I.e.d. Where desired, the value of R3 may be changed to increase or reduce the brightness of the I.e.d. The value specified should provide an adequately bright display under normal conditions of room illumination without excessive drain upon the supply. The minimum recommended value for R3 is 150ohm and, in this condition, the I.e.d.s will be operated with forward currents of approximately 20mA each. De-coupling of switching transients appearing upon the supply rail is provided by C1.

Logic Level Generators

Four switched logic level generators are provided. Two of these are momentary and two provide a latching action. Each switch is fully "debounced" (i.e. momentary switching transients due to contact bounce have been removed by means of appropriate circuitry). The output of each of the four logic level generators is fully TTL compatible in terms of the output voltage levels produced.

The circuit diagram of the two momentary switches, S1 and S2, is shown in Fig. 2. IC1 is a hex inverter (hex simply means that it incorporates six individual and identical logic gates). Two inverters are used in each of the switch circuits; the first inverter provides the TTL compatible output whilst the second is used to complement the logic state and operate the I.e.d. R13, R14, and C2 perform the signal conditioning and de-bouncing necessary for S1. When S1 is closed, the input of IC1a (pin 1) will be at OV (logic '0'). Due to the inverting action of IC1a, its output (at pin 2) will be at approximately +3.5V (logic '1'). TTL gates can usually sink very much more current than they can 'source' (this subject will be explained at greater depth in the Introduction to Digital
Electronics series. The second inverting stage, IC1b, is thus used to further invert the logic state such that the I.e.d. becomes illuminated when its output (at pin 12) is in the logic '0' condition.

The circuit diagram of the two latching action switches, S3 and S4, is shown in Fig. 3. The switch de-bouncing circuitry is the same as that used for the two momentary action switches. The output of the first inverting stage is, however, taken to a bistable stage which "remembers" the logic condition and remains in that condition until the switch is pressed a second time. The i.c. used is a dual J-K bistable (the significance of the term will again be explained in Introduction to Digital Electronics) and it offers two complementary (i.e. logically opposite) outputs which are labelled 'Q' and 'Qbar'. One of these, the Q output, is used as the TTL compatible output, whilst the second, Qbar, output is used to 'sink' current for the I.e.d. indicator for the same reason as before.

Clock

The clock produces a low frequency square wave output at approximately 1Hz. The voltage levels produced by the clock are, again, TTL compatible. The circuit diagram of the clock is shown in Fig. 4. IC3 is a 555 timer connected in astable mode with timing components (R25, R26 and C10) chosen such that the output duty cycle (i.e. ratio of 'on' to 'on' plus 'off' times) is very nearly 50%. The clock frequency may be increased or decreased simply by changing the values of either R26 or C10. Note that, to preserve the 50% duty cycle, it is essential to use a value for R25 which is very much less than that used for R26. C9 provides supply de-coupling and D9 is used to indicate the logical state of the clock output.

Power Supply

The circuit diagram of the power supply is shown in Fig. 5. The power supply comprises a bridge rectifier, REC1, and a monolithic integrated circuit voltage regulator, IC4. The bridge rectifier has a dual function. When the Logic Tutor derives its power supply from a d.c. source (such as a 9V battery) the rectifier ensures that the supply polarity is always correct regardless of the actual polarity of the battery connections. When the Logic Tutor is to be operated from an a.c. mains adaptor (consisting of a 240V/6V step-down transformer) the bridge rectifier provides its normal function.
of rectification and produces a 'raw' d.c. output which is developed across C11. A highly accurate and stable 5V output is produced by IC4. This supply is provided at various points throughout the breadboard area and is also taken to the other integrated circuits, IC1, IC2 and IC3. Two separate contact points are used to provide a logic '1' level. Resistors, R28 and R29, are connected in series with these points in order to limit the available current in the event of an inadvertent short circuit. The maximum current which can be sourced from either of the two logic '1' points being a modest 5mA. Further de-coupling is provided by C12 and C13. It is, incidentally, good practice to include a number of supply rail de-coupling capacitors in a digital logic system. These capacitors can often be instrumental in reducing the unwanted effects of supply borne transients and should always be distributed throughout the area occupied by the digital i.c.s.

**CONSTRUCTION**

The PE Logic Tutor is built on a single sided printed circuit board measuring approximately 163×172mm. The foil layout for the p.c.b. is shown actual size in Fig. 7 and the corresponding component layout on the top side of the p.c.b. is given in Fig. B. The p.c.b. is available screen printed such that all components and connecting points are readily identifiable. Components should be fitted to the p.c.b. in the following order; i.c. sockets, connecting strip, connectors, resistors, capacitors, bridge rectifier, l.e.d.s, transistors and regulator. Care should be taken to correctly locate components prior to soldering them into place. Furthermore, it is particularly important to check the polarised components such as electrolytic capacitors, l.e.d.s and transistors.

The long term success of the Logic Tutor depends largely upon the ease with which reliable links can be made within
the breadboard area. It is, therefore, essential to use high quality connecting strip and i.c. sockets. The socket strip is supplied in 20-way lengths. These may be easily cut to produce any desired number of ways. The sockets themselves will accept connecting wires, or component leads, having diameters in the range 0.4 to 0.6mm. The sockets are of two-part machined construction with a four finger contact arrangement made from beryllium copper, gold plated over nickel. Such a high quality of construction does, unfortunately, carry a penalty! The i.c. sockets, and connecting strip, are relatively expensive, however it is felt that this is not too high a price to pay for reliability and ease of use.

When construction has been completed, carefully check the underside of the p.c.b. for dry joints and solder splashes between adjacent tracks. Finally, insert the integrated circuits into their respective holders taking care to observe the correct orientation of each device. Assembly is now complete and the Logic Tutor is ready for initial testing.

INITIAL TESTS
The following items of equipment are required in order to confirm that the Logic Tutor is fully functional:

(1) d.c. multi-range meter of 10kohm/volt minimum
(2) regulated d.c. power supply

The power supply should preferably incorporate some form of short-circuit protection. If such a supply is not available, then a fuse of 500mA rating should be incorporated in the positive supply lead to offer a measure of protection in the event of an inadvertent short-circuit across the supply rails. Similarly, if a d.c. supply is unobtainable, then either a 9V dry battery (such as a PP9 or similar capable of delivering a
should be flashing 'on' and 'off' at a rate of approximately correct, the next step is to check the low frequency clock. D5

4.5V to 5.5V. If this is not the case, check the regulator and connecting the meter, on the 10V d.c. range, across the rails output voltage from the regulator. This is easily done by con-

current is in the correct range, the next stage is to check the

similarly check for incorrectly located components, open cir-

nents and short circuits on the underside of the p.c.b. If the

overload protection in the power supply operates, or the in-

measure the supply current. Switch the supply 'on' and

the meter in series with the positive supply lead in order to

supply.

orientation of the bridge rectifier before connecting the

however, it is essential to check for short circuits and correct

load current of up to 100mA) or the recommended mains adap-

tor may be brought into service. In either case, however, it is essential to check for short circuits and correct orientation of the bridge rectifier before connecting the supply.

Set the d.c. supply to give an input of 12V d.c. and connect the meter in series with the positive supply lead in order to measure the supply current. Switch the supply 'on' and check that the supply current is in the range 30mA to 90mA. If the supply current is greatly in excess of 90mA, or the overload protection in the power supply operates, or the inline fuse blows, then check for incorrectly located compo-

nents and short circuits on the underside of the p.c.b. If the supply current is very much less than 30mA, or zero, then similarly check for incorrectly located components, open circuit connectors and dry joints. Assuming that the supply current is in the correct range, the next stage is to check the output voltage from the regulator. This is easily done by connecting the meter, on the 10V d.c. range, across the rails marked '+'5V' and '0V'. The reading should be in the range 4.5V to 5.5V. If this is not the case, check the regulator and associated components.

Having established that the nominal 5V supply rail is correct, the next step is to check the low frequency clock. D5 should be flashing 'on' and 'off' at a rate of approximately one flash per second. If this is not the case then check IC3 and associated components. The logic level generators, S1 to S4, should now be checked. D6 and D7 should become ill-

uminated when S1 and S2 respectively are depressed. The i.e.d.s should become extinguished when the switches are released, thus demonstrating the 'momentary' action of these switches. Depending upon the initial conditions, D8 and/or D9 may be illuminated. Depressing S3 and S4 should, however, change the state of D8 and D9 respec-

tively. These i.e.d.s will remain in the illuminated or ex-

tinguished state until the appropriate switch is depressed again, thus demonstrating the 'latching' action of these switches. If the action of any of the switches is suspect, check IC1, IC2, and associated components. It is also worth checking that the i.e.d.s have been fitted with the correct polarity!

Finally, the logic state indicators should be tested. This is very simply accomplished by feeding a logic '1' (obtainable from the appropriate connecting point marked on the p.c.b.) to the input of each indicator, D1 to D4, in turn. In each case, the appropriate i.e.d. should become illuminated. If this is not the case check the polarity of the i.e.d., transistor, and associated components. This completes the construction and testing of the Logic Tutor. If desired, the protected d.c. power supply may be replaced with the recommended 6V/3VA a.c. mains adaptor. Details of the first practical in-

vestigation using the Logic Tutor will be found in Introduc-

tion to Digital Electronics elsewhere in this issue of PE. *

LOGIC TUTOR BOARD KITS

Complete kits for the Logic Tutor are available from the following suppliers:

Howard Associates, 59 Oatlands Avenue, Weybridge,
Surrey KT13 9SU (0392 42376)
Riscomp Limited, Electronic Component Distributors,
21 Duke Street, Princes Risborough, Bucks HP17 OAT (0844 6326)
TK Electronics, 11 Boston Road, London W7 3SJ (01-579 2842)
Magenta Electronics Ltd., 135 Hunter St., Burton-on-
Trent, Staffs DE14 2ST (0283 65435)
G. D. & P. Cowan Services, 9 Harcourt Terrace,
Headington, Oxford (0865 60741)
Electronics World, 1C Dews Road, Salisbury SP2 7SN
Microstate Ltd., 5 Northfield Close, Fenhall Heath, Wor-
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Same Day Despatch

Practical Electronics October 1983
LET it be known that there's nothing wrong with the Church's eyesight. Hot on the heels of my plea in an earlier issue of PE for our spiritual leaders to employ the bountiful blessings of electronic technology, comes news of a positive and encouraging response.

A church computer-users' group, with no less than 200 ministers of all denominations on its membership roll, is using computers to manage parish accounts and, among other functions, maintain records of its church's members. The Rev. Peter Goodlad, minister of the United Free Church at Seven Kings, Essex, is even harnessing video games to teach the old Bible stories. He's kicked off by reconstructing the rebuilding of the walls of Jerusalem by that pioneer of property development, Nehemiah. Mr. Goodlad is obviously a canny cleric, for he's fixed it so that Nehemiah always wins.

The idea is an inspired one. The colourful and enduring Bible tales lend themselves admirably to modern technological interpretation. But where does the good Mr. G. go from here?

May I suggest he casts a computerised eye at that notable encounter between David and Goliath. All kinds of angles could be brought in: weather, wind velocity, the weight and trajectory of David's projectile and so on. All good stuff.

The opening of the Red Sea would make another excellent object among the various considerations here would be the likely effect of tidal variations and the danger of the old bore (the kind they get down on the Severn, not the type you so often find getting into Parliament) turning up and altering the whole course of Hebrew history.

And what about the feeding of the 5,000? Leave the compilation of this game to a mixed bag of statisticians and bright young management trainees from Trust House Forte, and they'd probably be able to show, computer-wise, they could have met double the catering requirement with half the materials, but plus VAT. The same may go for the changing of water into wine in Canaan.

Mr. Goodlad, you're still on the fringe.

* * *

We kids used to think my gran's doctor was about 100 years old. Gran herself used to reckon that he qualified around the time that Lord Lister—object of antisepsis—was sloshing the old carbolic around and turning major surgery from a likely death sentence into a sporting chance.

Dr. B. (I never found out his real name) wore a top hat and frock coat and carried a Gladstone bag. We firmly believed it contained habits. He was a traditionalist and even if electrical and electronic devices had been available then, he would have scorned them. Instead he stuck to standard remedies like purgatives, gaily-coloured tonics (which did wonders for the mind if nothing for the body) and evil-tasting expectorants. Ugly rumour had it that he even bred his own leeches in the scullery. When he died, a golden age died with him.

Mum's doctor was a different draught of syrup of figs. He was young and therefore, in the eyes of senior patients, not to be trusted. He was also daft enough to adopt the scientific approach. Putting on his best bedside face, he'd first observe, then question and finally examine. This was foreign to the old hands. Dr. B. just used to look. He knew what was wrong with you. But my mother's doctor was a real progressive. He favoured X-rays both for diagnosis and therapy, infrared radiation for muscular ailments, ultraviolet for skin conditions and—though it was mentioned only in hushed whispers—electric shock treatment for mental disorders.

My doctor is a man of compromise. He is always prepared to prescribe ready-made medicines—selecting the latest from the manufacturers' catalogues like a gourmet choosing a celebration dinner. At the same time he's ever eager, indeed rabid, to call in such high-tech facilities as body-scanning, electrocardiography, encephalography, deep X-ray therapy, electron microscopy, laser techniques... the lot. Indeed, his attachment to these things is such that he didn't speak to his wife for a week when she presented him with a birthday gift of a knitted jumper instead of the electronic stethoscope he'd set his heart on.

But whatever their failings and foibles, these three doctors of the Hippocratic order were at least tangible. You could communicate with them on human terms. They had a ready supply of sympathy, understanding and reassurance. And they offered it in the kind of language you could understand. They were people.

This is why I get a touch of wind round the heart when I read the forecasts, by those who profess to know, about the way medicine is likely to go in the not-so-far-off future.

We all know today's pattern. You phone for an appointment, toddle along to the surgery, thumb through a vintage copy of Woman's Own or Menswear, enter the Presence when the buzzer buzzes, pour your heart out and then leave, bearing a slip of paper which is your passport to a return to health and vigour.

All that's going to change, say the pundits. True, you'll still have to phone for an appointment, the date and time being determined by an electronically-controlled availability schedule. There will be no jolly mags to read while you're waiting (although, thanks to automated patient-traffic control, you won't have to). All you're going to have are uplifting works like Nature and New Scientist. And you can bet your last barbiturate they'll be current issues.

The most horrific change will be apparent when you sit before him who used to assure you that cremation wasn't around the corner and a couple of these three times a day would soon put you right. There will be no light preliminary chat about Arsenal's chances for the Cup or the price of fish. It will be straight down to business if your GP is to complete his quota as laid down by Those Above.

Fingers poised above his terminal keyboard, he will request you (in clipped Dalesque tones, I wouldn't wonder) to recite your symptoms, which will be fed into a computer standing where the examination couch used to be. A short pause, and an allegedly infallible diagnosis will appear on the read-out (with increasing sophistication you might get the treatment as well). Mind you, things won't always be as straightforward. If the system goes down you won't get a thrill.

Apart from its total lack of soul, this frightening way of life—or, if the computer happens to be in a bad mood of unreliability—death, the system is highly-prone to the consequences of human error. Both on your part and that of the medicos.

You may go along to your doctor feeling a bit under the weather, but perhaps unsure and not too explicit about the actual symptoms. Here lurks horror. One inaccuracy, one slip of the tongue, one ambiguity might spell the difference between a course of pep pills and a frontal lobotomy.

On the other hand your GP (who underneath is as mortal as you) may have been celebrating his latest pay rise the night before and be experiencing inescapable remorse in the form of the unsteady hand. Terminal buttons aren't all that big. Even total abstainers have been known to stab the wrong one. You know what I mean.

There is but one way to avoid this impending Armageddon. It can be expressed in seven simple words.

Come back Dr. B. We need you.

* * *

A few years back, until the cold wind of austerity began to blow up the commercial trouser leg, Mullard, the UK's biggest electronic components company, provided a unique educational service. It offered, sometimes free, sometimes at nominal cost, a vast range of studies in electronics in schools, colleges and technical training centres. Its passing was universally mourned, though those who never heard the sad news still write in asking for help.

It was therefore heartening when in 1982 Mullard made a modest return to the educational field by sponsoring—jointly with PE's sister-journal Everyday Electronics—a Schools Electronic Design Award Competition (SEDAC). It was a huge success and was repeated this year. The standard of entries—and the level of knowledge and innovation displayed—surpassed even that of 1982. In fact two of the judging panel, Andy Beer and Terry Giles, both top Mullard IC men, are said to be fearing for the future of their jobs!
DUAL SLOPE CONVERSION

Fig. 2 shows a successive integration waveform. To understand this it is first necessary to appreciate how a normal dual slope converter works. The simplest form consists only of an integrator, into which either the unknown input voltage or a known reference voltage can be switched, a comparator, a continuously running counter, and some simple logic. Starting with the integrator output at zero, the unknown signal is applied to the integrator for a fixed number of clock periods (determined by the counter). The integrator output will ramp away from zero at a rate directly proportional to the input voltage, and at the end of the integrate period will have reached a voltage directly proportional to the input voltage and the integration period, but inversely proportional to the integrator R-C time constant. Next, the reference voltage (which must be of opposite polarity to the unknown) is applied, causing the integrator to ramp linearly back towards zero. The time taken to reach zero will be directly proportional to the starting voltage, but inversely proportional to the reference voltage and the R-C time constant. The point at which the ramp returns to zero is detected by the comparator, and the logic registers the number of counts (i.e. the time) taken. It should by now be clear that this is proportional to the ratio of unknown and reference voltages, and is independent of the R-C time constant and of the frequency at which the counter is clocked. This digital count is the required output.

SUCCESSIVE INTEGRATION

The integrate and DE1 phases shown in Fig. 2 are therefore the classical dual slope waveform. In practice, however, it is necessary in all dual slope converters to detect the zero crossing synchronously with the clock, to overcome the effects of clock noise on the integrator output. Zero crossing is therefore not actually detected until the next clock edge after zero crossing occurs, and by this time the integrator will have overshot zero by an amount proportional to the fraction of a count by which the input value exceeds the registered result. The ICL7129 cunningly uses this fact to increase its accuracy. The DE1 phase gives a digital result essentially accurate to 3½ digits, then the residual integrator voltage is multiplied by −10, and de-integrated a second time. Now the accuracy has increased to 4½ digits. The residual is once again multiplied and de-integrated to yield a final resolution of 5½ digits.

To make a complete conversion, the ICL7129 repeats this cycle twice—once using the unknown input voltage and once with zero input. The difference of these results then gives a final result free of any zero errors, so the offset voltages of amplifiers and comparators on the chip don’t matter. Because the internal resolution is ten times the displayed resolution, auto zeroing is quite simple. A further refinement is that, by increasing the integrate period by a factor of ten, the chip can switch from 2 volts full scale to 200mV full scale (corresponding to 10 microvolts resolution) with no other circuit changes. A digital range input controls this facility.

Another novel feature of the ICL7129 is its direct drive to a three way multiplexed LCD. Multiplexing is necessary to keep a reasonable pin count. Because of the unusual drive waveforms, it is difficult to use external drivers for extra annunciators and decimal points. The ICL7129 therefore provides on chip decimal point drivers for four decimal points and two annunciators. The continuity annunciator indicates when the input voltage falls below approximately 6.5 volts and is useful for quick continuity checking, while the low battery annunciator warns that the battery voltage has fallen to approximately 7.2 volts. Continuity can be user disabled. Finally, an annunciator drive waveform is provided which is guaranteed to turn on any annunciator connected to it regardless of its backplane. This will most commonly be used for range or function flags.

The analogue part of the chip also features fully differential input and reference, allowing easy implementation of

**SPECIFICATION**

- **Input Impedance**: >100MΩ
- **Full Scale Reading**: 199.99mV
- **Accuracy**: 0.01% of reading ±1 digit.
- **Power Supply**: 6-14 V dc
- **Power Supply Current**: 2mA max.
- **Sample Rate**: 1-6 reading per sec.
- **Over Range Warning**: M.S.B.=1 other digits blank
- **Temperature Range**: 0-35°C
- **Temperature Stability**: 50ppm/°C typical
- **Digit Height**: 10mm
- **Low Battery Warning**: 6.3 to 7.7 volts
- **Continuity Detector Threshold**: 100 to 400mV
- **Overall Dimensions**: 72 x 36 x 27mm
- **Panel Cut Out**: 68 x 33mm
ratiometric resistance measurement and simplicity of use with bridge connected sensors or transducers. Input noise voltage is only 7 microvolts peak to peak, giving steady displays even at 10 microvolts resolution, while input bias current is 10 picoamps maximum at 25°C. On the digital side, control inputs include range change and run/hold control. Digital output signals indicate continuity, over-range, and under-range (i.e. less than 5% of full scale), allowing easy integration into autoranging DVMs.

Because of its combination of facilities, the ICL7129 is therefore equally at home as a stand alone DVM chip or as the heart of a sophisticated, auto ranging multimeter.

CIRCUIT

The ICL7129 has the unique feature of a range input. This is a digital input which if left unconnected, or held to DGND, will give a 200mV full scale meter. By taking the input high (to V+) the time for which the capacitor is charged will be reduced by a factor of 10 and thus give a 2V full scale meter.

Referring to Fig. 1, C3 is the integrator capacitor and R5 the integrator resistor. It should be noted that C3 is polypropylene as it must have a very low dielectric loss in order not to give the meter poor linearity. C4 is used to hold the reference voltage during the de-integrate phase of the converter cycle.

IC1 is a bandgap voltage reference which has a low temperature coefficient. The voltage is divided by R2-3 to form the required 1V reference voltage. The equation for a reading is given as:

\[ \text{Reading} = 10^3 \frac{V_L}{V_{\text{ref}}} \]

\[ \text{Reading} = 10^4 \frac{V_H}{V_{\text{ref}}} \]

Fig. 1. Circuit of Panel Meter. The pin-out of IC1 is shown top right

COMPONENTS

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<th>Resistors</th>
<th>10k</th>
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</table>

A kit of parts is available from Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts, SP5 25J. (Tel. 07948 567) at a price of £29.95 including p&p and VAT.
LATCH INTEGRATE DE INTEGRATE REST X10 DE2 REST X10 DE3 INTEGRATE

Fig. 2. Integrator waveform for negative input voltage showing successive integration phases and residue voltages

Ra and Rb are optional extra resistors which can form a potential divider if greater than 2 V f.s.d.s are required. Rb should be added on its own if the instrument is required to measure current.

<table>
<thead>
<tr>
<th>Required</th>
<th>F.S.D.</th>
<th>Ra</th>
<th>Rb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2V</td>
<td>HI</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>20V</td>
<td>HI</td>
<td>9M*</td>
</tr>
<tr>
<td></td>
<td>200V</td>
<td>HI</td>
<td>10M*</td>
</tr>
<tr>
<td></td>
<td>2kV</td>
<td>HI</td>
<td>10M*</td>
</tr>
<tr>
<td></td>
<td>200µA</td>
<td>LO (o/c)</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>2mA</td>
<td>LO (o/c)</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>20mA</td>
<td>LO (o/c)</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>200mA</td>
<td>LO (o/c)</td>
<td>—</td>
</tr>
</tbody>
</table>

*Ensure PCB link across Ra is cut

R4 and C2 form an input smoothing filter and R6 and C5 form the oscillator time constant. The oscillator runs at about 100kHz.

ANALOGUE INPUTS

IN HI, IN LO, REF HI and REF LO (pins 13, 12, 14, 15) are true differential inputs. That is to say that they respond to the voltage across them and not their voltage with respect to the power supply. There is a limit to this however, known as the common mode range. Any input can be no greater than (V+) -0.5V and no less than (V-) +1.5V. It is recommended, however, that for best performance the inputs are kept well within the common mode range. The ideal situation is to connect both IN LO and REF LO to COM (pin 10). Common is actively held at approximately 3.2V below V+.

By far the biggest problem encountered by users is failing to connect both IN LO and REF LO to COM (pin 10). Common is held. When held Lo, the result of the counter contents are held. When held Hi, the last displayed reading is shown incrementing during the de-integrate phase of the cycle.

DIGITAL SECTION

Digital ground (DGND) is held at between 4-5 and 6 volts below V+. This is the supply voltage for the digital section including the display drivers. If CMOS logic is used to provide or decode DPM60 digital signals, then it can be powered from V+ and DGND up to a maximum of 1mA. For greater power it will need to be buffered.

DISPLAY FORMAT

The ICL7129 is designed to drive a triplexed liquid crystal display. This type of display has three backplanes and is driven in a multiplexed format. The actual display is shown in Fig. 3. Notice that the polarity sign, decimal points, low battery and continuity annunciators are directly driven by the i.c. The individual segments and annunciators are addressed in a manner similar to row-column addressing. Each backplane (row) is connected to one-third of the total number of segments. BP1 has all F, A and B segments of the four least significant digits. BP2 has all the C, E and G segments. BP3 has all D segments, decimal points and annunciators. The segment lines (columns) are connected in groups of three, bringing all segments of the display out on just 12 lines.

MODULE FEATURES

The ICL7129 has a large number of features which make it very useful in such applications as auto-ranging digital multimeters. Note that 'Hi' means V+(6) and 'Lo' means DGND(16). Four of the pins are input/outputs featuring 'weak' outputs. Referring to Fig. 4, the output is connected to the input internally via a resistor. Thus to use it as an input, the 'output' is easily and safely overridden. In order to obtain the output data, the pin must be connected to a high impedance input.
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| Please send me full data on the Beckman enthusiast's multimeter range. (Tick box if required) |

I enclose a cheque/PO, payable to:

Beckman Instruments Ltd.

Name: ____________________________

Address: ____________________________

Please allow 14 days for delivery.
DP3/UNDER RANGE (3)
Input: When pulled Hi the next most left decimal point will be shown. If DP3 is not to be used, connect it Lo.
Output: The output will go Hi if the result is less than ±1000.
Note: If DP3 is to be shown and the U/R signal is to be sensed at the same time, then Pin (3) should be gated with latch/hold as described above.

DP2 (18), DP1 (19)
These pins have an internal 3µA pull down and need not be connected if the decimal points are not to be shown. To show the point, connect Hi.

RANGE (17)
This pin has an internal 3µA pull down and need not be connected for a 200mV full scale. For 2V full scale connect Hi.

LOW BATTERY (NO PIN)
If the power supply voltage between V+ and V− is less than 7.3V (nominal) then the low battery annunciator will be shown. The feature cannot be overridden.

CONSTRUCTION
The p.c.b. supplied is of the double-sided plated through hole type and if a mistake is made in soldering the components in (especially the ICL7129 or the LCD), it can be very difficult to rectify the fault. Avoid using excessive solder and hold the iron on the component for no longer than is necessary. The ICL7129 is a MOS device and although its inputs are protected, antistatic precautions should be taken. The order in which the components are soldered onto the board is important, so do follow the instructions.

All components except C3, VR1 and the plug are inserted on the top of the board. The top is the side marked DPM60/2/B. Because the LCD has to straddle the components on the board, they should be mounted as close as possible to it. Although the board is solder-masked, ensure no solder bridges are allowed to occur.

CONNECTOR FITTING METHOD
1. Assemble all the resistors (except VR1) onto the board and solder in place.
2. Bend and cut the leads of C3 to size, ensuring that when fitted underneath the board, the leads will not protrude more than 0.5mm above the top. Solder C3 in and the other capacitors. Ensure that C1, 4 and 6 are fitted with the correct polarity and that C2, 4 and 6 are fitted flat to the board (see Fig. 7).
3. Fit IC1 ensuring that the correct lead is removed (see Fig. 1). Fit close to the board ensuring correct polarity and solder.
4. Next fit IC2. Ensure that all the leads are correctly spaced and it is correctly orientated before soldering close to the board.
5. Now fit R1 from underneath the board and solder in place from top of the board.
6. Repeat 5 for the two-part plug, PL1.
7. If you intend to use the DPM60 inside the case then only fit the lower edge connector to the display. For general purpose panel meter applications fit the upper
Most semiconductor circuitry is very sensitive to excessively high supply voltages. A supply voltage below the rated minimum can cause incorrect functioning of the circuit, but voltages above the rated maximum, whether continuous or transient in nature, will often result in both malfunction and permanent damage. Such an 'overvoltage' condition is usually caused by either a short circuit between one supply rail and another, or by the failure of a voltage regulator, which could then pass high level unregulated voltages directly to the rest of the circuit. The problem is made especially serious when the main circuit components are particularly expensive. This can cause difficulties for many designers, who as a result may be unwilling to use a power supply of their own design with complex or costly circuitry.

The MC 3423 is an 8 pin i.c. which can give a considerable measure of protection against overvoltage conditions. It monitors the voltage of the power supply continuously, and as soon as the voltage rises above a predetermined level it trips, turning on an external thyristor and causing the supply to current limit, shut down, or blow a fuse, as appropriate. This arrangement of shorting out the power supply is often called crowbar protection. Naturally, it assumes that the supply itself is capable of withstanding such a short circuit.

The pinout and specifications of the device are shown in Fig. 1, and the basic overvoltage circuit is shown in Fig. 2. Note that D1, C1, and R4 are only needed if the positive supply is greater than 36V; they ensure that the positive supply to the i.e. is kept well below its maximum, while still allowing voltages of up to 45V to be used for the main supply. Normally, D1, C1 and R4 are omitted, and pin 1 connects directly to the positive supply. If these components are being used, R4 should be arranged to allow 25mA to flow through it:

$$R4 \text{ (in kilohms) } = \frac{\text{positive supply voltage}}{25}$$

 Pins 2 and 3 are the sense pins, with the potential divider formed by R1 and R2 determining the proportion of the power supply voltage fed to them. This sense voltage is compared with a fixed internal voltage reference of nominally 2.6V. The result of the comparison is used to determine whether or not to fire the thyristor. Hence, the voltage at which the MC 3423 trips is given by:

$$\text{Trip voltage} = 2.6 \times \frac{R1 + R2}{R2}$$

For best results, R2 should be kept below 10k. Note that both pin 2 and pin 3 must have reached 2.6V before the thyristor is turned on.

**Fig. 1. Overvoltage protector integrated circuit pin-out with its specification below**

**Table:**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>Minimum</th>
<th>Typically</th>
<th>Maximum</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>All specs measured at +5V supply</td>
<td>4.5</td>
<td>36</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Monitored voltage</td>
<td>Supply to pin 1 ≤ 36V</td>
<td>45</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>0°C</td>
<td>70</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiescent current</td>
<td>≤ 5mA</td>
<td>6.6</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense input voltage</td>
<td>Both sense input 1 and 2</td>
<td>7V</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote input voltage</td>
<td>≤ 300mA</td>
<td>3</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage</td>
<td>Pin 8</td>
<td>2.6</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal reference voltage</td>
<td>≤ 0.08V</td>
<td>220</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. variation of Vth</td>
<td>≤ 0.04°C</td>
<td>10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current from pin 4</td>
<td>Constant current source</td>
<td>100</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time delay</td>
<td>Minimum time, from overvoltage, to driving of thyristor</td>
<td>0.5</td>
<td>μs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output current rise time</td>
<td>0.4</td>
<td>A/μs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 2. Basic overvoltage protection circuit**

**Fig. 3. Circuit to give delay before tripping**

regulated supply, but the unregulated supply from which it is derived, since this will be presented to the circuit if the regulator goes short circuit. An unregulated d.c. supply may be capable of supplying a short circuit current of many amps for a few seconds, whereas the regulator may pass only 500mA or 1A typically. The usual arrangement is to provide a suitable fuse prior to the regulator i.e. or circuitry, to reduce the current carrying requirements of the thyristor. The continuous current rating of the thyristor should in any case be.

**Fig. 3. Circuit to give delay before tripping**
with overvoltage protection, with a current capability of up to 1A depending on the heatsink provided and the unregulated supply used. The basic regulator circuit is formed by IC2, with C3 and C4 providing decoupling (essential to prevent oscillations) and D2 providing a measure of protection against temporary shorts to negative supply rails. R4 and D3 (which can be any type of i.e.d.) merely give an indication that the supply is operational. R1 and R2 set the trip voltage at approximately 5·8V. (It is wise to leave a few hundred millivolts at least above the nominal regulator voltage to allow for device and component tolerances, noise, etc.) R3 is set to 47 ohms, not a short circuit as one may have chosen from Fig. 4, because if IC2 were to go short circuit a much higher voltage could be fed to IC1. With R3 equal to 47 ohms, this unregulated supply can safely be up to 25V d.c. (For other supplies, scale this accordingly).

Fig. 4. Graph of minimum value of R3 versus positive supply voltage

Fig. 5. Graph of value of C2 versus time delay (see Fig. 3)

The thyristor chosen is a 5A type, which in conjunction with a 1A regulator i.e. and a 1A fast blow fuse gives more than enough protection capability. Large, finned heatsinks should be provided, the largest being for IC2 since that might have to pass short circuit currents for quite long periods with high power dissipation, and silicon grease should be used between the semiconductor device and the heat sink surface. Beware of letting the heatsinks or their fixing screws short against anything; IC2's heatsink is connected to OV via IC2 itself, but TR1's connects to its anode (the positive supply rail) so take care. It may be necessary to open up the Veroboard holes a little with a fine drill to take the large leads of TR1; take care not to cut away all the copper track, and make a good solder joint to these leads.

The unregulated supply used should be chosen to suit IC2, i.e. a minimum voltage under load of 8·5V d.c., at 1A or more, but not too large a voltage or IC2 will dissipate too much power, and the amount of regulated supply current available will be small. (The voltage should, in any case, be kept under 25V off load). The final circuit can be tested by shorting IC2's input to its output, which should shut down the supply and blow the fuse, or by connecting a 9V battery across the 5V supply, which will shut down the supply but probably not blow the fuse. (Connect the battery only momentarily, or via a 1A fuse itself). Try not to let the circuit stay shut down for too long as IC2 will get rather hot. Naturally, all voltages given in this circuit can be scaled to suit different supply voltages as required.

The MC 3423 can be obtained from Watford Electronics.

Fig. 6. Circuit of 5 volt protected regulator (D1 and C1 of Fig. 2 are omitted)

Fig. 7. Board assembly details of regulator
## NEW LOGIC SYMBOLS

<table>
<thead>
<tr>
<th>OLD SYMBOL</th>
<th>REPLACED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>AND</td>
<td>(a)</td>
</tr>
<tr>
<td>NAND</td>
<td>(b)</td>
</tr>
<tr>
<td>INVERTER</td>
<td>(c)</td>
</tr>
<tr>
<td>AND</td>
<td>(d)</td>
</tr>
<tr>
<td>NAND</td>
<td>(e)</td>
</tr>
<tr>
<td>AND</td>
<td>(f)</td>
</tr>
</tbody>
</table>

NEW LOGIC SYMBOLS

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TWENTY-FIVE YEARS ago the use of digital electronics was almost solely confined to computers. At that time only about one thousand machines were completed in the whole year. Since that time, however, the growth of digital electronics has been both continuous and spectacular. Today, one manufacturer alone can produce more hand calculators in one hour than the total number of computers then produced worldwide in a whole year. To underline the rate of advance which has occurred, some of these new calculators now have more computational ability than any of those 1958 computers.

This series aims to provide a practical introduction to the subject of digital electronics. The material that we shall be covering is suitable for students in education, electronics hobbyists, and newcomers with an interest in digital electronics. All that we assume is that the reader has some elementary knowledge of basic electricity (a familiarity with voltage, current and resistance), and an understanding of simple wiring. No mathematical knowledge is required other than the ability to count up to two! Indeed, the most important requirements are a curiosity about the way in which things work, and an interest in building real circuits to solve practical problems.

The series will appear in eight monthly parts, and is supported by practical work on a Logic Tutor to simplify the construction and investigation of digital circuits. Each part of the series will build on the preceding parts, and the pages will be laid out in a constant format to allow them to be collected into a complete reference. Regular data sheets will be used to summarise useful practical information separately to avoid interrupting the flow of material. The basic approach that we will adopt is to introduce each logic element in terms of a small number of basic 'building blocks'. It should be possible to explain each new circuit in terms of these basic elements.

The most important point to make, however, is that this series is all about 'real' digital electronics. The idea is to use logic in practice, and to this end the examples given will involve using real integrated circuits to bridge the gap between theory and practice. It is otherwise all too easy to overlook the differences between 'perfect' paper devices, and the ones that can actually be bought in the shops. This problem usually only shows itself as a circuit which 'should' work, but doesn't.

ELECTRICAL SIGNALS AND INFORMATION

One effect of the continuous advance of semiconductor technology is that electronics are being used in an ever increasing variety of everyday applications. The complex functions of these electronic circuits can, however, easily obscure some of their basic characteristics. As a result, it is not always obvious at first sight that everything which is done in an electrical system involves either manipulating information or doing work, or sometimes a mixture of both. The 'information' in an electronic circuit is in the form of an electrical signal, while the 'work' done is often some type of mechanical movement. A radio receiver, for example, manipulates information in the broadcast programme which starts as a modulated radio carrier, and ends up as an audio signal; the work done is in making the loudspeaker cone vibrate to transfer the final sound to the listener.

The aim of this series is to investigate a branch of electronics which is devoted to manipulating electrical signals which are being used to represent information. We will start, therefore, by looking at the ways in which electrical signals can be used to represent information in practical circuits and systems.

ANALOGUE SIGNALS

We usually think of an electrical signal as a voltage which varies in level as time passes, but it can just as easily be a varying current. When this voltage is plotted against time on a graph, the result is known as the waveform of the signal during the time shown by the graph. A waveform which is often encountered in electronics is the sinewave, shown in Fig. 1.1. Examples of signals which have a sinewave shape include the mains electricity, and
the output signal from a microphone being used to record a tuning fork.

A sinewave has a simple and regular waveform which has two peaks at different voltage levels, and which repeats every cycle. The signal changes smoothly from one peak of voltage to the other peak, and then back again. Other signals, such as those shown in Fig. 1.2, are not as smooth as a sinewave, but they are still of a regular nature. Returning to the tuning fork for a moment, we can see that if we watch the microphone output for a longer time after it is struck, the shape of the signal remains the same but the peaks gradually die away as the sound gets quieter. This is an example of the way in which one waveform may be added to another. There is, however, no reason why the waveform of a signal needs to be regular at all, and Fig. 1.3 shows what the microphone signal might look like if used to record a singing voice, rather than a tuning fork.

Signals with waveforms of the type described above fall into a general category known as analogue signals. The voltage level of an analogue signal typically varies smoothly between two extreme limits, though not necessarily always reaching these limits. The variations will not always be regular, however, nor will the changes always be smooth. Circuits which use these types of signals are called analogue circuits, and are widely used in radio, television and audio, as well as in many types of measuring equipment.

DIGITAL SIGNALS

Digital signals are very different in nature to the analogue signals described above. A digital signal does not change its level smoothly, nor does it vary freely over a range of levels. When the voltage level of a digital signal is not rapidly changing, it remains steady at one of only two possible levels, called states. Any changes between these two states occur very rapidly (typically requiring only a small fraction of a microsecond), and are so fast that for practical purposes they occupy an almost negligible time. The two possible states for digital signals are commonly referred to variously as 'low'/'high', 'off'/'on', 'false'/true' or, most often, simply as '0'/1'. Conventionally, the two (binary) states in a digital system are defined so that the low/off/false/0 state refers to the lower voltage level, while the high/on/true/1 state refers to the higher voltage level. In this series we will adopt 0 and 1 to refer to the binary logic states since this is the most common and useful definition. The majority of practical digital applications are designed so that 0 is usually represented by a level near zero volts, and 1 by a level slightly below the supply voltage.

A transfer characteristic for a circuit shows graphically how the output responds to an input signal. The characteristic for a typical digital circuit is shown in Fig. 1.4. The output remains at the 0 level until the input exceeds a certain (threshold) value, at which point the output rapidly changes state from 0 to 1.

ADVANTAGES OF DIGITAL SYSTEMS

One of the attractions of digital systems is that they offer a number of significant advantages over their analogue counterparts. In an analogue system, changes in component values (due to ageing and temperature effects) can have a marked effect on circuit performance, and considerable care must be taken to combat such changes. Applications requiring high precision are particularly troublesome in this respect. Digital systems, however, use switching techniques and are much less susceptible to individual component changes, and they are thus not as prone to the effects of ageing and drift.

Noise and interfering signals can be a significant problem in some analogue circuits, particularly those handling small signals. Digital circuits, on the other hand, can be almost impervious to the effects of noise or interference. This is because, if it is to have any effect, the unwanted signal must have an amplitude which is comparable to the switching threshold of the circuit.

THE PE LOGIC TUTOR

The PE Logic Tutor is introduced on page 26 and a full description of the system, together with constructional details is given there. The purpose of the PE Logic Tutor is
DIGITAL ELECTRONICS

To allow us to investigate the behaviour of a wide range of practical digital circuits, we will be reviewing the range of facilities provided by the Logic Tutor a little later. For the moment, however, we will direct our attention towards some practical ways of indicating and generating the logic levels to be found in practical digital circuits.

INDICATING LOGIC STATES

We have seen that digital circuits transfer information by using signals which represent the binary states of 0 and 1. The designers of such circuits, while free to choose the actual voltages used to represent these two states, usually choose to keep to the convention of representing 0 by the lower voltage, and 1 by the higher voltage. The majority of today’s digital circuits in fact use the same voltage levels for 0 and 1 as those used in the PE Logic Tutor. These levels are such that any voltage below 1 volt is a logic 0, and any voltage above 2.5 volts is a logic 1.

When we investigate how a digital circuit works, it is useful to be able to look at the logic state (0 or 1) at any point. We could use a conventional voltmeter for this purpose, but it becomes rather tedious each time to have to measure the voltage, and then decide whether this represents 0 or 1. A much easier, and quite widely used, alternative is to use some sort of indicator which shows the logic state at a glance. Light emitting diodes (I.E.Ds) are ideally suited to this purpose, and are used extensively in the PE Logic Tutor. The normal convention adopted is that when an I.E.D is on, this indicates that a logic 1 is present, otherwise the state is a logic 0. The PE Logic Tutor follows this convention for displaying logic states.

Indicators D1 to D4 are each available to show the logic state at any point in a digital circuit. They are used by simply linking a wire between the point under investigation and the appropriate indicator’s connector: D1, D2, D3, or D4. A simple demonstration of this technique can be given by using the power supply rails as sources of logic signals. According to our definition above, +5 volts should indicate as a 1, and 0 volts as a 0 when connected to the input of D1 in turn. Therefore when +5 volts (logic 1) is connected, the I.E.D should be illuminated, whereas when 0 volts (logic 0) is connected, D1 should be extinguished. Repeating this demonstration using the signals from the sockets labelled ‘logic 0’ and ‘logic 1’ (adjacent to i.c. socket A) should produce similar results.

GENERATING LOGIC LEVELS

When investigating the behaviour of a digital circuit, it is useful to be able to produce a known logic level (0 or 1) to apply to the circuit in question. This allows us to see how the circuit responds to different combinations of inputs. As we have seen, the PE Logic Tutor provides us with indicators to show logic states at any point in the circuit. In addition, therefore, four logic level generators, S1 to S4, are provided to complement the indicators. These generators are operated by push-button switches, and allow us to produce logic 0’s and 1’s as required. Built in to each generator is an I.E.D to indicate the instantaneous logic state of its output. Operating these switches in turn will show that two of them (S1 and S2) produce a 1 for only as long as the switch is pressed, whereas the other two (S3 and S4), change the output state each time the switch is pressed. These two different types of logic generator will be useful in differing applications, as will be seen in due course.

FIXED LOGIC LEVEL

Sometimes, instead of a variable level, a circuit requires a fixed logic level at one of its inputs. This may possibly be routed via a switch or other external electromechanical device, before being input to a logic circuit. To cater for such requirements, the Logic Tutor provides fixed logic 0 and logic 1 sources. These have no indicator I.E.D.s associated with them since they are each capable of driving over twenty logic inputs. As before, however, indicators D1 to D4 may be used to verify their correct operation in case of any doubt. Wherever possible, it is preferable to use the logic 1 source rather than the +5 volt supply rail since this will minimise the effects of accidentally shorting the supply to the 0 volt rail. Even though the power supply is protected, a short circuit could still upset the logic states established in a circuit.

I.C. LOGIC FAMILIES

As we have mentioned, computers were the majority users of digital circuits during the 1950’s. Since then, however, digital techniques have been applied to the solution of an ever wider range of problems. One of the major reasons for this expansion has undoubtedly been the rapid advances in semiconductor manufacturing technology during the same period. Indeed, we are now seeing the introduction of some advanced circuits which manipulate analogue signals by first converting them into equivalent digital signals, processing the two using digital techniques, and then converting back to an analogue signal at the output. This, however, is running ahead of the present series, in which we aim to provide an introduction to the underlying principles of digital logic circuits.

The computers of the 1950’s used assemblies of discrete semiconductor devices (transistors and diodes) and passive components. Often the basic circuits were repeated many times over in a single unit, and as a result, the development of the integrated circuit (I.C.) in the late 1950’s led quickly to the introduction of digital i.c.s. Initially, these i.c.s were simply subcircuits (known as ‘gates’), comprising a few transistors, diodes and resistors in a single semiconductor ‘chip’. Capacitors were (and still are) rarely included due to the difficulty of fabrication. As a technique developed, a number of ‘standard’ gates came into common use, and these were subsequently interconnected in a single chip to produce more complex digital circuits. This increase in complexity has continued to the present day, to the point where a modern microprocessor i.c. may have the equivalent of over 20,000 basic gates in a single chip.

STANDARD LOGIC FAMILIES

As part of the development of digital i.c.s, a number of standard ranges have been introduced. The importance of the concept of standard logic families cannot be over-stated. The basic gate in each range gives the name to the complete family of devices, and determines the operational characteristics of all devices in the family. In this way, the designer is freed from the problem of checking that the logic levels between gates are compatible; the logic levels, power supply requirements, and general rules are common to all i.c.s in a logic family. This then allows the designer to concentrate on the design of the function of his circuit, and greatly simplifies his overall task once the basic ‘rules’ for that family are understood.

Over the years a number of different
logic i.c. families have been available, but many have now virtually dropped out of use. The main families to have emerged are as follow:

(a) DTL = Diode-Transistor Logic  (b) TRL = Transistor-Resistor Logic  
(c) RTL = Resistor-Transistor Logic  (d) DCTL = Direct-Coupled-Transistor Logic  
(e) RCTL = Resistor-Capacitor-Transistor Logic  (f) TTL = Transistor-Transistor Logic  
(g) TSL = Tri-State Logic  (h) ECL = Emitter-Coupled Logic  
(i) CMOS = Complementary MOS logic  (j) PMOS = P-channel MOS logic  
(k) NMOS = N-channel MOS logic  

Each logic family listed above has its own special characteristics which may make it more appropriate for particular applications, e.g. ECL is very fast, but requires considerable power. In current practice, however, the families which are most commonly used are TTL, TSL and CMOS; ECL is also frequently used where the highest speed is required. Without doubt, however, it is the TTL family in its various forms which is the logic family in widest use, and we have therefore restricted practical discussions in the majority of this series (parts one to seven) to TTL, with part eight providing coverage of CMOS.

At this point we should, however, stress that the theory of digital logic is the same for all logic families. The differences between the various families are confined to the practical aspects of building circuits, e.g. the power supplies required, the logic levels, etc. A clear understanding of the theory of logic circuits, therefore, can rapidly be applied to any logic family by simple reference to the electrical specifications and the operating 'rules'.

THE 7400 TTL SERIES

TTL is a form of logic which has gained a very high degree of acceptence. The internal circuit for a basic TTL gate is shown in Fig. 1.5: note the distinctive multi-emitter transistor associated with the input stage of the gate. We do not actually need to understand the details of this circuit in order to be able to use it, but it is an indication of the size of circuit which would be involved if i.c.s were not available. The commonest TTL family is known as the '7400 Series'. Each i.c. in the 7400 series has a type number of 4 or 5 digits, always starting with '74', e.g. 7404, 74123. Different manufacturers add various letters before and after the basic number, e.g. SN7400N, but i.c.s of the same number will always have the same function, whoever the manufacturer. The range of TTL i.c.s which is available is considerable, with many manufacturers offering hundreds of different types.

The basic transfer characteristic for TTL is shown in Fig. 1.6. As we can see, there is a range of input voltage which will produce an indeterminate output level. This means that the output for an input in this range cannot be predicted in terms of logic level. Although possibly surprising, this is quite common in digital logic circuits, and does not destroy the theory. A logic 0 is defined in TTL as a level of less than 0.8 volts, while a logic 1 is a level greater than 2.4 volts. The indeterminate outputs therefore correspond to illegal input levels! We shall return to consider the other characteristics of TTL at a later stage, but for the moment the only other information

![Fig. 1.5. Internal circuit for a basic TTL gate](image)

![Fig. 1.6 Transfer characteristic for TTL](image)

![Fig. 1.7. Main features of the PE Logic Tutor](image)
we require is that the supply voltage for TTL is +5 volts.

The basic characteristics of the TTL 7400 Series are summarised in the data sheets which accompany this series. Further details are available from manufacturers' data books.

**PE LOGIC TUTOR SUMMARY**

The aim of the PE Logic Tutor is to allow the user to construct and investigate the behaviour of a wide range of i.c. logic circuits. The main elements of the Logic Tutor, are summarised in Fig. 1.7. The items of significant interest are as follows:

(a) A regulated and protected power supply which provides supply rails at +5 volts and 0 volts
(b) A breadboarding area which can accommodate up to six 14-pin or 16-pin dual-in-line i.c.s
(c) Four logic state indicators incorporating i.e.d.s
(d) Four switch-controlled logic level generators; two of these have a momentary action, while the other two have a latching action
(e) A low frequency square wave signal generator which provides a logic-compatible clock at approximately 1Hz

In order to cater for developing and investigating the behaviour of more complex circuits than can be built in the existing breadboarding area, a 10-way extension connector is also provided. This allows the connection of external circuitry and, with the aid of a supplementary circuit board, also provides a way of increasing the breadboarding area.

The power supply to drive the board may be either an a.c. or d.c. source of between 8 and 12 volts, with a typical supply current of around 150 to 200mA. This type of supply is usually readily available in most laboratories and workshops. Just as suitable, however, is a simple a.c. mains 9V adaptor of the type used with many calculators and cassette recorders.

The use of the Logic Tutor provides a means of reinforcing the subjects covered in this series. The object is to supply examples every month which allow practical investigations to be undertaken, in order to provide the essential 'hands-on' experience. The examples have been carefully designed to complement the subjects discussed, and to develop a familiarity with the use of digital logic techniques. Even when the series has been followed through, the Logic Tutor will still be useful as a development tool in its own right.

**THE BUFFER**

We have already mentioned the fact that there is an almost bewildering array of digital 'building blocks' available to today's logic designer. The simplest of all active logic elements is without doubt the logic buffer. This has only one input and one output, and the logical state of its output is a direct copy of the logic state at its input. Hence an output of 0 is produced whenever the input is 0, and a 1 is produced for an input of 1. Since no apparent logical operation has been performed by the buffer, it may at first sight seem to be a rather strange element to want to include in any logic circuit. There are, however, a number of situations in which a buffer can be quite invaluable.

The first point to note is that the description given above refers only to the voltage levels at the input and output of the buffer. The current flowing at the output of a buffer, however, can be much greater than the current at its input, even though the logic levels (in terms of the input and output voltages) remain essentially the same. Hence a buffer is said to exhibit 'current gain', which is a consequence of its internal circuitry. In this way, buffers can be used to interface a logic system to circuitry which demands so much current that the logic levels could not be maintained within their limits if other types of logic elements were used instead. Similarly, it is often possible to connect more logic elements to the output of a buffer than is possible with other types; the buffer preserves the logic state of the signal, but increases the current 'drive' which is available.

Finally, buffers may be used to regularise and standardise the input signals, in terms of logic levels, that are presented to, or taken from, a logic circuit.

When drawing logic circuits, the symbol used to represent a buffer is shown in Fig. 1.8. In logic diagrams it is normal to show the input on the left hand side, and the output on the right. Thus, in most logic circuits, the 'progress' of a logic signal is usually from left to right across the page. At this juncture, it is worth illustrating these points by introducing the first of the rules which must be observed when connecting logic elements together. A single output may be connected to a number of different inputs, but each may normally only be taken from one output (i.e. you may not connect several outputs together and expect the circuit to behave properly!). We shall return to discuss this point in greater detail later on, but for the moment this important rule is summarised in Fig. 1.9.

**THE INVERTER**

An inverter, or inverting buffer as it is sometimes known, is a logic element which is like a buffer in that it has only one input and one output. Inverters are used to generate the logical opposite, or complement, of a logic signal. In order to understand this definition, however, we must first explain that the complement (or inverse) of 1 is 0, and the complement of 0 is 1. Hence, when the input of an inverter is 0, its output will be 1; similarly, when the input is 1, the output will be 0.

The action of an inverter can be illustrated by looking at the simple relay circuit shown in Fig. 1.10. When the
logical input is at a 0 level, no current flows in the relay coil and the contacts remain in the state shown, producing an output level of 1. When the logical input is a 1, current flows in the relay coil, the contacts change over, and a 0 is produced at the output. The relay thus inverts the logical signal so that an input of 0 becomes an output of 1, and vice versa. The relay in this example is in effect acting as an electromechanical inverter.

The 7404 consists of six individual inverters in a single 14-pin dual-in-line package. The pin connections and internal logic arrangement for the i.c. are shown in Fig. 1.12. When identifying the pins, view the i.c. from above (i.e. with the pins pointing downwards). The notch on the package is then between pins 1 and 14, and with the notch on the left, the pins are numbered anti-clockwise starting with 1 in the bottom left corner. In a few cases there will be no notch on the i.c. package, but instead there will be a round indentation on the top of the package next to pin 1. The power supply connections for 0 volts and +5 volts are at pins 7 and 14, respectively.

A 7404 should be carefully inserted into the dual-in-line socket marked 'A' on the Logic Tutor. It may be necessary to pre-form the i.c. leads so that both rows of pins will fit into the socket, or an i.c. insertion tool may be used instead. Care should, in any event, be taken to ensure that the chip is orientated with pin 1 in position A1; this will then mean that pin 14 will be in position A16; the notch should be between A1 and A16. As a final check before proceeding, it is worth verifying that all of the i.c. pins are correctly inserted in the socket, and that none have been bent under during the installation.

The first test circuit to be set up is shown schematically in Fig. 1.13, and uses the (a) inverter. The diagram here includes the connections to the power supply, as well as the logic interconnections. In normal practice, however, these power supply links are omitted from circuit diagrams since it is assumed that every i.c. will be connected to the +5 volt and 0 volt rails at the appropriate pins. The resulting diagram otherwise becomes very confusing. It is recommended that the circuit is wired up with the power supply to the Logic Tutor switched off. Link the positive supply to pin 14 of the i.c. by connecting a wire from any +5V point to A16. Similarly the 0V rail is connected to i.c. pin 7 by a wire between any 0V pint and A7. The input to the inverter (at i.c. pin 1) is connected to the logic level generator by a wire between S1 and A1. The output from the inverter (at i.c. pin 2) is connected to the logic state indicator using a link between A2 and D1. To re-cap, there should be a total of four links on the board, connected as follows:—

- S1 to A1 (input to inverter)
- A2 to D1 (output from inverter)
- A7 to 0V (ground)
- A16 to +5V (positive supply)

When the power supply to the Logic Tutor is connected, the output of S1 will be a 0 (shown by the associated I.E.D.), and the output of the inverter (shown by D1) should represent a 1. Pressing S1 will cause it to generate an output of 1, and the output of the inverter should now change to a 0, i.e. D1 should now be extinguished. Releasing S1 should cause the output of the inverter to resume its original state, i.e. 0.

Readers may wish to verify that the same behaviour is obtained from the other inverters in the 7404; the necessary pin connections may be taken from Fig. 1.12.

Keeping the circuit already set up, we can now extend it to demonstrate the result of cascading two inverters to produce the buffer action mentioned earlier. The two inverter circuit shown in Fig. 1.14 uses the (a) and (f) inverters from our 7404, though any pair may be used. This circuit is set up on the Logic Tutor using the following links:—

![Fig. 1.14. Double inverter test circuit](image-url)
DIGITAL ELECTRONICS

S1 to A1  A2 to D1  A7 to OV  A16 to +5V
A2 to A15 (connect O/P of (a) to I/P of (f))
A14 to D2  (O/P of (f) to D2)

As for previous circuit

When this circuit has been set up, D1 should normally be on and D2 off. Pressing S1 should cause this to swap over so that D1 is off and D2 is on; D2 should always be in the same state as the i.e.d. associated with S1.

The final circuit is left as an exercise for the readers, and uses all six inverters in the 7404. The idea is to prove that replacing each inverter in the circuit above with three inverters in series (i.e. output of first to input of second, and output of second to input of third), and using the input of the first and the output of the third, will give a circuit which behaves in the same way as the one last investigated. Thus if we have connected up the inverters in the sequence a-b-c-d-e-f, then connecting S1 to A1, D1 to A6/A11, and D2 to A14 will produce an equivalent circuit from a logical point of view. In effect, the whole i.c. has been set up to behave as a single buffer made up of six inverters!

NEXT MONTH: Logic gates, truth tables and fan-outs.

INTRODUCTION TO DIGITAL ELECTRONICS

FURTHER READING

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Ian Sinclair
Holt, Rinehart and Winston
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This is another in the excellent TI 'Understanding Series'. This one provides a self-teaching course on digital circuits, arranged in the form of a question and answer text. It covers digital components, logic systems, memories, and even looks briefly at computer hardware and software. The book is copiously illustrated, and as with the other books in the series, adopts an informal and essentially non-mathematical approach. Each of the ten chapters concludes with a quiz (answers provided), and the book contains a comprehensive glossary of terms.

Gene McWhorter
Texas Instruments
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TTL COOKBOOK

At first sight, a rather strangely titled book, but for all that one of the best selling technical paperback books of all time. The essential point of this book is that it presents the material in a manner which expects to be used. Chapter 1 looks at the basics of TTL, while Chapter 2 is a catalogue of some 80 TTL devices, each presented as a single-page data sheet. Chapters 3 to 7 look at logic and logic circuit techniques, all in an easily understandable manner, with numerous examples and practical tips. The final chapter looks at 'Getting it all together', turning the theory and ideas into practical TTL projects. An excellent book; do not be put off by the rather inflated import price.

Don Lancaster
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This book is unusual amongst electronics textbooks in that it starts right from the beginning, and assumes no previous knowledge of electricity or electrical circuits. Indeed, to quote from the preface: 'This book was created for the reader who wants or needs to understand electronics, but can't devote years to the study'. A glossary and self-test quiz is included for each chapter, and the entire text is presented as a series of questions and answers. Those who may have found other books using the Q&A format rather disjointed need not worry; "Understanding Solid State Electronics" is logically structured, and is eminently suited to the newcomer.

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Ian Sinclair
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Practical Electronics October 1983
Space Watch...

A COMPANION FOR UKIRT

The site of Mauna Kea, on Hawaii, has been disturbed again. The work was begun at an official ceremony on the 14,000 ft high mountain early in June. A budget of 1.5 million pounds per annum is to be shared between the Science and Engineering Research Council (SERC) and the Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek (ZWO). The capital cost of the project will be £7M, in the ratio of 80% from the United Kingdom and 20% from Holland. The telescope should be completed by 1986. It will be remotely controlled like UKIRT but cover a different part of the spectrum.

The view on the Universe is to some extent dependent on the atmosphere. There are as it were various windows through which the astronomer may examine the surrounding scene. Thus at certain frequencies there must be a window which is transparent to those frequencies. Also the clouds of gas and dust that lie between the stars and the Earth are the source of most of the radiation which is under study in this area. The frequency is between a few millimetres and a third of a millimetre.

There were a number of reasons why this area was relatively poorly developed by astronomers. The three main ones were—the lack of receivers which were sensitive enough, the signals being absorbed by water-vapour before reaching the telescopes and the problem of making large instruments with sufficiently accurate reflecting surfaces.

Detectors using elements as small as one micron square and cooled to a few degrees above absolute zero have been developed to satisfy the first difficulty. The second problem has also been overcome to a large extent now that the University of Hawaii has an observatory at such high altitude. The new telescope will be 15 metres in diameter and will overcome the third problem. To be capable of efficient operation the reflecting telescope used must have a surface accuracy of a small fraction of the wavelength of the radiation to be received. The surface of the 15 metre bowl must not deviate from paraboloid by more than 50 microns, including the effects of gravitation when the bowl is tilted or as the temperature changes. To protect it from the weather and from Solar Radiation it will have a co-rotating enclosure which will turn with the telescope. This will have a window covered with a special membrane which is transparent to the wavelengths required but which will reflect much of the sunlight which falls upon it. This also helps to control the temperature gradients that will be encountered in the environment.

The paraboloid surface of the telescope will be made up of 276 panels mounted on a steel frame designed for the minimal and also predictable distortion under gravity as the elevation angle is changed. The panels are of lightweight construction consisting of anodised aluminium honeycomb covered with thin skins of aluminium sheet. Each is supported on three mounts which can be adjusted remotely. The measurement of this surface is very difficult and a sophisticated machine which incorporates a laser interferometer is being developed to deal with this problem. The mount of the telescope is of the Alt-Azimuth type with motor drives and friction contact with the tracks.

The optical design is that of the folded Cassegrain type with a 75cm diameter secondary mirror to focus the radiation on to one of a number of secondary mirrors via a third mirror mounted behind the primary. By mounting a number of receivers simultaneously, each set at a particular frequency or range of frequencies, it will be possible to optimise the use of the telescope and observe at the highest frequencies when the transparency of the atmosphere permits.

Although the telescope has been sited at the highest major observatory in the world, thus providing outstanding conditions for sub-millimetre wavelength observations, the conditions do vary both seasonally and on a much shorter time-scale. Substantial testing of the site has been carried out and the atmospheric conditions are being continuously monitored to assist in the planning of future programmes.

THE ECLIPSE FROM JAVA

As is usual at the time of an eclipse the most suitable observation point is the subject of an invasion of scientists both professional and amateur to catch the very fleeting moments of this event. This time the site was at Surubaya, East Java. It is a remarkable thing that observing such occurrences in various parts of the world reveals details of the diversity of mankind in its daily life and worship. In Surubaya the populace remained indoors so that they could pray to be free of blindness from the visitation of a power to black out the Sun.

There is quite an amount of lore in Java connected with the eclipse. Though there are some eighteen eclipses each year they occur mainly in inaccessible places or at sea. It is therefore not possible to do much more than just watch the eclipse itself. On this occasion it was possible to measure the shadow of the eclipse. A very accurate measure of this was the task of a team from New Scientist and University College, London. The standard semi diameter of the sun is 959.63 arc-seconds.

To check this figure it is necessary to ensure that there is a facility for doing this. Observers were stationed at suitable positions and the measurements averaged. From this the team were able to say that for 1983 the diameter of the Sun was smaller than the standard figure. Their measurements gave a figure for the polar radius as 0.34 arc-seconds less than the standard figure.

SATELLITE TDRSS-A

It took 39 steps to put this satellite into correct orbit. From this experience a ten years functioning period of thruster operation was accomplished. Thus necessity provided a bonus while doing an essential task. This satellite was the first of four in the planned Tracking and Data Relaying Satellite System. Stabilisation was obtained for a very elongated elliptical orbit after the upper stage failed following deployment by the Shuttle. For a time it was thought that it would have to be abandoned. But the ground controllers decided on rescue. They were eventually faced with the onerous task of getting it into the correct orbit. This task was completed after several weeks of painstaking effort. They used the attitude thrusters to slowly put the satellite into orbit. The thrusters finally succeeded at the 39th burn which itself took 5 min. 48 sec.

During this positioning some 817 lb of Hydrazine was sacrificed to the repositioning. For its original task it is now left with only 500 lb of fuel. However it has been worked out that to do its normal task the thrusters would need only 200 lb. This would leave enough for emergencies. It was fortunate as it turned out that a cancelled experiment allowed an excess of Hydrazine to accrue. It is expected that TDRSS will be ready for testing on the 8th shuttle mission and for operational purposes on the 9th mission.

The special bonus of this emergency operation was the fact that the thrusters had some 817 lb of fuel through them during the period of orbit correction. These thrusters are about the size of a thimble and have had what is the equivalent to ten years of working life during the sixty days of this emergency use.

EUROPEAN SPACE AGENCY

EXOSAT, the X-ray Observatory Satellite, has already sent detailed information on the location, spectral and temporal characteristics of cosmic X-ray emission sources. The satellite was launched from the Vandenburg site in May last.

On-board experiments include two imaging telescopes to collect information on cosmic X-ray sources in the 0.04-2 k-electron volts range. X-rays in this part of the electromagnetic spectrum have a wavelength 1,000 times shorter than the eyes are able to see. Imaging telescopes for low energy sources such as remnants from supernova stars are also included. A colour catalogue of extra galactic X-ray sources which vary between milliseconds and days will be made. It would in fact take a complete Spacewatch to cover the tasks which are set. This is really an extension of the work of new discoveries made by the Cos-B satellite of the European Space Agency.

Frank W. Hyde
LAST MONTH, construction of the basic unit was described. This month the circuit description and construction details of both the display options are given. At least one option must be fitted to the basic unit; however, fitting both options vastly increases the versatility of the instrument.

SCOPE OPTION

This option allows stored data to be displayed as timing diagrams on an ordinary dual trace oscilloscope. The oscilloscope must have X—Y capability. The option displays eight traces, one trace per data line, and each trace displays 16, 32 or 64 bits, depending on the EXPAND function. The circuit has been designed for oscilloscope displays with a minimum of 1cm square graticule markings. Smaller sized displays may impair readability of the displayed data.

THEORY

Eight traces are displayed on the oscilloscope in the following manner. A repetitive ramp waveform is applied to the X input of the oscilloscope, causing the beam to move across the display. Eight d.c. levels, equally spaced and in decreasing value, are in turn applied to the d.c.-coupled Y input of the oscilloscope, each for the duration of a single sweep. If the sweep repetition rate is fast enough, then the eye will see eight traces on the screen. When an analogue (or digital) signal is superimposed on the d.c. level, then eight traces of data can be seen. Remember though, that each trace follows sequentially the one preceding it and therefore eight real-time data signals cannot be displayed in parallel. Since the analyser is displaying stored data, this is of no concern to us. What happens is that a multiplexer applies a d.c. shifted signal with the DO bus one superimposed on it to the oscilloscope. The RAM is clocked for 16, 32 or 64 clock cycles, during which the trace is moving across the screen. This causes the DO contents of 16, 32 or 64 memory locations to be displayed as a waveform of ones and zeros. At the end of the trace, D1 is connected through, and the memory is again cycled through the same locations. Thus the data bits of D1 are displayed directly under the corresponding bits of DO. All eight data lines are therefore displayed and then the whole sequence repeats itself. In this manner a display of 16, 32 or 64 bytes of 8-bit data is built up. A timing diagram is shown in Fig. 3.1.

CIRCUIT DESCRIPTION

Refer to the block diagram and circuit diagram, Figs. 3.2 and 3.3 respectively. IC101 is configured as an oscillator running at 64kHz. The output is fed to IC102, IC105b and S20c via buffers IC105a & d. IC102 and IC103 are binary counters, used as dividers. The frequency at QA of IC102 is 32kHz and QB is 16kHz. IC103 is 1/64th of the input frequency, i.e. 1kHz. When QC goes high, IC104d goes low, albeit for a very short time, as the 64kHz clock resets the flip flop via IC105b. This short duration negative going pulse reloads the counters so that they count from zero again, triggers IC108 and provides the LD pulse used on the main p.c.b. for reloading the RAM base address (refer to part 1) and for the HEX display option (see below). Because these pulses are 1ms apart and are derived
Fig. 3.3 Scope option circuit diagram
from the 64kHz clock, the RAM address counters increment 64, 32 or 16 times between the pulses, corresponding to the expand function allowing 64, 32 or 16 bytes to be displayed. IC108 is configured as a monostable, with its timing capacitor being charged via a constant current generator formed by TR101, VR102 and R102-R104. When IC108 is triggered, a ramp waveform is generated at the junction of TR101 and C106. The timing components have been chosen (and can be adjusted with VR102) such that the period of the ramp is just less than 1ms. The ramp is buffered and amplified by IC109, the output of which drives the X channel of the oscilloscope. VR103 is used to adjust the ramp amplitude and thus the width of the sweep on the display. With the ramp period slightly under 1ms and the ramp start tied to the 64kHz clock, the ramp is just long enough for the 64, 32 or 16 clock pulses to be completed before the next LD pulse is generated. TR102 level-shifts the square wave output of IC108 (period 1ms) to a level compatible with the dual supply rails used on the CMOS i.c.'s. IC110 is a 1-of-8 counter, each output goes sequentially high with every clock pulse. The outputs of IC110 control the analogue gates in IC’s 111 and 112 with the result that every 1ms (equivalent to the ramp length, or a set of 64, 32 or 16 clock pulses) the outputs of IC’s 114 to 117 are gated sequentially for 1ms to R130. R130 is in turn connected to the Y input of the oscilloscope. In other words, the 8 outputs are switched in turn for 1ms to the Y oscilloscope input. The data bus is buffered by IC113 and IC104b & c and applied to the op-amp IC’s 114-117. The associated resistors (for example R106 and R107) are chosen such that the gain of the op-amp is 0.18. Multiplied by 5V, the output is 0.9V and with the oscilloscope Y input set to 1V/div, the waveform sits nicely within the graticule squares. Summed with the input signals are d.c. levels, adjusted by VR104-VR111. The gain of the d.c. level is 1 and therefore the signals fed to IC111 and IC112 consist of 0.9V amplitude waveforms superimposed on d.c. levels which can be adjusted from approximately -7V to +7V. These presets enable the traces to be correctly spaced on the oscilloscope screen.

CONSTRUCTION

Construction procedures follow closely those of the main p.c.b.—Soldercon sockets, followed by components and then the through-hole connections. Refer to Fig. 3.6. Fit the i.c.’s in place, then check for solder splashes and correct component orientation. Use Veropins for the connections to S20 and SK101, SK102 and SK103. If you intend fitting the HEX display option at this stage, complete it first, as it is fitted below the oscilloscope option. (If the HEX option is only to be fitted at a later stage, it will be no problem to lift the oscilloscope option board and place the new option board in between. It is therefore not essential to fit both options now.) The display option board(s) are mounted on stand-offs, between SK6 and SK8 on the main p.c.b. Wire the board to the front panel (i.e. S20 and SK101-103).

SETTING UP

With a frequency counter or an oscilloscope connected to pin 3 of IC101, adjust VR101 for an output of approximately 64kHz. Then connect up the oscilloscope with X input set to 0.5V/div. and the Y input to 1V/div. Apply a clock to the analyser, let the data inputs float high, ARM the analyser and store the high inputs. Adjust VR104-VR111 so that the traces are in order from the top of the screen downwards and that the traces are just under their respective upper graticule lines (i.e. indicating a high). Note that the presets are not in order on the p.c.b. (the author wasted an hour trying to figure out why the scope data did not agree with the HEX data, and all because the traces were adjusted in the wrong order!). Adjust VR103 so that the length of the traces just fit in the graticule area. Connect up (on protoboard or vero-board) the test circuit in Fig. 3.7 and store the data.
Fig. 3.5. Scope option p.c.b. track (component-side)

Fig. 3.6. Scope option component layout (actual size)
With the EXPAND switch set to 16, adjust VR102 so that the top trace (DO) has 16 cycles on the screen. It may be necessary to readjust VR103 while the adjustment of VR102 is being done. Changing the position of the EXPAND switch will cause more bytes to be displayed. Final testing of the unit will be described at the end of the article, as the procedure is common to both display options.

**Fig. 3.7. Analyser test circuit**

### COMPONENTS . . .

#### SCOPE DISPLAY OPTION

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R101,R103</td>
<td>4k7 (2 off)</td>
</tr>
<tr>
<td>R102</td>
<td>2k2</td>
</tr>
<tr>
<td>R104</td>
<td>6k8</td>
</tr>
<tr>
<td>R105,R130</td>
<td>10k (2 off)</td>
</tr>
<tr>
<td>R106,R109,R112,R115</td>
<td>100k (8 off)</td>
</tr>
<tr>
<td>R118,R121,R124,R127</td>
<td>10k (8 off)</td>
</tr>
<tr>
<td>R107,R108,R110,R111</td>
<td>10k (8 off)</td>
</tr>
<tr>
<td>R113,R114,R116,R117</td>
<td>10k (8 off)</td>
</tr>
<tr>
<td>R119,R120,R122,R123</td>
<td>18k (8 off)</td>
</tr>
<tr>
<td>R125,R126,R128,R129</td>
<td>18k (8 off)</td>
</tr>
<tr>
<td>R131</td>
<td>47k</td>
</tr>
</tbody>
</table>

All resistors 1W 5%

**Capacitors**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C101</td>
</tr>
<tr>
<td>C102,C104,C107</td>
</tr>
<tr>
<td>C103,C105</td>
</tr>
<tr>
<td>C106</td>
</tr>
</tbody>
</table>

**Transistors**

<table>
<thead>
<tr>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR101,TR102</td>
</tr>
<tr>
<td>BC177 (2 off)</td>
</tr>
</tbody>
</table>

**Integrated Circuits**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC101,IC108</td>
</tr>
<tr>
<td>7555 (2 off)</td>
</tr>
<tr>
<td>IC102,IC103</td>
</tr>
<tr>
<td>74LS191 (2 off)</td>
</tr>
<tr>
<td>IC104</td>
</tr>
<tr>
<td>74LS02</td>
</tr>
<tr>
<td>IC105</td>
</tr>
<tr>
<td>74LS00</td>
</tr>
<tr>
<td>IC106</td>
</tr>
<tr>
<td>7808CT</td>
</tr>
<tr>
<td>IC107</td>
</tr>
<tr>
<td>7808CT</td>
</tr>
<tr>
<td>IC109</td>
</tr>
<tr>
<td>741</td>
</tr>
<tr>
<td>IC110</td>
</tr>
<tr>
<td>4022B</td>
</tr>
<tr>
<td>IC111,IC112</td>
</tr>
<tr>
<td>4066B (2 off)</td>
</tr>
<tr>
<td>IC113</td>
</tr>
<tr>
<td>74LS04</td>
</tr>
<tr>
<td>IC114-117</td>
</tr>
<tr>
<td>1458 dual 741 (4 off)</td>
</tr>
</tbody>
</table>

(1558 may be used)

#### HEX DISPLAY OPTION

This option displays the HEX value of the data byte corresponding to the base memory address selected on the ADDRESS display, on two 7-segment displays. The HEX characters are displayed as shown in Fig. 3.8. The 7-segment displays should have already been fitted to the front panel p.c.b.

**HOW IT WORKS**

Fig. 3.9 shows the circuit. Incoming data is latched in IC201 by the LD input from the oscilloscope option via IC205C. If the oscilloscope option is not fitted, then as explained in Part 1, the latch is always disabled (i.e. unlatched).

The output of the latch is connected to IC202 which is a quad 2-line-to-1-line multiplexer. The output lines A, B, C or D are either connected to D0–D3 or D4–D7, depending on the S input. This input is derived from IC205d and IC207, which is configured as a 100Hz oscillator. The oscillator allows the multiplexing of the data to the displays, minimising the HEX decoding circuitry and the connections between the option board and the front panel p.c.b. Multiplexing is achieved by TR201 and TR202 switching on alternately and hence enabling each display in turn. The selected 4 bits are decoded into 7-segment format by IC203. This i.c. decodes the values 0-9. IC204c and IC205b detect when the value is greater than 9 and when this is the case, enables IC203's lamp test facility and enables IC206. IC203 was chosen because it displays a complete "G", compared to the more common 7447 which has the tail missing. It is therefore easy to differentiate between a "6" and a "b" corresponding to the HEX "B". To explain how the display works, we will consider an example, say a "1". To display a "1", outputs b and c of IC203 will be high (off), allowing current to flow via R208 and R207 through the b and c segments to the common cathode. All other outputs will be low (on), shorting out the segments, so they do not light. When the lamp test facility is enabled, all outputs are off, allowing all segments to light. However, IC206 decodes the 3 bit binary input to 1-of-6 lines and the selected line, buffered by IC208, blanks the not-required segments via the diode matrix, leaving the corresponding HEX character lit.

**CONSTRUCTION**

Once again, construction follows the previous procedures. Refer to Fig. 3.12 for the component overlay. The board is fitted to the main p.c.b. with stand-off pillars and is connected to the front panel p.c.b. via a 14 way ribbon cable, with headers connected such that the pin numbers correspond 1 to 1. There is no setting up required and testing is done as described below.

**FINAL TESTING**

Set up a word on the word recogniser switches and select WORD trigger, POST trigger and SYNCH clock. Select CQ1 and CQ2 to "dont care" and CQ3 to 0. Connect up the test circuit in Fig. 3.7, leaving the qualifiers open. ARM the unit and switch the CQ3 switch to "dont care". The analyser will

**Fig. 3.8. Hex character display**
Fig. 3.9. Hex option circuit diagram

**COMPONENTS . . .**

**HEX DISPLAY OPTION**

**Resistors**
- R201: 1k
- R202: 100k
- R203-209: 330 (7 off)
- R210,R211: 10k (2 off)

**Capacitors**
- C201-203: 100n/16V tant. (3 off)

**Transistors & Diodes**
- D201-213: 1N4148 (13 off)
- TR201,TR202: BC108 (2 off)

**Integrated Circuits**
- IC201: 74100
- IC202: 74LS157
- IC203: 74LS248
- IC204: 74LS32
- IC205: 74LS00
- IC206: 74LS155
- IC207: 7556
- IC208: 7407

**Miscellaneous**
- Soldercon i.c. socket strips
- SK3b can be a 14-pin i.c. socket

Capture the counter's output. Now check that the HEX display corresponds to the chosen trigger word (on the switches) and that the left hand byte displayed on the oscilloscope also corresponds. (If only one of the options is fitted, then obviously it is only necessary to check that option.) Repeat the procedure with PRE and CENTRE triggering. Activating the UP/DOWN switch should cause the HEX display to increment or decrement between 00 and 99. (The 7490 is a decimal counter, therefore no HEX characters will be displayed.) The waveforms on the scope display should also move to the left or right. Switch off the analyser and switch on again. The memory will contain random data. Scan up the memory and check that the HEX characters are correctly displayed. Finally, check that MANUAL and EXT trigger (by applying an external signal, positive and negative edge selected) work and that the clock qualifiers work. If the option(s) and the unit work satisfactorily, the power supply wiring can be neatly finished off. The fuse is mounted on the back panel and remember to twist the mains wire going to the ON/OFF switch to reduce noise radiation. The analyser is now ready.

**NEXT MONTH: Z-Mod and Internal Clock Options.**

**NOTE . . .**

Fig. 1.6, the Main p.c.b. circuit schematic (August issue) should be corrected to show a link between pins 3 and 4 of IC32 and pin 5 of IC30.
Fig. 3.10. Hex option p.c.b. track (track-side)

Fig. 3.11. Hex option p.c.b. track (component-side)
Fig. 3.12. Hex option component layout (actual size)

ELECTRONIC HOBBIEST FAIR

We are sorry to announce the cancellation of this year’s Electronic Hobbies Fair, planned for 27th–30th October.

In spite of a significant success last year, the continuing recession is hitting the electronics hobby industry pretty hard. This has meant that many companies feel that this year they cannot sensibly allocate the resources of time, money and manpower involved in participation in exhibitions.

We feel that any exhibition sponsored by PE must offer the visitor a full range of components, equipment, projects and demonstrations from a wide selection of companies across the industry. As we cannot be absolutely sure of doing just this, we have decided, with regret, that we must disappoint our readers now rather than in October. Practical Electronics would like to thank those companies who had undertaken to support the Electronic Hobbies Fair this year. With our apologies for the disruption of their plans we combine our hopes for a future event in a more buoyant business climate.
SINCE the invention of a means of permanently recording an image made by "painting with light", photography still requires the same techniques as it did 150 years ago. There has always been a light tight box or camera and there has always been a pinhole or optical lens to form an image.

At first the image was copied by hand, a small portable camera being a popular means of sketching tourist views for the non-artistic traveller. When light sensitive emulsions were discovered, photography as we know it was made possible. Over the years the sensitivity of film emulsion has been improved, the optical performance of lenses and the method of varying and controlling the amount of light reaching the film, with some form of aperture and shutter arrangement, has been the subject of continual invention.

The actual method of exposing the film for a particular length of time has always been mechanical, clockwork gear trains or pneumatic systems, subject to variation and failure and requiring expensive and precision maintenance. When electronic control of these functions was introduced, it was without doubt one of the most important fundamental developments in the techniques of practical photography.

ELECTRONIC CONTROL

The huge “snap-shot” market was the first to benefit from electronic control, not only in the camera at the taking stage (which shall be dealt with later) but in the developing and printing of vast quantities of amateur colour negative films in 35mm, 126, 110 and Disc formats.

Meticulous attention to processing standards at the laboratory is required, to ensure acceptable quality prints at economical prices. To try to achieve adequate control by manual means is impossible due to time/cost considerations in a mass market.

The films are developed in automatic sequence where time, temperature and replenishment of used chemicals is strictly monitored. After development, the films, either in individual, short lengths or joined together on a continuous spool, are printed on to roll paper which is processed and cut into single prints. The laboratory printers used for this work can be either:

A. Fully automatic,
B. Partly automatic, where the operator can override or modify the function.
C. Manual.

Amateur developing and printing is always automatically printed. A typical standard subject, based on the holiday view or group picture on a particular type of mass sale film, like Kodacolor II with C41 process, is programmed into the printer, which adjusts the function to compensate for any variables in the subject lighting and exposure.

OPERATING THEORY

The operating theory, established by Kodak in 1946, depends on the premise that most colour photographs can be integrated or scrambled to a standard grey. If a full colour image is projected onto a screen through a diffuser, the mixture of coloured light will produce the same effect on the screen irrespective of the content of the picture, assuming that the picture is a typical standard subject. If the picture is untypical, i.e. a white seagull against a blue sky, or a white cat on a red rug, the printer must have manual correction or sophisticated programme memory systems to estimate the required compensation.
Laboratory printers for the more exacting market of professional photographers are usually automatic with manual operator override. The film is handled in short strips, say three 2½" square negatives; these are numbered and test printed, checked and printed again with any required correction. These printers are capable of handling roll paper in a range of widths and format, the size being selected and set up prior to batch printing.

As distinct from laboratory printers operating in a mass quantity market, enlargers are used for the independent printing of negative and slide originals onto sheets of paper in a wide range of sizes and surface finishes. Individual treatment, shading, masking and local correction and optical distortion control, to correct for camera angle errors, can be done during the printing process.

PRINT ANALYSIS
The correct combination of exposure times through the BGR filters in the case of additive enlargers and the exposure and filter densities in the case of subtractive, can be arrived at by a series of test prints, which can be wasteful of time and materials. To overcome these problems analysers are used, programmed to a standard subject. To illustrate the operation of an analyser we will look at the Durst CM300, a sophisticated home darkroom electronic analyser and timer. When used in conjunction with a colour head enlarger fitted with "dial in" dichroic filters the printing filter settings and exposure are quickly established, to a set programme.

To calibrate the unit, a negative is selected having a good distribution of colour, a market place or fairground shot is usually ideal, the negative should be of normal density and correctly processed.

The negative is test printed until a satisfactory result is obtained.

The analyser is then programmed. With the enlarger set exactly as for the test print, filters, lens aperture and magnification, the analyser probe is placed on the baseboard under the lens. The slide on the probe is moved until the i.e.d. on the cyan channel lights and the calibration knob is adjusted until the two i.e.d.s come on together. The process is then repeated for magenta and yellow.

Any other negative of a similar type can be focused to a particular size, the probe placed on the baseboard and the filters adjusted in turn to light the two i.e.d.s together on each channel.

The Durst CM300 analyser measures the colour and density of colour negatives and directly controls the exposure procedure of the enlarger.
For a portrait negative a print can be made by test and the analyser can be programmed by placing the probe (without the diffuser) on part of the face projected on the baseboard and calibrated as before. This will be for a typical skin tone and will yield an identical colour and tone in future prints irrespective of the background colour. The unit can be used for exposure determination for slides and black and white printing and as a basic exposure timer.

All analysers and computers for colour printing, work on the same principle irrespective of the manufacturers' operating sequence and attempt to provide guidance on optimum printing conditions for any negative, but the successful interpretation and use still depends to a large extent on the skill of the operator. To cater for different combinations of film and paper batch, some analysers have switchable memory banks or plug in modules for any number of calibration programmes.

STAGE TIMING

The accuracy and repeatability of electronic control has enabled a number of darkroom aids to be designed, one of which is the Nocon timer, an interesting electronic timer with programmable memory.

When making a test strip for exposure determination either in black and white or colour, it is necessary to make a series of time stages, maybe 2, 4, 6, 8, 10, 12, seconds or a doubling up range like 2, 4, 8, 16, 32, seconds. A laborious technique subject to errors of repetition. The final print as a result of information obtained from the test, may require a different exposure in certain areas of the print and can be repeated any number of times, exactly the same.

LEVEL PEGGING

The relative merits of additive versus subtractive colour printing systems have been expounded for a number of years without any real evidence of either's superiority. Most enlarger manufacturers use the subtractive system for manual enlargers, where the colour of the light projecting the negative, or positive image, is adjusted by means of a complementary filter pack, of gelatine or resin filters, or dial in fade free dichroic filters, using one exposure.

The Philips Tri-one colour enlarger uses a system which is a single exposure, as in the subtractive method, but a single exposure from three separate bulbs, one with a blue filter, one with green and one with red. The colour of the resulting mixture of light is varied by adjusting the intensity of each bulb, infinite control is thus obtained. The Durst AC650 is intended to give the advanced amateur and professional photographer an enlarger with the characteristics of a laboratory printer, with the ability to constantly vary the size of print and selectively compose the final result. A tungsten halogen bulb provides the illumination for 35mm and 6 x 6cm negatives and slides. Exposure is made by three consecutive exposures, each one timed automatically.

All the necessary colour and density measurements are carried out automatically once the photocells have recorded the correct amount of light for each colour. However, the unit carries four control knobs for calibration to the standard negative and for personal manual override.

All automatic printing systems are subject to failure due to the inconsistency of the negative. Where there is a variation in density either through a negative process fault or wide change in the magnification, a reciprocity fault can occur. Each batch of paper has its own characteristics and the three layers of emulsion can be different in their response to over and under exposure, ideally, the photocell and filter response would match the sensitivity of the three emulsion layers, but in practice a shift occurs in both colour and density because of variations in the three characteristic curves. Special provision must be made in automatic printers to allow for this error and the adjustment is known as the slope control.

SLOPE CONTROL

For the mass market printer the slope control must be automatic without operator intervention. If it is found that the shift is toward green from an over exposed negative and toward its complementary, magenta, with an under exposed negative, a proportional reduction in the green exposure is required for under exposed negatives and an increase in the green exposure for over exposed negatives. In each channel adjustable response is provided, in series with the integrating condenser the photocell will read a "thinner than normal" negative and proportionately vary the green exposure.

An analyser used with an enlarger is subject to user override and the operator will make an allowance for thin or very heavy negatives and for larger or smaller degrees of magnification after normal analysis.

EQUIPMENT OPTIONS

Laboratory printers are now available in a wide range of specifications in both additive and subtractive variants. Mainly to cater for the professional photographer, there are package printers which analyse and simultaneously, through a cluster of lenses, produce a set of prints of different sizes, perhaps 1 @ 8 x 6, 2 @ 5 x 4, 4 @ 3 x 2, all exactly matched for colour. Also in the laboratories catering for the professional photographer, particularly in wedding and portrait work where a consistently high
standard of printing is required at reasonable prices, methods to
avoid the reprint of unsatisfactory prints are in demand.

Video systems enable the operator to view the negative rever-
seS in values to a correct colour image on the screen, the image
is compared to a correct standard alongside, the colour balance
is automatically assessed and fine tuned manually. The printing
values are entered and produce a readout on punched tape or
magnetic retrieval systems, this data with the negative is passed
to the printer and high quality "one off" prints are produced.

This method with moderate quantity production is not suitable
for the mass market.

In general the printing of slides usually involves the making of
an "interneg", so that the prints can then be made on automatic
printers with other negatives. Slides can be printed on enlargers,
with selective control and composition and many laboratories
offer this service, which is well within the scope also of the home
darkroom. In the home the colour can be balanced visually and
the exposure established by a meter or the exposure channel of
an analyser.

Successful photography depends to a large extent on accurate
standardisation. Exposure of the film in the camera is critical if a
high quality negative or transparency is to be produced. A
professional photographer should have the skill to measure and
judge the infinite variety of the effects of light and get his ex-
posures correct; an amateur, who may only use his camera on
holidays and occasionally at special events, will not have the
experience and get very uneven results so it is in this area where
automatic camera exposure control is very beneficial.

A simple meter system measuring the whole of the image area
can produce very good results and more sophisticated camera
exposure controls, measuring the centre of the image, an area
around the centre and the outside edges and calculating the
overall average. As the main subject is probably around the cen-
tre of the frame the method can hardly be faulted.

Standardisation in processing the film and printing the
resulting negative is absolutely vital. Electronic control of
process temperature and time and control of chemical replenish-
ment, together with the programmed analysis of printers and
enlargers, has revolutionised the practice of photography as it
has been known since its invention, replacing years of experience
and trial and error, with accurate, predictable and repeatable
results, leaving the photographer free to concentrate on the pic-
ture composition.

LOOKING AHEAD

The future of silver based photography is now challenged by
electronic image recording. Video has largely replaced home
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seeing the results on the domestic television must be obvious.
There is still, however, the problem of producing a high quality
print from a video image comparable to that obtained from the
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EXPANDING THE VIC 20

PART ONE

SAM WITHEY

8K STATIC RAM . . .

FOR AROUND £17

FALLING prices of the Commodore VIC 20 home computer have outpaced the prices of expansion packs, which, perhaps due to the high price of 2K RAMs, remain beyond the pocket of many home programmers. However, for the hobbyist constructor, an 8K static RAM card can be made for around £17, a considerable saving over the normal price of approximately £45.

Included in this series of articles is an 8K RAM pack, which uses 4x6116 2K CMOS static RAM, an 8K ROM board, which can accommodate a single 2716 EPROM, a single 2532 EPROM, 2x2532 EPROMs, or one 2532 and one 2716 EPROM. A simple modification to the 8K RAM board enables it to be converted into a 3K RAM card with provision for 4K of RAM. Finally, there is a mother board capable of holding 3 cards vertically plus a horizontal socket for further extension. An independent power supply can be added to the mother board at any time.

All boards are constructed on double sided fibreglass laminate and are designed so that a minimum of lines on the top (component) side of the board make through plating unnecessary.

An EPROM programmer and other interfaces designed specially for the VIC 20 are being prepared in this series. (We expect these to include a stepper motor controller for robotics, DAC/ADC board, and an i.e.d./switches simulator I/O control port for designers.)

ADAPTABLE TO OTHER SYSTEMS

Since decoding is carried out on the individual cards, the only problem in direct interfacing with other systems is the arrangement of Data, Address, R/W, Enable and power lines on the edge connector, and the physical spacing of the segments. This can be easily overcome, by preparing a suitable connector on a ribbon cable harness.

THE 8K RAM BOARD

The 8K RAM board (Fig. 1.1) has provision for 4x24 pin devices laid side by side to facilitate paralleling of Data and Address lines. All of this is carried out on the under side of the board. Address lines A0 to A10 are taken directly to the edge connectors, whilst A11 and A12 are taken from the upper surface of the board using through-the-board link pins. Similarly, the +5V rail is distributed to all devices after transfer from the upper surface via a link pin. The ground rail appears on both sides of the board, interconnected by the -ve leads of decoupling capacitors C1 and C2.

Data lines D0 to D7 are taken directly to the edge connectors on the upper surface of the board from the adjacent 2K RAM IC4. The R/W is taken from pin 21 (WE) of IC1 to edge connector 17 and Pin 20 (OE) of IC1 is taken to ground. As stated earlier, these lines are paralleled on the under side of the board.

Pin 18 (CE) of IC1 to IC4 are decoded by one half of IC5, a 74LS139, 1 of 4 decoder. Data Select A and B from this device are taken to All and Al2 respectively on the lower side of the board with link pins. Pin 13 (EN) of this device is taken to RAM blocks 1, 2 or 3, selected by a suitably placed blob of solder on the pads provided.

C1 and C2 are 330nF tantalum bead capacitors used for decoupling. The values are not critical, physical size being the more important. 10nF ceramic discs would probably provide sufficient noise suppression.

The 6116 CMOS RAM has the advantage of a very low operating current, avoiding the need for an additional power supply. Also, if 100k pull down resistors are soldered between the address lines and ground, the quiescent current is as low as 2µA, enabling a 2.4V back-up battery pack (2x1.2V nicads or 2x1.5V penlight) to be installed between the +5V rail and ground, to maintain programs during switch-off time.

CONSTRUCTION

4x6116, 150ns CMOS 2K Static RAMs are used for I.C.s 1 to 4 and it is therefore advisable to use sockets. Unless the constructor is a real novice IC5, being TTL, can be safely soldered directly on the board, Pins 8 to 15 on the upper surface and Pins 8 and 16 on the under side. See Fig. 1.4.

The socket of IC4 should be mounted first, because it has pins to be soldered on both edges. Do not insert the sockets fully, but leave sufficient clearance to enable a fine soldering tip to touch the pins from the upper surface of the board. Having done this, tack the socket in position by soldering the corner pins on the lower side of the board. After soldering
Fig. 1.1. 8K RAM card

Fig. 1.2 (below). RAM board track layout (track-side)

Fig. 1.3. RAM board track layout (component-side)
CONVERTING THE 8K RAM BOARD TO 3K RAM PLUS 4K ROM (SUPER-EXPANDER)

Having designed an 8K RAM board it became obvious that at some time it would be desirable to fill in the 3K memory gap at location 0400Hex. Because of its pin compatibility with the 6118 first consideration was given to the use of the 4118A static RAM. At first it was decided to modify the 8K RAM board by eliminating one socket and the decoder. Then the possibility of using the 4th socket as a 4K ROM socket was considered. Since all Data and Address lines are shared and the 4118A and 2532 are also compatible a further look was taken at the 8K RAM board to realise that very few modifications were necessary in order to use the same board for both purposes.

The only pin connections which differ are 18, 19, 20 and 21. For the 3 x 4118 RAMs Pin 21 (WE) remain in parallel and connected to edge connector 17, whilst the track was cut under the board at IC4 and a small link made between Pin 21 and Pin 24 on the upper surface to tie Vpp to +5V. Pin 20 (OE) on the 3 x 4118A RAMs remain in parallel and tied to ground, Pin 20 on IC4 once more being isolated by cutting the track under the board. Pin 20 of the 2532 is the CE and a short insulated lead is taken from this pin to Block select 3 or 5. As there is no internal connection at Pin 19 of the 4118A it was decided to leave the existing line connected in parallel as A10 is required by the 2532. Pins 18 (CE) of the 4118A RAMs are taken individually to RAM 1, 2, and 3 at edge connectors 16, 15 and 14. Use is made of the pads of the decoder i.c. to keep leads short and neat. Pin 18 of IC4, 2532 ROM is also taken from the pad of the decoder i.c. and the link pad formerly used as a through-the-board link to A11 on the lower side of the board.

For the hobbyist who produces his own printed circuit boards this eliminates a considerable amount of work required in producing a new set of double sided board masks. It is suggested that provision should be made for this modification when preparing the 8K RAM board mask, i.e. provide pads over edge connectors 13 to 16 and a provisional line from Pin 20 of IC4 terminating in a pad by the side of Data 7.

NOTE: Whilst using the “Super-Expander” alone, VIC 20 BASIC ignores it when extra RAM blocks are added. It may, however, be used for m/c routines.

PINS 9 TO 18 (INCLUSIVE) ON THE UPPER SURFACE OF THE BOARD

Check that there are no bad joints before proceeding to IC3. This is best done by inserting an old 24 pin device in the socket and checking continuity with a multimeter.

Next insert IC3 socket where only Pins 12 and 18 have to be soldered on the upper surface. IC2 socket is the same. IC1 socket has to be soldered on Pins 12, 18, 20 and 21. As these are all clear of the previously mounted sockets this presents no difficulty. If the pins on the underside of the board were not soldered previously, solder them now.

The CMOS RAMs should be handled with care and it is worthwhile inserting an old 24 pin device into the sockets, not only for continuity checking, but also to “break-in” the socket and avoid risking bending the pins of the RAMs.

C1 and C2, together with the through-the-board links, are soldered in place before inserting the RAMs.

It is time well spent to check all solder joints before using the board on the computer. In particular, check that there is no short between +5V and ground.
8K ROM BOARD

The ROM board (Figs. 1.5 and 1.8) is arranged in a similar manner to the 8K RAM board, having 2 x 24 pin devices laid side by side. All pins are paralleled on the under side with the exception of Pins 24 (+5V) and Pins 21 (A11), which are tied to +5V on the upper side and Pins 20 (OE), which are decoded by IC3, a 74LS00 Quad 2 Input NAND Gate. As with the RAM board, all Data and Address lines are taken directly to the edge connectors, A12 being taken to Pins 1, 2, and 13 of IC3.

The ground rail is on the lower side of the board, but is taken from Pin 12 of IC1 on the upper side of the board to supply ground for IC3. The +5V rail is on the upper side of the board. C1, a 100nF ceramic disc, supplies sufficient noise suppression and is connected to the +5V rail via a through the board link pin.

If sockets are to be used, it is advisable to insert and solder Socket 1 first, leaving sufficient clearance for a fine soldering iron tip as with the RAM board. An insulated wire link selects ROM Block 3 or 5.

ROM is normally located in memory at A000Hex for ROM Block 5, or 6000Hex for RAM/ROM Block 3. If the latter arrangement is chosen, IC1 is located at 6000Hex and IC2 at 7000Hex. Referring again to the schematic diagram it will be seen that when A12 is low OE of ROM 1 is low and therefore active. OE of ROM 2 would be high and would not be selected. Inversely, when A12 is high, OE of ROM 2 is low and would be active, whilst OE of ROM 1 would be high and not selected. Blocks are always active low. Unlike the RAM used by BASIC, the ROM memory locations do not have to be one continuous program, but can be 2 or more separate functional routines that can be called from BASIC or machine code. Whilst a 2532 would normally occupy each socket, there is nothing to prevent a 2716 being used to provide programs from 6000Hex to 67FFHex or 7000Hex to 77FFHex.
THE MOTHER BOARD

The Mother Board (Fig. 1.11) described here holds 3 boards vertically and a socket is provided for further horizontal expansion. Unused lines have been omitted, but it will be necessary to drill holes if sockets are to be used.

On the prototype, the first positions were used for RAM Blocks 1 and 2, memory locations 2000Hex and 4000Hex. The third position was taken by a 2 x 4K ROM Board, covering memory location 6000Hex at RAM/ROM Block 3. The lower 4K of the latter was used for the VICROM Machine Code Monitor, leaving the section 7000Hex to 77FFHex free for user Machine Code programs.

Since these boards were intended for regular use they were soldered directly to the Mother Board, with wires, saving the cost of sockets and leaving the rear horizontal socket for such applications as games cartridges.

Construction presented no difficulties, but it should be observed that boards or sockets should be mounted starting from the rear position first. This is because the mounting pads for the top lines are towards the front and should not be obstructed. Additional pads are provided on the lower surface for extra support for these pins. Sockets should, of course, be mounted slightly proud of the board to permit application of solder on the top pads.

The sockets required are 0.156 inch, or 4mm spacing and are 2 x 22.

COMPONENTS...

MOTHER BOARD

Miscellaneous

Edge connectors: 0.156in. (4mm) 2 x 22 contact
Printed circuit board

Constructors' Note

Edge connectors to suit (and most components) are available from Watford Electronics.

* If p.c.b.s are found to be unavailable from PE's usual suppliers, they may be obtained from Meridan Ltd., 0639 898277.

Fig. 1.9 Mother Board p.c.b. (track-side)
Fig. 1.10. Mother Board p.c.b. (component-side)

Fig. 1.11. Mother Board component layout (actual size)
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INDEX TO ADVERTISERS

A.D. Electronics ................................ 32
Audio Electronics ................................ 8
Beckman ............................................ 38
BICC-Verco ........................................ 8
Bi-Pak .............................................. 12
Blackstar .......................................... 71
British National Radio & Electronics School .... 13, 71
Cambridge Learning ............................... 32
Clef Products ...................................... 32
Cricklewood ....................................... 21
Croxton ............................................ 31
C.R. Supply Co. .................................... 1
Electronics Mailorder .............................. 72
Electronics World ................................ 28
Electrovalue ....................................... 50
G.C.H.Q. ........................................... 50
Greenweld ......................................... 24
Global Specialties ................................ 23
Hallett, Gordon ................................... 24
ICS-Interfex ....................................... 24
ILP Electronics .................................... 7
Imperial College ................................... 73
Logic Tutor ....................................... 22
Magenta .......................................... 22
Maplin ............................................ 22
Marco Trading ...................................... 71
Marlborough Electronics ......................... 72
Microflame ........................................ 73
Microstate ........................................ 50
Midwich .......................................... 49
Modern Book Co. ................................. 73
Parndon ............................................ 32
Phonosonic ....................................... 10
P.K.G. Electronics .............................. 73
Plus 80 ........................................... 50
Powertran ........................................ 28
Proto Design ...................................... 73
Racom ............................................. 71
Radio Component Specialists .................. 73
RisCon ........................................... 10
Radio & TV Components ......................... 4
Scientific Wire Co. ............................... 73
Service Trading .................................. 31
Sparkrite .......................................... 5
Swanley .......................................... 71
Technomax ....................................... 74
T.K. Electronics .................................. 9
Twyford .......................................... 14
Watford Electronics ............................. 2, 3

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