PRACTICAL ELECTRONICS

FEBRUARY 1984

90p

Computer Terminal

P.E. COMPUTER TERMINAL
GLASS TELETYPewriter
* SERIAL INTERFACE
* ASCII & GRAPHICS CHARACTER SET
* EXTERNAL CONTROL TIMES FOR BELL, ETC.

Plus...
TEMPERATURE CONTROLLER

and
CLOCK TIMER

21:17
0:3:31

Buyer's Guide: MONITORS FOR HOME COMPUTERS
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 six independent axes are capable of simultaneous operation and all except the grip axis have sensing devices fitted to provide positional control by a closed loop 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, Hebot 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
Weight: 8.7kg
Max. lifting capacity: 100g
Robot kit with power supply: £145.00
Interface board kit: £48.50
23 way edge connector: £2.50
A real, programmable robot for under £200!
Micrograsp has an articulated arm joined at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and four of these are servo controlled giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP
Universal computer interface board kit: £48.50
23 way edge connector: £2.50
ZX81 peripheral & RAM pack splitter board: £3.00

All prices are exclusive of VAT – allow 21 days for delivery.
CONSTRUCTIONAL PROJECTS

**COMPUTER TERMINAL** Part 1 by Ray Pinchin
Remote VDU/keyboard terminal

**CLOCK TIMER** by T. J. Johnson
Four digit clock with output relay for switching 10A at 240V

**STARDesk** Part Two by Peter Newbury
Construction details

**TEMPERATURE CONTROLLER** by T. J. Johnson
Provides a temperature controlled output for switching mains appliances

GENERAL FEATURES

**SEMICONDUCTOR CIRCUITS** by Tom Gaskell BA(Hons)
LED bargraph drivers (UB..B Series)

**MONITORS FOR HOME COMPUTERS** by M. Tooley BA and D. Whitfield MA MSc CEng MIEE
Specifications explained — buyers guide

**VERNON TRENT AT LARGE**

**INTRODUCTION TO DIGITAL ELECTRONICS** by M. Tooley BA and D. Whitfield MA MSc CEng MIEE
Part 5 of our electronics course

**MICRO-BUS**
A monthly focus on micro's for the home constructor

NEWS AND COMMENT

**EDITORIAL**

**NEWS AND MARKET PLACE**
Including Countdown and Silicon News Corner

**BAZAAR**
Free readers' advertisements

**INDUSTRY NOTEBOOK** by Nexus
News and views on the electronics industry

**SPECIAL OFFER-CASSETTES**
Improved stereo TV

**SPACEWATCH** by Frank W. Hyde
SERC scientists 'weigh' a black hole

DUE TO LACK OF SPACE PART FIVE OF EXPANDING THE VIC 20 AND MICRO-FILE HAVE BEEN HELD OVER TILL NEXT MONTH

OUR MARCH ISSUE WILL BE ON SALE FRIDAY, FEBRUARY 3rd, 1984
(for details of contents see page 31)
**OPTO**

- **LED Displays**
  - LP21 Green 3mm
  - LP17 Yellow

- **Rectangular LEDs**
  - LP23 7" Red

- **Segments Displays**
  - LP17 2.5" White

- **Color**
  - LP22 3V Red

- **Rainbow**
  - LP21 Yellow

- **Rectangular**
  - LP21 Red

**POWER SUPPLY**

- **Regulated**
  - 5V
  - 12V

- **Variable**
  - 5V
  - 12V

**SWITCHES**

- **Slide 250V**
  - 1A DPST @ 250V

- **Push Button**
  - 1A DPST @ 250V

- **Miniature**
  - 10mA @ 250V

- **Rotary**
  - 1A DPST @ 250V

**RIBBON CABLES**

- **10m**
  - 1A DPST @ 250V

**CABLES**

- **25m**
  - 25m Single screened, 2x20A 12V, in & out, 200V, 12V

**TRANSFORMERS**

- **312204V**
  - 312204V

**DIL SOCKETS**

- **Low**
  - 8 pin

**DIAC**

- **T272**
  - 272

**IC HOMEWORK**

- **Bridge Rectifiers**
  - 1A, 600V

- **Zener**
  - 4.7V, 500mA

- **Vishay**
  - 4.7V, 500mA

**SOLDERING**

- **Soldering Iron**
  - 30W

**CRYSTALS**

- **24**
  - 24MHz

- **30**
  - 30MHz

**BROTHER HR-15 DAISY-WHEEL**

An exceptionally high quality Daisy Wheel printer at the price of a Dot matrix printer. 11CPM Bi-directional, has 3K of buffer, has clear buffer facility, Carriage Skip key, memory, proportional spacing, underlining, Bold print and Shadow print. Prints in two styles of colour and sizes, with a high quality, Impact control facility to vary pressure on paper for making carbon copies, Uses parallel or RS-232 interface. Connect directly to a BBC Micro. A ribbon cassette 1mm wide red ribbon. Optional extras - Single Sheet Feeder takes up to 150 A4 sheets, Keyboard with transform HR15 into a sophisticated electronic typewriter. Activatingly in Beige. Special Introductory Offer: Only £375 (Carr. £475)

**NEW LAUNCH**

280A 2nd Processor Board

With CP/M and Double Density 1MB RAM for BBC MICRO

Yes it's here. Z80A 4 MHz 2nd Processor board with 64K memory, 4K monitor PROM, Parallel printer interface, CP/M disk handling, direct power on, will handle, 3", 5", & 8" Floppy Disk Drives and many more features including the new twin slimline disk drive case. Only £399

**BEEFONT ROM**

A character ROM FONT that goes 5 x 16 predefined FONT. The ROM is ideal for those who want a variety of fonts on screen and when used in conjunction with EPSON printer, allows printing of letters etc in mixed type faces. The software is compatible with CP/M makes it easy to design your own Fonts and several spare Fonts can be included if required which could be run from RAM. Supplied complete with ROM, software on DBC/ascii and Manual. Price £45
125W HIGH POWER AMP MODULES

The power amp kit is a module for high power audio applications - disco units, group amplifiers, public address systems and even high power domestic systems. The kit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, resistors, a high powered output stage.

The PCB board is fixed printed, etched and ready to drill for ease of construction and the aluminium chassis is predrilled and ready to use. Supplied with all parts, circuit diagram and instructions.

ACCESSORIES: Stereo/mono mains power supply kit with transformer £15.50 plus £2.75 p&p.

STEREO CASSETTE RECORDER KIT

Hameg HM 103 10MHz Oscilloscope £158
Hameg HM 204 20MHz Oscilloscope £365
Hameg HM 203-4 20MHz Oscilloscope £264

For detailed specifications of our complete range send for our new catalogue.

NEW FLUKE 70 SERIES

Analogue/ Digital Handheld Meters. All meters have 3 year warranty, all feature measurement functions of volts, ohms, amps and diode test.

Philips PM2517X Handheld DMM £172
Multi-function, 4 digit autoranging with manual override. True RMS to 10Amp. Battery operation. Optional accessories extend measurement capabilities.

Philips PM 3207 15MHz Oscilloscope £295
Tough light - weight portable for field service work with big screen. Dual trace, TV triggering, X-Y operation, add and invert.

Philips PM5503 Pattern Generator £139
Small, light-weight for TV servicing. Five different test patterns for colour and monochrome. Tone for audio checking. Video output.

Philips PM 6687/01 Frequency Counter £260
High resolution. 7 digit computing counter from 1kHz to 120MHz. Auto ranging or all waveforms. PM 6687/01 (245%) performs to 10kHz.

New Fluke 70 series

Philips PM2517X Handheld DMM £172
Multi-function, 4 digit autoranging with manual override. True RMS to 10Amp. Battery operation. Optional accessories extend measurement capabilities.

PRACTICAL ELECTRONICS

STEREO CASSETTE RECORDER KIT

ONLY £31.00 plus £2.75 p&p.

• NOISE REDUCTION SYSTEM: • AUTO STOP • TONE COUNTER: • REMOVABLE E.O. • INDEPENDENT LEVEL CONTROLS • TWIN V.U. METER: • W.O. & FLUTTER 0.1% • RECORD/PLAYBACK I.C.W. WITH ELECTRONIC SWITCHING: • FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES.

For all Hameg instruments.

Hameg HM 204 20MHz Oscilloscope £365
High performance instrument, with sweep delay, Variable triggering to 50MHz, variable hold off controls. 2 modulation and internal illuminated gratuice.

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AUDAX 8" SPEAKER
£10.50 plus £2.50 p&p.

Audax 8" speaker with built-in crossover. Ideal for home use. 100W RMS. 4Ω.

GOODMANS TWEETERS 8ohm
£12.50 plus £2.00 p&p.

Goodmans 1" tweeter with built-in crossover (3.5kHz) for use in systems up to 60W. £12.50 plus £2.00 p&p. (£8.95 + £1.50)

ELECTRONIC BROKERS LTD,
61/65 KINGS CROSS ROAD, LONDON WC1X 9LH.TEL: 01-833 1166. TELEX 298694.
**Practical Electronics**

**FREE YELLOW CATALOGUE vol1?**

- **SOT SMD S8 9 X 1 9 0 mm**
- **7 Layers of printed circuit boards/layered boards**
- **MOSFETs, SCR's, MNQ's, Zener diodes, transistors, transistors & relays**
- **400 MOSFETs, 100 SCR's, 200 MNQ and 300 Zener diodes**
- **900 transistors, 500 relays and 500 transistors & relays**
- **400 layers of printed circuit boards/layered boards**

**NEW CATALOGUE!**

- **1000 extra components**
- **500 extra boards/printed circuit boards**
- **1000 extra devices**
- **2000 extra components**

**COMPONENTS**

A wide range in stock including:

- **ICs**
- **Resistors**
- **Capacitors**
- **Transistors**
- **Diodes**

**Home Lighting Kits**

- **3 LED 3W 240V Dimmer**
- **3 LED 3W 240V Dimmer**
- **3 LED 3W 240V Dimmer**
- **3 LED 3W 240V Dimmer**

**Electronic Lock Kit**

- **XK112**
- **Comes with all necessary components and instructions**
- **ICs**
- **Transistors**
- **Resistors**
- **Capacitors**
- **Other components**

**Components**

- **ICs**
- **Resistors**
- **Capacitors**
- **Transistors**
- **Diodes**

**New Clock**

- **Digital 24-Hour Clock**
- **Switchable to analogue**
- **Choose from over 1000 components**
- **ICs**
- **Resistors**
- **Capacitors**
- **Transistors**
- **Diodes**

**Electronic Showroom**

- **Hours:** Mon-Fri 9am - 5pm, Sat 10am - 4pm
- **Commodore 64**
- **Draco**
- **BBC**
- **ORIC-1**
- **Spectrometer**

**All Prices Exclude VAT**

**Home Security Kit**

- **MKI2 16-CHANNEL LR RECEIVER**
- **MK SIMPLE INFRA RED TRANSMITTER**
- **MKI2 16-CHANNEL LR RECEIVER**
- **MKI2 16-CHANNEL LR RECEIVER**
- **MKI2 16-CHANNEL LR RECEIVER**

**Components**

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- **Low Prices**
- **No Circuit Complete Without A Call To**

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- **01-567 9842 TECHNICAL INSTRUCTIONS**

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

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

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

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

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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.

THE 1984 GREENWELD CATALOGUE

Now in the course of production, the 1984 GREENWELD catalogue will be published in January. It’s Bigger, Brighter, Better, more components than ever before. With each copy there’s a discount vouchers, Bargain List, Wholesale Discount List, Bulk Buyers List, Order Form and Reply Paid Envelope. All for just £1.00! Order now for early delivery!

MOTORIZED GEARBOX

These units are as used in a computerized tank, and offer the experimenter in robotics the opportunity to buy the electro-mechanical parts required in building remote controlled vehicles. The unit has 2 x 3V motors, linked by a magnetic clutch, thus enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive speed to approx 50rpm. Data supplied with the unit showing various options on driving the motors etc: £5.95. Suitable wheels also available: 3" Dia plastic with black tyre, drilled to push-fit on spindle. 2 for £1.30 (limited qty). 3" dia aluminium disc 3mm thick, drilled to push-fit on spindle: 2 for 85p.

NUTS, SCREWS, WASHERS & BOLTS

Over 1,000 metal in stock, metric, BA, self-tappers etc. SAE for list.

VEROBOLOC £1 OFF!!

Our biggest selling breadboard on offer at a special price of £4.10.

2N2905 SCOOPI!

Made by Texas - full spec devices 60p each: 10 for £4; 25 for £8; 100 for £34; 250 for £75; 1000 £165.

STABILIZED PSU PANEL

A199 A versatile stabilized power supply with both voltage (30v) and current (20mA-2A) fully variable. Many uses inc. bench PSU, Ni-cad charger, gen purposes testing Panel ready built, tested and calibrated. £7.75. Suitable transformer and pots, £6.00. Full data supplied.

FERRIC CHLORIDE

New supplies just arrived — 250mg bags of granules, easily dissolved in 500ml of water. Only £1.15. Also abrasive polishing block 55p.

ELECTRO-DIAL

Electrical combination lock — for maximum security — pick proof. 1 million combinations! Dial is turned to the right on one number, left to a second number, then right again to a third number. Only when this has been completed in the correct sequence will the electrical contacts close. These can be used to operate a relay or combination lock dia 65mm x 60mm deep. Only £3.95.

COMPUTER GAMES

Z901 Can you follow the flashing light/pulsating tone sequence of this famous game? Supplied as a fully working PCB with speaker (no case) plus full Instructions. Only £4.95.

Z902 Probably the most popular electronic game on the market — based on the old fashioned pendant and paper battleship game, this computerized version has brought it bang up to date! We supply a ready built PCB containing 76477 sound effect chip, TMS1000 micro-processor chip, R's, C's etc. Offered for its component value only (board may be cracked or chipped, it’s only £1.95. Instructions and circuit, 30p.

PUSH BUTTON BANKS

W4700 An assortment of latching and independent switches on banks from 2 to 7 way, DCO to 3DCO. A total of at least 40 switches for £2.95; 100 £6.50; 250 £14.00; 1000 £46.00.

THE SENSIBLE 64"

David Highmores new book on the Commodore 64 now available £5.95.

TELESCOPE AERIALS

As used in Sinclair microvision, 9 sec 10-30mm. Only £1.95.

NICAD CHARGER

Versatile unit for charging AA, C, D and PP3 batteries. Charge/test switch, LED indicators at each of the 5 charging ports. Mains powered. 210 x 100 x 55 mm £7.95.

BULK BUYERS

Send SAE for latest list, translators from £3.22, zeners from £1.70.

REELS

Reel relays like RS 348-970 etc.

W959 12V SP make 500R 60p

W953 12V SOCO make 500R 90p

W954 24V SP make 750R 60p

W958 24V SP make 750R 90p

RIBBON CABLE

Special purchase of multi-coloured 14 way ribbon cable = 40p/colour: 50m £18.00; 100m £32.00; 250m £65.00.

TTL PANELS

Panels with assorted TTL Inc. LS types. Big variety. 20 chips £1.00; 100 chips £4.00; 1000 chips £30.00.

HEATSSINK

Z905 Finned black alloy heatsink 125 x 198 x 23mm with 4 x Z90505 and 4 x OR25 R's. Only £2.50.

TREAT YOURSELF TO A NICE NEW DIGITAL MULTIMETER!!

K0855A A DVM for the professional — this 3½ digit multimeter has overload protection, low battery and over range indication. Full auto-polarity operation. AC Volts: 0.2-700 DC Volts: 0.2-1000 DC Current: 20mA-10A AC Current: 20mA-10A Resistance: 200Ω-20MΩ Total 28 ranges for just £44.95.

GREENWELD

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ALL PRICES INCLUDE VAT: JUST ADD 60p P&P EX-STOCK
FLEXY DRIVER
A flexible start screwdriver for those awkward to get at screws. Overall length 690 mm. Order No: Y064.

MINIATURE TOOL SETS
Screwdriver with spring loaded grip on to end to hold screws in position while reaching into those difficult places. Order No: D1 - Flat blade 4mm F22 Cross point no 1 £1.75 each.

GRIP DRIVER
A flexible finger grip screwdriver with spring loaded grip on to end to hold screws in position while reaching into those difficult places. Order No: D1 - Flat blade 4mm F22 Cross point no 1 £1.75 each.

5721 SCREWDRIVER UNIT
6 precision screwdrivers in hinged plastic case.
Sizes: 0.8, 1.4, 2, 2.4, 2.9 and 3.8mm.
Price: £1.75

5731 NUT DRIVER UNIT
5 precision nut drivers in hinged plastic case. With turning rod. Sizes: 3, 3.8, 4, 5.5 and 6mm.
Price: £1.75

5401 TOOL SET
5 precision instruments in hinged plastic case. Crosspoint (Philips) screwdrivers - HD and H1 key wrenches. Key sizes: 1.5, 2 and 2.5mm.
Price: £1.75

5751 WRENCH SET
5 precision wrenches in hinged plastic case. Sizes: 4-6, 5, 5.5 and 6mm.
Price: £1.75

ELECTRONIC SIREN 12v DC
Red plastic box with adjustable fixing bracket. Exits high pitched warning note of varying pitch. 100 cycles per minute. Dimensions: 90mm x 60mm (68mm deep). Power: 12v DC.
Price: £5.50

MINIATURE HF TRANSMITTER
Price: £5.50

MICROPROCESSOR KIT
A 8 MICROPROCESSOR KIT
National NMOS7800 series 8 bi DC 16 pin DIL Cartridge Kit. As used in all National NMOS Micro Computer Family.
Price: £20

MINIATURE LCD VOLTMETER
DC Voltage 0-200mV, 0-2-20-200mA, 0-1A Accuracy 1%
DC Current 0-20-200uA Accuracy 1%
Resistance 0-2-20-200K ohms Accuracy 1%
Voltage switch. Lead with multi plug. Input 270V AC/DC, Output 3.5, 8.5, 9.15, 12, 15, 18V DC Rating - 300 mA MM88

BRAND NEW LCD DISPLAY MULTIMETER
RESISTANCE 0-200 Ohms Accuracy 1%
DC Voltage 0-200V Accuracy 0.5%
AC Voltage 0-200V Accuracy 5%
AC Current 0-1A Accuracy 1%
Voltage range: 9V to 30V
Power Supply: 1 x PP3 or equivalent 9V battery
Consumption: 20mA
Size: 125x22x21mm
Price: £35.00

OUR GREAT NEW 1984 CATALOGUE
Presented with a Professional Approach and Approach to ALL who require Quality Electronic Components. Semiconductors & other Accessories ALL at realistic prices. There are no pages wasted of useless information. Catalogue is published nowadays to sell quality components at competitive prices and THAT WE STILL DO.

We hold vast stocks in "stock" for fast delivery, all items in our catalogue are available immediately at very competitive prices. The Catalogue is designed for use with our 2 hours "assistance" service and our Accessory credit cards, which we accept over the telephone.

To receive your NEW 1984 BI-PAK CATALOGUE, send 75p PLUS 25p p&p to:

THE THIRD AND FOURTH HAND
...you always need but have never got until now. This helpful and unique tool for use with Heavy Base Crocodile clips attached to rigid ends. 8x6 x4 and 6x4 sockets plus additional combi-sockets. Works with or without magnifier. Our price with magnifier as illustrated ORDER NO T402 £5.50.

TRIACS - PLASTIC
4 AMP - 400V - 1000V - 100 VOLT - 40V - 400V
Price: £3.75 £17.50 £30.00

VOLTAGE REGULATORS TO220
Positive + Negative +
7805 - 500 7815 - 500
7812 - 400 7814 - 100
7905 - 400 7912 - 100
7915 - 500 7914 - 100
7924 - 400 7925 - 100

36
60
Price: £5.75 £25.50 £50.00

This offer is valid from 1st January 1984 and ends 31st December 1984. No order may be accepted after this date unless special arrangements are made.

To order, send your orders to Dept PE? BI-PAK PD BOX 6 WARE, HERTS.


**MDVICH**

**COMPUTER COMPANY LIMITED**

RICKHALL HOUSE, HINDERCLAY ROAD, RICKHALL, SUPTON 192 [HLO, TEL:DIS 0227 [071]].

**BBC Microcomputers**

Model B $1129.36
Model B 8+ $1720.8
Model B 8+ disc $2058.9

**BBC Micro Eeetet**

Full size products available, installation service available.

**BBC Compatible Disc Drives**

Cased drives fitted to match the BBC Micro are supplied complete with connectors, manual and ablalter discs.

All single speed drives may be expanded to dual configuration by the addition of the appropriate Connectors.

Dual capacity Single Dual Unboxed

10K 800K $1632.45
20K 800K $1632.45
40K 800K $1632.45
80K 800K $1632.45
160K 800K $1632.45

In box units available.

Please note: Our Micro price list is full of errors and mistakes.

**Memorizers**

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<th>Type</th>
<th>Capacity</th>
<th>Price</th>
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<td>121A</td>
<td>20K</td>
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<td>121D</td>
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<td>121I</td>
<td>640K</td>
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**Supers**

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<th>Type</th>
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<td>2.1M</td>
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<tr>
<td>131D</td>
<td>4.2M</td>
<td>£115.70</td>
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<tr>
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<td>4.2M</td>
<td>£115.70</td>
</tr>
<tr>
<td>131F</td>
<td>8.4M</td>
<td>£231.70</td>
</tr>
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<td>141D</td>
<td>16.8M</td>
<td>£462.70</td>
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**Regulators**

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<th>Type</th>
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<tr>
<td>5105</td>
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**DATA SHEETS**

Pin 1 Gold (W/W)

- 10  0.125  0.079  0.047
- 12  0.125  0.079  0.047
- 14  0.125  0.079  0.047
- 15  0.125  0.079  0.047

**Regulators**

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**Power Supplies**

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**Full range of the Regulators products is carried in stock and is listed in our FREE catalogue.**

**DOUNS D1 394.70 B2 00008.70 C1 143.50**

**800 Family**

<table>
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<tr>
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<td>£92.70</td>
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**SPECIAL OFFER - SPECTRUM 128**


Prices quoted are exclusive of VAT and are subject to change without notice.

Quantum Discounts are available on large quantities, please ring for details.

Official Distributors welcome from Education Embankments, Government Bodies and Private Companies.

Credit Accounts are available on different subject matters. Payment is due strictly by the 15th of the month.

Credit Cards are accepted (Access and Visa) on telephone and post order only NO SURCHARGE.

Out of stock items will be sourced automatically, at our discretion, or a refund will be given on return.

**SPECIAL TELEPHONE NUMBER FOR FAST, IMMEDIATE ORDER: 021 723 1088**

**ORDER TO DISS (0379) 898751**

**DIGITAL MULTIMETERS**

- **800 Family**
- **500 Family**
- **300 Family**
- **200 Family**
- **100 Family**

**DIAGNOSTIC BOXES**

- **Comprehensive Test Boxes**
- **Professional Test Boxes**
- **Basic Test Boxes**

**THANK YOU FOR YOUR BUSINESS**

**Sewell 2000.**

**DIGITAL MULTIMETERS**

- **COMPRHENSIVE TEST BOXES**
- **PROFESSIONAL TEST BOXES**
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**DIGITAL MULTIMETERS**

- **CHERRY ADDER ON KEYPAD**
- **DIAGNOSTIC BOXES**

**PRESIDENTIAL MULTIPORS**

- **SANYO DM212 HIGH RESOLUTION MONITOR**
- **BBC Microcomputers**

**DIGITAL MULTIMETERS**

- **800 Family**
- **500 Family**
- **300 Family**
- **200 Family**
- **100 Family**

**DIGITAL MULTIMETERS**

- **CHERRY ADDER ON KEYPAD**
- **DIAGNOSTIC BOXES**

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- **DIAGNOSTIC BOXES**

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- **BBC Microcomputers**

**DIGITAL MULTIMETERS**

- **CHERRY ADDER ON KEYPAD**
- **DIAGNOSTIC BOXES**

**PRESIDENTIAL MULTIPORS**

- **SANYO DM212 HIGH RESOLUTION MONITOR**
- **BBC Microcomputers**
Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

**SX 1000 Electronic Ignition**
- Inductive Discharge
- Extended dwell circuit stores greater energy in coil
- Three position changeover switch
- Patented clip-to-coil fitting
- Easy to assemble, easy to fit
- Contact breaker triggered - includes bounce suppression circuit

**SX 2000 Electronic Ignition**
- Reactive Discharge
- Combines inductive & capacitive energy storage
- Gives highest possible spark energy
- Patented clip-to-coil fitting
- Easy assembly sequence
- Contact breaker triggered - includes bounce suppression circuit

**TX 1002 Electronic Ignition**
- Inductive discharge
- Extended dwell circuit stores greater energy in coil
- Three position changeover switch
- Contactless or contact breaker triggered
- Clip-to-coil or remote mounting
- Rugged die-cast case

**TX 2002 Electronic Ignition**
- Two separate systems in one unit
- Reactive Discharge OR Inductive Discharge, with three position changeover switch
- Gives highest possible spark energy
- Clip-to-coil or remote mounting
- Rugged die-cast case
- Contactless or contact breaker triggered
- Contactless adaptors included for majority of 4 & 6 cylinder vehicles

**AT-40 Electronic Car Alarm**
- Guards doors, boot, bonnet from unauthorised entry
- Armed/disarmed using concealed switch
- 30 second delay-to-arm: 7 second entry delay
- Can alternatively be wired to exterior key switch
- Flashes headlights & sounds horn intermittently for 60 seconds when activated
- Security loop protects accessories
- Low consumption C-MOS circuitry

**AT-80 Electronic Car Security System**
- Guards doors, boot, bonnet from unauthorised entry
- Armed/disarmed from outside vehicle by magnetic key fob passed across sensor pad adhered to inside of windscreen
- Individually programmable code
- 30 second delay-to-arm
- Flashes headlights and sounds horn intermittently for 60 seconds when activated
- Security loop protects accessories
- Function lights to assist setting-up
- Low consumption C-MOS circuitry

**ULTRASONIC Intruder Detector**
- Supplementary to AT-40 & AT-80
- Will work in conjunction with any door switch input or voltage sensing alarm
- Detects attempted break-in and movement within passenger compartment & triggers alarm
- Includes high efficiency ultrasonic transducers
- Crystal controlled for low drift
- Ingenious sensitivity control allows rejection from false alarms
- Low current consumption

**VOYAGER Car Drive Computer**
- 12 functions centred on Fuel, Speed, Distance and Time
- Single chip microprocessor
- Large high brightness fluorescent display with auto-dimming feature
- High accuracy distance & fuel transducers included
- Displays MPG, L/100km and miles/litre at the flick of a switch
- Visual & audible warnings of excess speed, ice, lights-left-on
- Independent LOG & TRIP functions
- Low consumption crystal controlled circuitry

**MAGIDICE Electronic Dice**
- Triggered by waving hand over dice
- Completely random selection
- Bleeps & flashes during 4 sec tumble
- Throw displayed for 10 seconds then flashes to conserve battery
- Low consumption C-MOS circuitry

**SPECIAL OFFER**
- "FREE" MAGIDICE KIT WITH ALL ORDERS OVER £40.00

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**PRICES REDUCED ON SUPER SAVE D.I.Y. KITS**

**BRAND LEADING BRITISH ELECTRONICS**

** phone your order with **

**PRICES INC. VAT, POSTAGE & PACKING.**

**CUT OUT THE COUPON NOW!**

**NAME**

**ADDRESS**

**I ENCLOSE CHEQUE(S)/POSTAL ORDERS FOR £**

**KIT REF.**

**CHEQUE No.**

**PE2/84**

**SPARKRITE (A Division of Stadium Ltd.) 82 Bath Street, Walsall, WS1 3DE England**

**Tel: (0922) 611338-9.**

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**Tel: (0922) 6114791.**

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**Tel: (0922) 6114791.**

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**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 optimised for efficiency, flexibility, reliability, easy usage, outstanding performance, valuable for money.

With over 10 years experience in audio amplifier technology I LP...
**Heathkit - IT'S A PLEASURE TO BUILD**

Bring the enjoyment back into your hobby with a kit from Heathkit. The beautifully illustrated documentation and step-by-step instructions make building a Heathkit a relaxing, absorbing pleasure! Choose from their huge range of fascinating kits and self-instruction electronics and computing courses.

The Heathkit range includes the ultimate in amateur radio kits, computerised weather stations, a highly sophisticated robot, a 16-bit computer kit and a range of home (or classroom) learning courses. These state-of-the-art courses have easy-to-understand texts and illustrations, divided into sections so that you can progress at your own pace, whilst the hands-on experiments ensure long-term retention of the material covered.

---

**You’ll be proud to say, “I built it myself”!**

You’ll find Heathkits available for Amateur Radio Gear • Car Test Equipment • Kits For The Home • Self-Instruction Courses • Computer Kits • Test Instrument Kits • Kits For Weather Measurements.

All the most popular kits and educational products are fully detailed in the 1984 Maplin catalogue (see outside back cover of this magazine for details) or for the full list of Heathkit products send 50p for the Heathkit International Catalogue complete with a UK price list of all items.

All Heathkit products available in the UK from:

**Maplin Electronic Supplies Ltd.**
P.O. Box 3, Rayleigh, Essex, SS6 8LR.
Tel: (0702) 552911.

(For shop addresses see back cover.)

---

**TOROIDALS**

The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidal offer in size, weight, lower radiated field and, thanks to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

**15 VA**

<table>
<thead>
<tr>
<th>62 x 34mm</th>
<th>0.35kg</th>
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**SERIES SECONDARY HUS**

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<tr>
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<td>1 9</td>
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<td>12</td>
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<tr>
<td>0x03</td>
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<td>0.5</td>
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<td>0x04</td>
<td>14</td>
<td>0.4</td>
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<tr>
<td>0x05</td>
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<td>0.3</td>
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<td>0x07</td>
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*(encased in ABS plastic)*

**30 VA**

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<thead>
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<th>90 x 35mm</th>
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**50 VA**

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**SERIES SECONDARY HUS**

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**120 VA**

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**SERIES SECONDARY HUS**

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**225 VA**

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<tr>
<td>4x10</td>
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**500 VA**

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<thead>
<tr>
<th>140 x 55mm</th>
<th>4kg</th>
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<tr>
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**SERIES SECONDARY HUS**

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<th>Volts</th>
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</tr>
<tr>
<td>5x10</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

**Why a Toroid?**
- Smaller size & weight to meet modern "slimline" requirements.
- Low electrically induced noise demanded by compact equipment.
- High efficiency enabling conservative rating whilst maintaining size advantage.
- Lower operating temperature.

**Why ILP?**
- Ex-stock delivery for small quantities.
- Gold service available. 21 days manufacture for urgent deliveries.
- 5 year no quibble guarantee.
- 36 realistic delivery for volume orders.
- No price penalty for call off orders.

**Prices Including P&P and VAT**

<table>
<thead>
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<th>£</th>
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</tr>
<tr>
<td>120 4</td>
<td>11.13</td>
<td>625 9</td>
<td>31.63</td>
</tr>
</tbody>
</table>

For 220V primary (Eurpean insert "2") in place of "X" in type number.
For 220V primary (Eurpean insert "8") in place of "X" in type number.

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GOOD AND BAD

In line with much of the rest of industry electronics companies have had a mixed year in terms of profitability. The recently published Jordan Survey shows the fortunes of 500 UK electronic and electrical companies during 1982. While some well known names have achieved remarkable profits, others have suffered dramatic decreases in turnover and substantial profit drops.

A few examples of well known companies will give an illustration: Farnell Electronics achieved almost 25 per cent profit against turnover. Amstrad Consumer Electronics achieved an increase in turnover of more than 98 per cent, while Celestion International registered a trading loss of nearly £1.3 million. Perhaps more interesting is that a number of companies have managed to reverse a downward trend. Muirhead for instance have moved from a loss of almost £2.3 million in 1980 to a profit of more than £1.2 million in '82.

WAGE RATES

The survey covers many areas concerned with finance, including average wage rates calculated from the wage bill and number of employees. Average wage of the top thirty companies is over £7,900 and at the top of the list IBM UK Holdings Ltd. are paying an average wage of £13,700. The top thirty include Digital Equipment, ICL, National Panasonic (UK), Hewlett Packard, JVC (UK) Ltd., Ampex, Burroughs Machines, Pirelli UK, RCA, BICC, Robert Bosch, Racal, Pioneer High Fidelity (GB) and Rank Precision Industries Ltd., plus others whose names are not quite so familiar.

Obviously not all the figures can be taken at face value, for instance a new company last year should have little problem in achieving a substantial increase in turnover this year. A company that employs only a few "directors" may come top of the average wage table; but, in general, those examples shown above are realistic.

One point that comes to mind when reading the list of companies on the wage table is that there are a sprinkling of Japanese based organisations in the top 30. Perhaps it is not only the lower names are not quite so familiar.

The moral must be that you have to be good to survive in any market.

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MULTITASKING ZX81

You would not think that even major surgery could turn the ZX81 into a fast, multitasking machine, so it comes as a surprise to learn that changing just one i.e. achieves exactly this.

Swap the ZX81's Sinclair BASIC ROM for David Husband's ZX81 FORTH EPROM, and you have a machine that will run about 300 times faster, and can work a schedule comprising many different "background" jobs (multitasking) without the use of interrupts.

Up to 63 different tasks may be timetable/priority activated, although ten simultaneous tasks is a practical limit if editing new programs is not to be painfully slowed down. Like we humans, the more divided the computer's attentions, the slower becomes its execution of individual tasks.

Requiring at least 2K RAM, the EPROM provides user-defined split screen format, it being possible to run the editor whilst the "execution" screen is running a program. ZX81 FORTH is a compiler directive language (quite unlike BASIC) and does not use fig-FORTH's inner interpreter approach—a departure that makes it faster than fig-FORTH. ZX81 FORTH matches fig-FORTH's standards but lacks some of the vocabulary (restricted by memory space). On the other hand, it includes extra words for multitasking.

The ZX81 FORTH EPROM is available from David Husband, 2 Gorleston Road, Branksome, Poole, Dorset BH12 1NW. Tel: 0202 764724. Price: £25 plus VAT (includes manual). Ready converted ZX81s are also available.

The ZX81 FORTH operating system and language incorporates a realtime clock, but has only integer arithmetic, although an extension ROM p.c.b. containing floating-point arithmetic and other refinements is to become available.

MODULAR RACK SYSTEM

Just one of the equipment housing options available from the 1984 Bicci-Vero catalogue (Hobby Herald) is the KMT Card Frame range, in kit form.

This system is extremely flexible and incorporates an extruded aluminium and plastic box into which can be plugged different sized modules each with their own front panel, veroboard and edge-connector. There is ample access for interconnections between modules within the unit. A further advantage is the partitioned rear section in which power supplies can be both electrically and thermally segregated.

The 1984 Hobby Herald costs 50pence, it contains over 100 new products, the KMT system however costs slightly more: around £12 for the box, with modules extra. All available from, Retail Department, Bicci-Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Hants SO5 3ZR (04215-62829).

PI's PLUG

Microcomputers suffering from amnesia need no longer be terminal cases!

Spikes and holes in the domestic mains electricity supply (caused by switching off and on, electrical equipment) can create havoc for microprocessor users—at worst, a complete crash, at best, a corruption of vital data.

To prevent downtime, reprogramming and to enhance the microcomputer's reliability, Power International's 'PLUG'—a neatly packaged RFI filter and transient suppressor of innovative design contained in a modified 13 amp plug case—effectively absorbs spikes in the power line and reduces their voltage to a tolerably safe level.

The cost of the plug is £15.50 (including post, packing and VAT) from Power International Ltd., 2A Isambard Brunel Road, Portsmouth, Hants.

ERL's LEAD

The increasing popularity of home computers, video, and hi-fi separates means that many households are suffering from a proliferation of cable ‘spaghetti’ in their living rooms. To overcome this problem ERL has developed the multiplug.

This is a compact four-way mains distribution unit. Supplied with high quality three core cable and plugs the complete unit measures only 175x35x35mm. It can be mounted either on a wall or directly onto the back of the equipment.

Alternatively it could form the basis of a simple do-it-yourself housing for computer, television, video or hi-fi equipment. The unit is rated at thirteen amps and can handle up to six amps at each outlet. The recommended retail price is £7.95 or less.

ERL has also developed the Aerial Adaptor. It's a switched two way adaptor which allows the user to select either of two coaxial inputs (such as roof top aerial or computer) into the TV monitor. Alternatively it can be used with a stand alone games unit as well as a micro computer. The recommended retail price is £15.00. Both products are available through electrical, hi-fi and computer stores.
CAPACITANCE METER CM200

The newly released CM200 from Thurlby Electronics Ltd is a digital capacitance meter which has a maximum delay between connecting a capacitor and getting the first valid reading of less than half a second. This rapid settling combined with a reading update rate of 3 per second makes the meter unusually fast to use.

The CM200 has a 41 digit digital crystal display with a maximum reading in excess of 25,000 counts. It measures capacitance between 1pF and 2,500µF to an accuracy of 0.2%.

Very low power consumption enables the CM200 to operate for several hundred hours from batteries. Alternatively it can be operated from the a.c. line adaptor supplied with it.

A special input socket arrangement allows for the direct connection of a wide variety of capacitors, or for the connection of standard test leads. A zero calibration control enables the user to null out up to 25pF of test lead capacitance.

The CM200 costs £89 plus VAT. Details from Thurlby Electronics Ltd., New Road, St Ives, Cambs. Tel (0480) 63570.

Silicon News Corner

CTS Microsystems

- CTS108AGB high specification precision op. amp. Extremely low offset voltage.
- CTS0061B hybrid high voltage, high current driver. 45V supply and 1.5A pulsed load. Ideal for non-linear resistive loads such as incandescent lamps.
- CTS111GB voltage comparator with input currents around 100 times lower than 710. Can drive lamps or relays direct (up to 50V @ 30mA).
- CTS0041ZB general purpose diff. input op. amp. gives output of 200mV.
- CTS211IEB dual voltage comparator (2 x CTS111GB type comparator).
- CTS2108AEB dual op. amp. Contains two “105A” type precision op. amps. with extremely low offset voltage.
- CTS2101AEB dual op. amp. comprises two “101A” type devices featuring high gain, slew rate capability and excellent temp. stability.
- CTS0034CB dual high level shaper interfaces TTL/DTL to MOS/JFET

- CTS108GB cermet hybrid i.e. is a log. (if.) amplifier, 10MHz to 100MHz. Voltage gain of 12dB.
- CTS0024GB very wide bandwidth, high slew rate op. amp. for buffers, D/A & A/D converters and high speed comparators. Useful gain to 50MHz.
- CTS0033ZB voltage follower (high speed buffer) for line driving.

Exar Systems Inc.

- XR-14412 contains everything necessary to construct a complete FSK modulator/demodulator (modem) system, in either US or CCITT standard.
- XR-2120 self-contained CMOS bandpass filter set designed to realise the BELL 212A compatible 1200bit/sec FSK modem.
- XR-2123 contains the heart of a full duplex BPS modem.

CTS and XR devices both available from Rastra Electronics Ltd., 275-281 King Street, Hammersmith, London W6 9NF. Tel: 01-748 3143.

CONTROL 65

Control 65 is a small low cost microcontroller p.c.b. allowing ‘stand alone’ terminals to have intelligence and flexibility. A +5V supply is all that is required to make the compact 75mm x 100mm p.c.b. into a versatile controller offering 16 TTL compatible Input/Output lines, up to 8KB of EPROM decoding, 2KB of user RAM plus the popular 6502 microprocessor. Onboard links allow 2716,2732 EPROM type devices to be used. P/I/O interrupts are serviced for fast I/O response times.

The card, which can be easily programmed, is supplied with full user notes and circuit diagram at a price of £49.95 plus VAT from J.P. Designs, 37 Oyster Row, Cambridge (0223) 322234.

Countdown...

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

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Electrex Feb. 27–March 2. NEC, B'ham. L3
Seatelex March 6–8. Anderson Exhibition Cntr., Glasgow. T
Home Appliances International March 12–15. NEC, B'ham. M
Electro-Optics/Laser International March 20-22. Metropolis, Brighton. T1
Scottish Computer Show March '84. Holiday Inn, Glasgow. T1

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M Monthbuild 01-486 1951
O Online 09274 28211
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THE computer terminal (glass teletype) presented in this article is a serial device being connected to the host computer system via an RS232 link (which is compatible with the BBC's RS423 link). The display consists of 1024 characters arranged as 16 rows each of 64 characters, with the full 128 ASCII character set being supported (see Fig. 1.1). Seventeen of the 32 ASCII control characters are displayed as graphic characters whilst the remaining fifteen provide facilities such as BEL and the various cursor movements (see Table 1.1). Three of these, DC2, DC3 and DC4, together with a small amount of extra circuitry, provide the options of controlling external devices, such as a cassette recorder motor, selecting normal or reverse video, or any other function the reader may care to include.

The computer terminal will drive either a normal television or video monitor, and operate in full or half duplex, with the data format and Baud rate selected by printed circuit board mounted switches. The majority of components are mounted on a single-sided, double Eurocard size p.c.b. A doublesided through-plated-hole p.c.b. was considered but rejected on cost grounds, even though it would eliminate the use of links. The system is housed in an easily constructed case with wooden end plates and painted aluminium panels, to give it a professional appearance.

CIRCUIT DESCRIPTION

The system is designed around the Thomson SFF96364 cathode ray tube controller (CRTC). This chip contains all the logic necessary to generate the address lines to update and refresh the memory as well as provide the horizontal and vertical sync pulses. In addition, the cursor position can be controlled by means of the C0, C1, C2, inputs. This facility is very useful as it allows characters to be positioned at random, a definite improvement over a mechanical Teletype.

The characters to be displayed are stored in a 1K x 7 bit memory, comprising seven 2102 1K x 1 memory devices IC1 to IC7. A seven bit memory allows the full 128 ASCII character set to be implemented. This type of Random Access Memory (RAM) has separate data input and output lines. It was first thought that it would be better to use a single device such as the 6116; however, as these devices have common data inputs and outputs it would be necessary to include two tri-state buffers. It is true this would reduce the component count, but it would also increase and complicate the p.c.b. layout.

Parallel data from the keyboard is fed to the transmitter section of the 6402 UART (Universal Asynchronous Receiver Transmitter). This device converts the keyboard's parallel output to serial form suitable for transmission to the
host system. These signals do, however, need to be transformed from TTL levels to the RS232 levels of +12 volt and −12 volt. This is achieved by IC18b, logic “0” being represented by +12 volts and logic “1” by −12 volts. Incoming data from the host system is converted from RS232 to TTL levels by IC21a before being fed to the UART’s receiver section. This section works in the opposite mode to the transmitter section in that it converts serial data to parallel data. When a complete character has been received, the UART produces a strobe to inform the SFF9 6 3 64 that a character is available. Pins 35 to 39 on the UART allow it to be programmed so that the data format is compatible with that of the host system. Table 1.2 indicates the possible formats that may be selected by means of S5 to S10.

By making a very simple modification to the p.c.b. it is possible to install an AY-5-1013 type UART in place of the 6402. The only difference between these two devices is that the AY-5-1013 requires a −12 volt supply whereas the 6402 does not. All that is required is to connect the UART’s transmitter section in that it converts serial data to parallel TTL levels by IC2 1a before being fed to the UART's receiver section. This section works in the opposite mode to the transmitter section in that it converts serial data to parallel data. When a complete character has been received, the UART produces a strobe to inform the SFF9 6 3 64 that a character is available. Pins 35 to 39 on the UART allow it to be programmed so that the data format is compatible with that of the host system. Table 1.2 indicates the possible formats that may be selected by means of S5 to S10.

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Not only does the data sent to the host system have to be in the correct format as stated above, it also has to be transmitted at the correct speed. A crystal controlled Baud rate generator IC16, whose output frequency is selected by switches S1 to S4, is therefore included in the design. S1 to S4 should be set for the desired Baud rate (55 to 640 Baud) by referring to Table 1.3.

Switch S11 is included to allow the “glass teletype” to link to the AY-5-1013, which operates in either full or half duplex. In most applications the host system echoes the received character back to the sending device, which is called full duplex. However if the

---

### Table 1.1: Terminal functions

<table>
<thead>
<tr>
<th>Function</th>
<th>( \text{D}_2 )</th>
<th>( \text{D}_3 )</th>
<th>( \text{D}_5 )</th>
<th>( \text{D}_6 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cursor left</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cursor right</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Home cursor</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Erase line</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Clear screen</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Erase current line</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Home cursor</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Normal character</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

---

### Control EPROM outputs

**NB**  \( \text{D}_3 = \text{BEL} = \text{A} \)

\[ \text{D}_2 = \text{DC1} = \text{B} \]

\[ \text{D}_3 = \text{DC2} = \text{C} \]

\[ \text{D}_6 = \text{DC3} = \text{D} \]

---

### Terminal functions

- **BEL** = A
- **DC1** = B
- **DC2** = C
- **DC3** = D

Available through the RS232 link.
host system does not echo the character, or if the glass teletype is to be tested, it should be set to half duplex. In this mode the glass teletype's output is directly connected to its input, which is disconnected from the host system's output.

The seven bit word from the UART's receiver is fed to a 2716 Erasable Programmable Read Only Memory (EPROM). This, the control EPROM, is programmed to provide the SFF96364 with data so that the various cursor movements can be implemented, as well as control external devices. The EPROM program is available from PE. The seven bit word from the UART's receiver is also fed to the series of gates IC17a,c,d & IC18b,d & IC19b,c,d. For normal characters (alpha-numeric and graphic) the outputs from these gates are the same as their inputs as the SFF96364's Clear Screen line (pin 13) is at logic "1". However, if the code for clear screen (CT/L) is received, the SFF96364 will hold the Clear Screen line at logic "0". This forces the outputs of these gates to the ASCII code for space (20 HEX), whilst the SFF96364 writes this code into all the RAM's memory locations thereby effectively clearing the screen.

CHARACTER GENERATOR

The RAM's outputs are latched by IC8 before being fed to the character generator EPROM IC12, a second 2716. Readily available character generators, such as the RO-3-2513, are normally used in this type of design, but they will only support either upper or lower case alpha-numeric characters. The use of a 2716 EPROM is not only a cheaper solution, it also allows this system to have both upper and lower case alpha-numerics, plus some graphic characters. In addition the use of an EPROM allows the reader to produce whatever character set he or she may desire. For example, one application may require the Greek alphabet instead of lower case. The method of devising the EPROM data will be discussed later.

<table>
<thead>
<tr>
<th>Switch</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>S5</td>
<td>OFF No parity bit</td>
</tr>
<tr>
<td>S6</td>
<td>ON Parity bit</td>
</tr>
<tr>
<td>S7</td>
<td>OFF Even parity</td>
</tr>
<tr>
<td>S8</td>
<td>ON Odd parity</td>
</tr>
<tr>
<td>S9</td>
<td>OFF 2 Stop bits</td>
</tr>
<tr>
<td>S10</td>
<td>ON 1 Stop bit</td>
</tr>
<tr>
<td>S11</td>
<td>OFF 5 Character bits</td>
</tr>
<tr>
<td>S12</td>
<td>ON 6 Character bits</td>
</tr>
<tr>
<td>S13</td>
<td>OFF 7 Character bits</td>
</tr>
<tr>
<td>S14</td>
<td>ON 8 Character bits</td>
</tr>
</tbody>
</table>

NB S10—not used

Table 1.2. Formats selected by S5-S10

<table>
<thead>
<tr>
<th>Baud rate</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>75</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>110</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>134.5</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>150</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>200</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>2400</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>3000</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>4800</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>7200</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>9600</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>19200</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

Table 1.3. Baud rate selection

Fig. 1.2. PSU and video mixer circuit diagram
Fig. 1.3. Full circuit diagram
The output from the character generator EPROM is loaded into a shift register IC15. This device provides two complementary outputs which can be used to provide either normal or reversed video as required, via link "L". IC20a and IC20b are connected to form a gated oscillator running approximately 13 MHz, the dot rate clock. This clock is fed to the shift register to provide the required series of dots to form the characters on the screen, i.e., the video signal. As each character is eight bits wide IC13 and IC20d divide the dot rate by eight to produce the character rate clock. This is fed to the shift register and the latch, thereby setting the dot sequence for the next character. This arrangement allows the EPROM's address lines to be set one character before being output from the shift register, thereby giving the EPROM sufficient time to access the data. A variable resistor VR1 allows the dot rate, and hence character width, to be altered to suit the video monitor, or television used.

A second output from IC13 is fed back to the SFF96364 so that correct synchronisation of the character generator row counter output (RO,R1,R2) may be achieved. During the time between the last character on a line and the first character on the next line being displayed no information should be output from the shift register. To achieve this the SFF96364 outputs a signal from pin 10 that inhibits the 13 MHz dot rate oscillator, thereby preventing spurious data being displayed on the screen.

The video output from the shift register IC15, either normal or reversed, and the sync pulses from the SFF96364's pin 26, are combined by TR1 and buffered by TR2 to produce a composite video signal suitable for driving an external video monitor, and the onboard UHF modulator type UM1233. The latter's output may be used to drive a standard television. VR2 is included to allow the composite video voltage to be adjusted to suit the monitor, or television used.

An output from the control EPROM (03) is produced whenever the ASCII character CTL/G (BEL) is received. This signal is fed, via a filter (R18,C19) to IC14, a monostable whose output pulse is used to energise a small on-board buzzer for approximately half a second to produce the BEL signal whenever the ASCII character CTIJG (BEL) is received. This is also the case when returning from the end of the last line to the beginning of the first. This is called "fly-back".

To generate the required picture, the intensity of the beam is varied according to the level of the video signal, thereby producing light and dark patches on a monochrome television. Fig. 1.4 shows how the word "GLASS" is generated by the scanning beam. As the system scans line by line the word is built up by displaying a sequence of dots. First the top row of the characters is displayed, followed by the second row, then the third and so on until the characters are complete.

This sequence is repeated for a complete frame, whereupon the beam is returned to the top left-hand corner of the screen ready to repeat the frame.

CHARACTER GENERATOR EPROM

Fig. 1.5 shows the format for the character "E". As can be seen, the character is contained within a cell 8 dots wide and 11 dots high. For alpha-numeric characters columns 1, 2 and 8, and rows 1, 9, 10 and 11 are blank to provide inter-character spacing both vertically and horizontally. EPROM address lines A3 to A9 are provided by the latch IC8, and select which character is required. As each character consists of 11 rows, the row displayed is determined by the EPROM's A0 to A2 address lines; these are fed by the SFF96364's R0,R1,R2 outputs. However, the reader will have noticed that although the character displayed has 11 rows, only data for 8 rows is stored in the EPROM. The reason for this is that the SFF96364 provides the same data on the EPROM's A0 to A2 address lines for row 1 as it does for rows 9, 10 and 11. Therefore, whatever is programmed for row 1 will appear in rows 9, 10 and 11. Reference to the graphic characters shown in Fig. 1.1 will confirm this.

For normal alpha-numeric characters, row 1 is always blank, but this may not be so for graphic characters. A point to consider when using or designing graphic characters is due to the internal operation of the SFF96364. This is such that a dot be present in the first column of the first character in a line, or in the last column of the last character in a line, it will produce a line to the left or right extremities of the screen respectively. A similar effect occurs if a dot is

POWER SUPPLY

The majority of the circuit works on 5 volts, but the RS232 link requires +12 volts and −12 volts. In addition keyboards using the AY-5-2376 keyboard encoder also require −12 volts. The centre tapped output from transformer T1 is rectified by the bridge rectifier D1 to D4, and smoothed by capacitors C3,C4. Two 78 series and one 79 series voltage regulators IC23 to IC25 provide the required voltage levels, and are mounted on a heat sink. Capacitors C5 to C10 decouple the regulators whilst C11 to C27 decouple the p.c.b. circuitry.

PICTURE GENERATION

Before discussing the method of calculating the EPROM data it is worth considering the method by which a video display is generated. Careful examination of a domestic television screen will show that the picture is composed of a number of horizontal lines. The picture is generated by an electron beam scanning the screen, line by line, starting at the top left-hand corner. The time taken to produce one complete picture or "frame" is 20ms, i.e. fifty times per second.

When a line is complete, the beam is returned to the start of the next line, during which time no information is displayed. This is also the case when returning from the end of the last line to the beginning of the first. This is called "fly-back".

To generate the required picture, the intensity of the beam is varied according to the level of the video signal, thereby producing light and dark patches on a monochrome television. Fig. 1.4 shows how the word "GLASS" is generated by the scanning beam. As the system scans line by line the word is built up by displaying a sequence of dots. First the top row of the characters is displayed, followed by the second row, then the third and so on until the characters are complete.

This sequence is repeated for a complete frame, whereupon the beam is returned to the top left-hand corner of the screen ready to repeat the frame.

CHARACTER GENERATOR EPROM

Fig. 1.5 shows the format for the character "E". As can be seen, the character is contained within a cell 8 dots wide and 11 dots high. For alpha-numeric characters columns 1, 2 and 8, and rows 1, 9, 10 and 11 are blank to provide inter-character spacing both vertically and horizontally. EPROM address lines A3 to A9 are provided by the latch IC8, and select which character is required. As each character consists of 11 rows, the row displayed is determined by the EPROM's A0 to A2 address lines; these are fed by the SFF96364's R0,R1,R2 outputs. However, the reader will have noticed that although the character displayed has 11 rows, only data for 8 rows is stored in the EPROM. The reason for this is that the SFF96364 provides the same data on the EPROM's A0 to A2 address lines for row 1 as it does for rows 9, 10 and 11. Therefore, whatever is programmed for row 1 will appear in rows 9, 10 and 11. Reference to the graphic characters shown in Fig. 1.1 will confirm this.

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Fig. 1.5. Format of character "E"

present anywhere in the top row of a character on the top line of the display. In this case a vertical band to the top extremity of the screen will be displayed.

EPROM address line A10 is controlled by the SFF96364's cursor output (pin 15). This address line has the effect of dividing the EPROM into two sections, a lower half when A10 is low and an upper half when A10 is high. Reference to the EPROM's contents shows that all memory locations in the upper half of the EPROM contain the same value (3E HEX). Thus whenever a cursor is required a small horizontal line is displayed in place of whatever character was in that position. The cursor signal is switched at approximately 3Hz by the SFF96364 thereby producing a flashing cursor. The reader may alter the cursor format to suit his application by altering the data stored in the upper half of the EPROM, taking into consideration the restrictions above regarding the design of graphic characters.

To calculate the eight data bytes required for a particular character, that character should be drawn in an 8 x 11 matrix, bearing in mind the above comments. The value of each byte is determined by adding the weightings for each dot in a row together and then converting that value to its hexadecimal form. The eight words are stored consecutively in the EPROM, row 1 first followed by row 2 and so on.

The address of the first byte is found by using the following formula:

Start address = ASCII character number x 8 where all values are Hexadecimal.

For example consider the character "E" (Fig. 1.5) start address = 45H x 8H = 228H.

CONTROL EPROM

It was stated earlier that the SFF96364 has the capability of cursor position control. Table 1.1 shows those available together with their respective ASCII control characters and execution times. In order to determine which cursor control is required, if any, the SFF98634 examines the status of its CO, C1 and C2 inputs. The tables also indicate which codes correspond to which facilities. These signals are provided by IC10 the control EPROM via its D0, D1 and D2 outputs. EPROM output D7 determines whether the ASCII character present is to be displayed or not; (logic "1" = print, logic "0" = inhibit).

A 2716 type EPROM has 8 outputs. With four used for cursor control, four remain to be used for the control of external devices, such as the BEL facility described earlier. As a 2716 EPROM has 2K memory locations and only 128 are used, one for each ASCII character, only the lower address lines, A0 to A6 are used, address lines A7 to A10 are connected to ground.

Should the reader wish to produce his or her own character set and/or control functions, the control EPROM should be programmed so that the memory location with the same value as the character's ASCII value contains the appropriate control byte.

For example, if the ASCII character "NUL" (00) were to be replaced by a graphic character, the byte stored at memory location 00H should be changed from 06H to 87H, the code for a normal printing character.

NEXT MONTH: Construction and testing is covered, along with how to drive additional features, and interface to the BBC microcomputer.
casting given adequate data input with
Futurism
will
and that
week, let alone ten years ahead which is
shuffle and temporary loss of confidence.
political scandal which may embarrass a
as an upsurge in union militancy or even a
celerating, hot wars proliferating, default of
unpredictable than the weather. 1983 saw
events which depend on people, even more
trading nations
and predict an average harvest.
one has to make assumptions and hope
national corporations. The trouble is that
of government policies or that of multi-
level of personal finance, the complexities
ecessary to take a 'view' on the future
forecasting
different schools.
large disagreement between economists of
in economic predictions and apart from a
computer processing. We already have this

Given that,
puter, has one fundamental assumption

With such volatility
in
local and world
airs it is doubtful that even the most
powerful computer complex fed with the
most accurate and up-to-date data can
ably even though they are demonstrably bet-
ter off. Electronics will remain the growth
industry of the decade.
My long-term prediction is for a con-
tinued improvement in the standard of liv-
ing. This view is based on historical projec-
tion which tells us that for the past 40 years
our economy has been in 'crisis' every year
and yet there has been consistent gain over
the period measured in terms of home ow-
ership, hours worked, holidays, pensions,
longevity. There are always difficulties but
they are always overcome. Short-term ups
and downs when averaged out show steady
in living standards.

Distributors
Electronic engineers like to be associated
with genuine creative activity. To be a pro-
ject leader or a member of a team respon-
sible for a technical breakthrough or an
acknowledged best-in-the-world product is
something to be proud of.
But if your interest is just in making
money then to be a humble peddler of com-
ponents is the thing. An investor can also
do well in the business. A recent listing
revealed that £1,000 invested in Farnell in
1968 would be worth almost £103,000 to-
day. Number two on the list is Diploma,
another distributor, with old friend Elec-
trocomponents fourth with £64,560 return
on £1,000 invested in 1967. Of the manufac-
turers Ricam is leader with
£75,000 for £1,000 invested in 1965. GEC
is way down at Number nine and Plessey
one from the bottom of the top twenty at
Number nine, with a return of £9,450.
In April 1983 Lex Service Group bought
the Jermy Group for £15 million cash.
Such is the lure. Last October Lex spent
another £3.5 million buying two dis-
tributors in West Germany,
I call them humble peddlers for that is
what they are. The supermarkets of the in-
dustry. But like their high-street equivalents
the profitable ones are those with the most
sophisticated data-processing and manage-
ment techniques for stock and credit con-
trol. High investment and high volume are
the order of the day and fierce competition
ensures good service to the industry.
There are still a few small distributors,
mainly of specialised components, who
might be categorised as corner-shops. They
also exist on service, assisted by low over-
heards. It would be a pity to see them go.

Open Warfare
The price war in small business and
home computers continues to intensify.
And that before the Japanese are fully in
the market and the IBM challenge yet to ap-
pear in the UK for another few months.
Texas Instruments has withdrawn hurt
from the personal market having lost over
200 million dollars in nine months but
stuck with having to honour 12-month guar-
antees, periods, on recent stock-
clearance sales. The service operation must
result in further loss as up to 20 per cent
of some makes of machine (not necessarily TI)
are reported to fail in their first year.
With prices tumbling by up to 50 per
ent it is clear that margins are being
squeezed to the limit in the hope that in-
creased volume will maintain profits. But
already it would seem that some manufac-
turers are on break-even or less on the
original purchase and relying on peripheral
purchases later on to generate the real
profit. Once a customer is hooked it is
almost inevitable that he will want to
enhance his system.
Futurism is rampant in this area. It
automatically fails because the input data is
suspect. A number of analysts are making
projections, all with conflicting results. The
biggest error is in claimed market share
which when added up from the various
manufacturers often exceeds 100 per cent.

Ma Bell and BT
The final break-up of AT & T, the giant
USA telephone company, occurred on New
Year's Day. It included divestiture of local
Bell Telephone companies by the parent
with consequent re-formation into several
new companies.

Naturally, our own trade unions are at-
tempts to equate privatisation of British
Telecom with the break-up, by the order of
USA courts, of AT & T. As part of their op-
position to privatisation the BT Unions
Committee has issued a report "The Ameri-
can Experience" pointing out all the
difficulties and disadvantages of
 demolishing an existing monopoly.
BT responded by pointing out that
privatisation plans for BT are quite different
in kind and that most of the comparisons
and conclusions in the report are mis-
leading and confused. Sir George Jefferson,
BT's chairman, is enthusiastic on privatisa-
tion which, he maintains, will free them
from the web of government interference
and control and is the best way to succeed
in the years ahead.
Sir George's view on the unions is, "They
are consumed with a nostalgia for a past
that advancing technology and changing
markets have made obsolete". And to ram
the message home he quotes TUC leader
Len Murray who is on record as saying "The
countries with the highest standard of living
are those which cope best with structural
changes in industry".
The actual American experience will be
watched with interest. Like our own BT ex-
ecutives, those in Ma Bell see the break-up
of monopoly power, which also imposed
restrictions, as a great new opportunity to
expand and flourish. Time alone will tell.

Upturn
Recovery from recession continues un-
abated led by the USA's economy. The
spin-off in electronics is world-wide. Moto-
rola is spending E11 million on a fully
automated IC packaging plant at the com-
pany's East Kilbride premises creating over
100 new jobs. The plant will package chips
from Motorola production lines in Munich
and Toulouse as well as the East Kilbride
product. The revealing and encouraging
fact is that the new plant is needed because
Motorola's Far East assembly operations
cannot keep pace with expanding demand.
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£19.95
- 90-120-150-180 Hold-Position Hinge
- Includes Test Leads and Instruction Manual
- DC Volts: 0 to 1200, 7 ranges.
- AC Volts: 0 to 1200, 5 ranges.
- DC Current: 0-60μ, 3-30-300 mA.
- Resistance: 0-2-20-200k-2 megohms (centre scale 24). dB: -20 to +63 dB, 5 ranges.
- Accuracy: ±3% DC, ±4% AC.
- Measures 7 1/4 x 4 9/16 x 1 1/4". Requires "AA" battery. 22-211

Micronta™ Pocket Sized Multitester

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- Keep One In Your Glove Compartment
- Ideal For The Electronics Hobbyist
- 8-range, 2000 ohms/volt pocket sized multimeter is small enough for your glove compartment, toolbox or pocket. Has a single-knob range selector for high accuracy.
- DC Volts: 0 to 1000, 3 ranges.
- AC Volts: 0 to 1000, 3 ranges.
- DC Current: 15C mA.
- Resistance: 0 to 10,000 ohms (3600 centre scale).
- Accuracy ±3% DC, ±4% AC.
- Measures 3 1/2 x 2 1/4 x 1 1/4". Requires one "AA" battery. 22-212

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Deluxe Competition Joystick

£9.95 Each
- Features a "jet fighter" contoured handle and two firing buttons - one on the handle and another on the base. You can grip the base for "two-hand" operation aso, and it includes a 4ft. cable. With universal nine position connector. 270-1701

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£2.49
- [A] Semiconductor Reference Guide. Cross-reference and substitution section lists over 80,000 types and their low-cost Tandy equivalents. 276-4007 £2.99
- [B] Getting Started in Electronics. Introduction to electronics written in clear, easy-to-understand language, the book encourages "hands-on" experience. 276-5003 £2.49

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Practical Electronics February 1984
THE Clock Timer presented here enables any single appliance to be switched on and off at any time within a 24 hour period. The unit features a four digit clock operating in the 24 hour format, and a relay output capable of switching up to 10 amps at 240 volts.

The on and off times are easily programmed and may be verified at any time within the timing period. The timing period may be set to operate once only or repeated every 24 hours.

A typical application would be in conjunction with an electric heater, to switch on and off at predetermined times.

BLOCK DIAGRAM
The Clock Timer is based on the AY-5-1230 i.c., the details of which are given in Fig. 1. A simplified block diagram of this i.c. is shown in Fig. 2.

The set time logic takes the programming information from the input switches, either on or off times or clock time, and presents this information to the on/off memory or clock logic as appropriate. As the clock time approaches that of the 'on' time in the memory, various comparators detect this coincidence and switch the output on. A similar sequence occurs when the clock time reaches the 'off' time stored in the memory.

The switch marked repeat allows this timing period to be performed again after 24 hours. If this switch is not operated, the set times are cleared after the timing period.

Two I.e.d.s are provided to give the user an indication that on and off times are set and are currently stored in the memory.

CIRCUIT DESCRIPTION
The full circuit of the Clock Timer is shown in Fig. 3. The i.c. requires a supply of approximately 15V and this is given by the simple power supply consisting of T1, BR1 and C1. C2 and R21 provide the necessary 50Hz clock signal for the i.c. If this switch is not operated, the set times are cleared after the timing period.

Two I.e.d.s are provided to give the user an indication that on and off times are set and are currently stored in the memory.

The seven transistors TR1 to TR7 are segment drivers and are connected to the appropriate segments on the multiplexed displays X1 to X4. TR9 to TR12 are the digit drivers for each of the four displays. Transistor TR8 is the seconds indicator driver, and drives the two I.e.d.s D1, D2 at a pulse rate of once per second. The two I.e.d.s D3 and D4 are the off and on indicators respectively. These I.e.d.s illuminate when an off or on time has been set.

The last transistor, TR13, drives the relay which, via its single contact, supplies an output of 240V at the p.c.b. terminals.

The three switches S1–S3 are all centre off/biased both ways types and perform the following functions: S1—this switch in conjunction with S3 sets either the 'on' or 'off' times when placed in the correct position, or when the switch is in the normally off position and again using S3, sets the clock time; S2—this switch, depending on the position, either cancels the programmed times or turns the output on and off with each activation of the switch; S3—used in conjunction with S1 to set the various times. When in the normally off position the clock is allowed to run.

The last switch S4 is used to set the Clock Timer in either the 'once only' or the 'repeating' mode.
Fig. 3. Circuit diagram of the Clock Timer

**COMPONENTS . . .**

**Resistors**
- R1–R8 120 (8 off) ±5%
- R9,R11,R13,R15,R17 6k8 (5 off)
- R10,R12,R14,R16 100k (4 off)
- R18 22
- R19,R20 120 (2 off)
- R21 47k
All resistors are 1W ±5% except where otherwise stated

**Capacitors**
- C1 1000μF 25V elect.
- C2 15n polyester

**Semiconductors**
- TR1–TR12 2N3704 (12 off)
- TR13 BFY51
- IC1 AY-5-1230
- BR1 W04 bridge rectifier
- D1–D4 TIL209 red i.e.d. (4 off)
- X1–X4 TIL322 0.5" red display (4 off)

**Switches**
- S1–S3 s.p.d.t. centre off/biased both ways miniature toggle (3 off)
- S4 s.p.s.t. miniature toggle

**Miscellaneous**
- RLA OUD type 12V 400 ohm s.p.d.t.
  10A contact
- T1 0-6 0-6 6VA transformer
- red perspex front panel
- two printed circuit boards
- p.c.b. three way connector block
- 0-1" Veropins (15 off)
- ribbon cable
- mains cable
- connecting wire.

**Constructor’s Note**
The 'Time Box' and front panel are available from West Hyde Developments Ltd., Unit 9, Park Street Industrial Estate, Aylesbury. Bucks, HP20 1ET.
Fig. 4. P.c.b. design for the Main Board

Fig. 5. Component layout of the Main Board

Fig. 6. P.c.b. design for the Display Board

Fig. 7. Component layout of the Display Board
CONSTRUCTION

All the components with the exception of the switches are built on two small printed circuit boards; the track patterns and component layouts are shown in Figs. 4, 5, 6 and 7.

The two p.c.b.s are mounted at right angles to each other, with the display board being soldered to corresponding Veropins in the lower board. It is advisable to mount the two boards mentioned in the way described before any components are mounted. This is particularly important as the space between the transistors and the display board will not allow the middle pins to be soldered without damage.

Remember that the area around the relay carries mains voltages and should be checked very carefully after construction. The mains input lead may be soldered directly to the copper pads as in the prototype, or soldered to Veropins. In either case ensure that the three separate leads cannot touch each other if they are accidentally disturbed.

Finally the switches can be wired up according to Fig. 8, using, say three inches of ribbon cable. At this stage the switches are not mounted inside the case and the i.c. is not inserted into its socket.

Connect the Clock Timer to the mains and measure the voltages on the pins of the socket. All except pins higher indicates a fault and should be investigated. Next voltage across C1. This should be about 17V or so, any of insulating tape over this area will prevent any accidents.

TESTING

4 HOLES 'B'
2 HOLES A Z DIA

1 and 27 should show little or no voltage with pin 6 at about 8V. Pins 1 and 27 of course should show the supply voltage.

CASE

For the case specified in the components list, the dimensions of Fig. 9 are exact. Check though that the transformer can actually fit inside the case and does not come into contact with any wiring or other components. A number of small holes may be drilled in the rear panel to allow for ventilation.

CASE

2 HOLES 'A' 3/8 DIA
4 HOLES 'W' TO SUIT SWITCHED
2 HOLES 'Y' 3/8 DIA

Fig. 9. Case drilling details

TESTING

The usual checks such as looking for solder bridges etc, should be carried out. This is particularly important in the region of the relay, as mains voltages appear here as soon as the Clock Timer is connected to the mains. One or two layers of insulating tape over this area will prevent any accidents.

Connect the Clock Timer to the mains and measure the voltage across C1. This should be about 17V or so, any higher indicates a fault and should be investigated. Next check the voltages on the pins of the socket. All except pins 1 and 27 should show little or no voltage with pin 6 at about 8V. Pins 1 and 27 of course should show the supply voltage.

Fig. 8. Wiring diagram

Fig. 10. Annotation for the switch bank

If all is well the unit is switched off and the i.c. plugged into place. Upon reconnection of the mains supply, the four digit display should illuminate and show '0000'. Operation of S3 to either position should start the clock and start the seconds i.e.d.s pulsing.

SETTING TIME

Assuming the clock is running correctly, the exact time may be set. Place S3 in the 'Set Hour' position, the hours should advance at twice per second. Release S3 when the correct hours have been reached. Next put S3 in the 'Set Minutes' position and allow the display to reach the desired time. Once again the display should advance at twice per second. During setting of the minutes, if the time required is accidentally passed, then the switch is held on and the display allowed to go round again until the correct time has been reached. Note, the minutes will not overflow into the hours thus causing the hours display to advance.

To set either an on or off time the following procedure is adopted. Set S1 to the required function, say 'Set on time', and while holding S1 in this position, use S3 to set the hours and minutes as described above. Once the correct time has been reached, both switches can be released thus setting the 'on' time. A similar procedure is adopted when setting the 'off' time, only this time S1 is placed and held in the 'Set off time' position.

Assuming both an 'on' time and an 'off' time has been set, the two i.e.d.s will indicate this fact by turning on. If only an 'on' time has been set then only the 'on' i.e.d. will illuminate, with the result that the output will switch off ten minutes later after the programmed time. This provides a foolproof method of operation ensuring that, if an off time has been forgotten, then no damage to the controlled appliance can occur.

To allow the Clock Timer to perform the programmed on and off times every 24 hours the repeat switch S4 is operated. To cancel the set times, S2 is operated once only to the 'cancel' position. Note that the times are not erased from the memory when cancelled, and although they will not cause the output to switch on and off, they may be recalled for further use. An example here is when the 'once only' mode has been selected but it is required for the Clock Timer to perform the same times a further time. To bring the times back into operation, S1 is set to both positions whereupon the two 'time set' i.e.d.s should illuminate, indicating the output will be switched at those times. This procedure can also be used at any time to check the state of the memory.

The second position of S2 allows the user to turn on or off the output at any time without waiting for the timer to switch the output. Each operation of S2 to the 'on/off' position turns the output alternately on and off.
THE I.E.D. bargraph is a popular way of displaying rapidly changing information; it is often more rugged and versatile than an analogue meter movement, yet it can be easier to read when its displayed value is changing than a 7-segment readout.

In the September '83 issue we discussed the U.A.A. 170 light spot driver, which proved to be excellent for driving many I.E.D.s as a moving spot, but was unable to produce a moving bar, or ‘bargraph’ effect. Furthermore, it was only available as a linear device, since the logarithmic version was being discontinued.

The LM 3914, LM 3915, and LM 3916 are popular I.C.s to use for these specific applications, although in turn they present their own particular constraints on the designer; they are expensive if only a small number of I.C.s are to be driven, and they are intended to drive the I.E.D.s in parallel, which can consume a great deal of power and limit the permissible current drive to very low levels. Although there are design techniques which can be employed to drive the I.E.D.s in series, these cannot necessarily be used in all circuit arrangements. Hence, although these devices are unsurpassed in many applications, there are some cases in which better alternatives are available.

These are the “U2..B” series from AEG-Telefunken, comprising the U237B, U244B, U247B, U254B, U257B, and U267B. They are all 8-pin d.i.l. integrated circuits designed for driving up to five I.E.D.s each in a series arrangement, which dramatically reduces the total drive current required. The voltage thresholds at which the I.E.D.s turn on are fixed, and while this can occasionally complicate the preceding circuitry, in most cases it makes the I.C.s very easy to design with.

THE FAMILY

The six integrated circuits are arranged as three pairs of devices; U237B and U247H are conventional linear law devices, U254B and U267B are logarithmic law devices, and U244B and U257B are ‘overlapped’ or smooth transition devices with a linear law. (The I.E.D.s fade in slowly, rather than turn on and off abruptly, giving an apparently smoother response). The thresholds of operation for the various I.C.s are shown in Fig. 2. Each pair of devices have their thresholds interleaved, so that each device can be used on its own or two can be used together, with common inputs, to drive ten I.E.D.s. (Each I.E.C. driving alternate I.E.D.s in the bar).

The pinout and specifications for the whole family are shown in Fig. 1. A number of the specifications have their figures taken from actual measurements made on the I.C.s in the applications circuit, due to the very limited information available from the manufacturers. The nominal constant current feed to the I.E.D.s is specified at 20mA. In practice, this was measured to be 22mA, and hence the quickest current of 23mA shows that the I.C. only consumes approximately 1mA over and above the I.E.D. driving current.

Fig. 1. Pinout and specifications for U2..B family

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>Min</th>
<th>Typically</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td></td>
<td>12</td>
<td>19</td>
<td>25</td>
<td>V</td>
</tr>
<tr>
<td>Quiescent current</td>
<td>(Irrespective of number of I.E.D.s driven)</td>
<td>-</td>
<td>23*</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Constant current output</td>
<td>Drive current to I.E.D.s</td>
<td></td>
<td>20</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Hysteresis of comparators</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Constant current source voltage</td>
<td>Voltage between pins 6 &amp; 8</td>
<td></td>
<td>2.0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Input bias current</td>
<td>Pin 7</td>
<td></td>
<td>-0.31*</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>Input resistance</td>
<td></td>
<td>40*</td>
<td></td>
<td></td>
<td>MΩ</td>
</tr>
<tr>
<td>Variation in voltage comparator thresholds</td>
<td>Error in input voltage detection circuitry</td>
<td>±30</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
</tbody>
</table>

* As measured on prototype

OPERATION OF THE CIRCUITRY

Fig. 3 shows a block diagram of the internal circuitry of the I.C. family. The only slight exceptions are the U244B and U254B, which have gradual transition comparators in place of the Schmitt trigger comparators. The operation of the circuitry is quite straightforward, if a little ‘upside down’ conceptually! D1 is the least significant I.E.D. (i.e. at the bottom, or the left hand side of the display) and D5 the most significant (top, or right side of the display). With the input at 0 volts all the comparators are turned on, and hence all the driver transistors are turned on, so the current from the constant current source is sunk from pin 6 to 0 volts; no I.E.D. is turned on. As the input, pin 7, slowly rises in voltage, it reaches a point where the uppermost comparator in Fig. 3 turns off (because its inverting input voltage exceeds the non-inverting input voltage). Hence, the uppermost transistor also turns off, allowing the current to flow through D1 then via the transistor connected to pin 5 to 0 volts. Higher input voltages cause successive transistors to turn off, allowing more I.E.D.s to turn on.

PRACTICAL CONSIDERATIONS

The supply voltage must be at least sufficient to allow for the total forward voltage drop of the I.E.D.s. This depends on colour and type, but is typically 1-8 to 2-2V for red, and 2-0 to 2-5V for yellow and green I.E.D.s. Allowance should also be made for the 2V maximum drop across the constant current source.

Typically, this results in a minimum supply voltage of 13V for red, and 15V for green or yellow, with a mixture of colours falling between these figures.

A decoupling capacitor must be provided between pin 6 and 0 volts; a 100n disc ceramic capacitor is ideal. Without this, spurious oscillations can cause several I.E.D.s to illuminate...
simultaneously at the point of turn on and turn off of one of them.

Finally, although the input impedance is very high indeed, problems can arise with high impedance driving circuitry. A capacitor placed across the input, with a very high value resistor across it as a load, can be slowly charged up by the i.c.'s input, giving a false display reading. Typically, try to keep the driving impedance 100k or less.

Fig. 4 shows the circuit of a very simple audio level meter based on the logarithmic law i.c. U267B. (The ear's response to sound amplitude is approximately logarithmic, hence the use of this particular device). IC2 provides amplification of the input signal, and D1 rectifies it. This half-wave rectified signal is smoothed by C2, with R3 determining the attack time of the bargraph, and R4 with R5 the decay time. Note that the i.e.d.s are shown upside down, with D5 normally appearing at the top of the display, and D1 at the bottom.

APPLICATIONS CIRCUIT

Fig. 5 shows the circuit diagram of a sophisticated PPM or VU audio level meter, based on the principles shown in Fig. 4. To provide an accurate response to both positive going and negative going peaks of the audio signal, full-wave rather than half-wave rectification must be used.

Precision rectifiers based on op amps are used to overcome the inherent forward voltage drop which would be produced by a conventional full-wave rectifier. Two precision half-wave rectifiers are used in series, IC3c, with D1, D2, R6, and R7 forming the first, and IC3a, with IC3b, D3, D4, R9, R10, and R11 the second. IC4 provides adjustable amplification of the input signal, and R9 in series with R10 adds the output of the first rectifier to the input signal (feeding into the input of the second rectifier) in the ratio 2:1. When summed together in this ratio, these two waveforms produce an inverted full-wave rectified signal. The second precision rectifier is used to invert this signal again, and charge C2 via R3, giving an attack time of approximately 2.5 milliseconds. R4 determines the decay time constant of the system, which is approximately 1 second, to correspond with the PPM (peak programme meter) characteristic used extensively in broadcasting. For a faster, more conventional, 'VU' decay, R5 should be linked to 0 volts. IC3b is used as a unity gain voltage follower in the feedback loop of IC3a, to prevent R11 having an unwanted loading effect on C2, which would cause the decay time to be far too short for a PPM characteristic. IC3d is another unity gain voltage follower which prevents the inputs of IC1 and IC2.
from having any unwanted effects on C2.

IC1 and IC2 are used in a very conventional way, with the exception of the peak overload indication. When D17, the top l.e.d., is turned on, the output voltage on IC2 pin 2 rises above 1.5V. This turns on TR1, charging of C5 and turning on the p.n.p. Darlington pair TR2 and TR3. When D17 is turned off, the charge on C5 takes several seconds to decay away, so TR2 and TR3 remain turned on for a short while, illuminating D17 via D7 and R14. Hence, whenever D17 is illuminated at a 'peak', it remains on for several seconds after the signal amplitude drops again, giving an easily recognisable indication of 'overload'.

CONSTRUCTION

Fig. 6 shows the Veroboard layout of the meter. If used horizontally, the components should face downwards for correct orientation. Take care with the bending of the l.e.d. legs, since it is very easy to damage the devices themselves. The values of R3 and R4 (or R5) can be adjusted to give the dynamic characteristics required and the value of R1 or VR1 can be altered to change the sensitivity of the system. (Keep R3 above 2k, though, or IC3a will not be able to supply enough instantaneous charging current for C2). Most conventional, FET, or BIFET op amps will suffice for IC4, with a similar quad op amp for IC3. The transistors can be most medium to high gain types, but beware of different pinouts.

Although these applications show only the logarithmic law i.c.s in use, the design of circuitry using the other i.c.s is directly comparable. The whole family is a useful addition to the range of i.c.s available for I.e.d. bargraph driving. AEG-Telefunken have just started incorporating some of the drivers with I.e.d.s all in one package: the D620P, D630P, and D634P. The basic i.c.s, though, probably offer the greatest flexibility at the moment, and can be obtained from: Coles Harding, 103 South Brink, Wisbech, Cambs, PE14 ORJ. (0945-4188). The U237B and U247B are £3.36 each, the U267 is £3.30 and the others are £3.60 each. These prices include postage, but add VAT. (Minimum order is £10).
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Feature article...
INMOS The BRITISH chip manufacturer

MARCH ISSUE ON SALE FRIDAY, FEBRUARY 3rd, 1984
In this part final circuitry and constructional details of the board will be given.

**MASTER DIMMER AND TIMED CROSSFADE**

On the Stardesk, there are just two controls, the master dimmer/crossfader and the timer delay potentiometer (Fig. 8). The master control, VR7, is fed with 10V stabilised, and the output from the slider buffered and fed through a variable resistance VR5. If the timer control is set to minimum, then the voltage on C34 will follow that on the slider with a negligible delay. At full resistance, the voltage on C34 takes about a minute to catch up. TR24 presents a high impedance to the voltage on the capacitor to prevent inaccuracies occurring at high values of VR5, and the resulting output is fed to the first of two op-amps. Note that TR24 is a BC184 or similar high gain type. All the other transistors, with the exception of course of the f.e.t in the audio section, are common or garden types.

I have specified BC172, but almost any n.p.n. small signal device could be used. TR24 however, needs the maximum gain so that there is no voltage drop across VR5 when it is at maximum.

The op-amps are two sections of an LM3900 used to avoid the need for a further supply rail. The output of the first op-amp supplies the 'B' bus. This is the common feed to the preset sliders in the lower or 'B' row. The inverted output results in the 'A' bus for the top row of presets.

D52 and D53 monitor the outputs of the op-amps and are situated at the bottom and top of the master A/B slider respectively.

IC24 (Fig. 9) is a central switching point used to inform the static section as to which x channels are performing what duty. Three of the address inputs (A0, A1, A2) receive information as to what channels have been selected for sequencing effects. The other eight inputs, A3–A10, are divided amongst the flash buttons. This input information is then correlated and the eight outputs fed to the 'C' switches in each 4016. Selection of any particular channel for a sequence effect, or the operation of the flash button on that channel, disables the static dimmers for that channel.

It may seem a waste to have used over 70% of the 2716 for eight basic on/off operations, but since the principle of using the memory to route the sequence effects left the rest of the memory unused, and since wiring the flash buttons via the memory would obviate the need for additional circuitry around the buttons, the result was really a foregone conclusion.

**STATIC SECTION AND OUTPUT STAGE**

Fig. 9 shows the circuit of one of the eight left hand sections of the Stardesk. This circuit includes the two preset sliders, flash button and quad bilateral switches which, following instructions from the rest of the unit, decide what that particular channel will be doing.

Working back from the comparator stage, an op-amp, being one quarter of one of two LM3900s, the input current on the inverting input is compared with that on the non-inverting input. Since the ramp generated by TR2/3 in Fig. 1 has its highest value at the beginning of each half cycle of mains, the signal input to the inverting input of the comparator will have to be at a maximum for the output of the op-amp to go negative and switch the MOC3020 opto-triac (IC36–43). As the value of the ramp decreases through the half cycle, the qualifying input current at the inverting input falls, and the output stages will therefore trigger at lower signal levels, be they derived from the preset sliders, the sequential section, or the flash buttons. However, the lower the value of the ramp, the later in the half cycle is the triac switched, and the lower the total power fed to the load. Thus is the dimming action accomplished.

If the blackout line is at a logic low, which will be the case if the blackout button has been operated, no signal will reach the comparator through bilateral switch A. If the mixer is on, and switch A is effectively 'closed', the next obstacle to be considered is switch B, which is off when the strobe switch
Practical Electronics comes from IC24, the routing memory, will be removed and sequence group, then the control signal on switch C, which may come from a variety of sources. If the channel in question is not part of a sequence group, switch C will be 'on' and the outputs from the preset sliders will be presented to the routing memory outputs. When the sliders are in operation there is no problem, since the inputs and outputs of switches A, B and C are all at the potential of the op-amp input, viz 0-5V. When the dimmers are disabled, however, the input voltage to switch 'C' can rise to nearly 10V if either slider is at maximum. This will cause faulty operation of that section of the 4016, with part of the signal being leaked through to the op-amp input. The input to switch 'C' is thus clamped by the Zeners to within the device operating limits.

A word about the eight Zener diodes, D70-77. The control voltages for the 4016 switches are all rather less than 5V, with the exception of the flash button, which provides exactly 5V to the 'D' section of each. I say rather less since the blackout and strobe lines are derived from TTL gate outputs and the routing memory outputs provide the fourth control signal.

For proper operation the supply voltage must therefore also be 5V. This in turn limits the maximum input voltage to each switch to 5V. The flash level input is limited by the potential divider comprising R171 and VR3; the sequence input could never rise above about 4V, and the only problem is therefore the slider outputs. When the sliders are in operation there is no problem, since the inputs and outputs of switches A, B and C are all at the potential of the op-amp input, viz 0-5V. When the dimmers are disabled, however, the input voltage to switch 'C' can rise to nearly 10V if either slider is at maximum. This will cause faulty operation of that section of the 4016, with part of the signal being leaked through to the op-amp input. The input to switch 'C' is thus clamped by the Zeners to within the device operating limits.

**AUDIO SECTION**

Although the audio section (Fig. 10) has a balance control, this is merely for fine adjustment, the input stage comprising an AVC amplifier. The input signal may be from a few hundred millivolts to in excess of 50V, depending on the choice of input resistor. With the link wire behind the earth terminal in place the input impedance is 1M, and the maximum input signal for proper operation is about 5V. With the link cut, or removed, the input impedance is 10M and the higher range of inputs acceptable. The output of the first op-amp, one of the remaining two sections of IC25, is taken to the balance control, but is also rectified to provide d.c. bias for TR35. TR35 is used to shunt the feedback path comprising R160/161, but, as the bias increases, its effect becomes less and less, and the gain of the stage reduces. The balance control serves to compensate for the necessary difference between the outputs of the op-amp for low and high input signals, without which difference the bias on the f.e.t. would not change. The control also provides a degree of latitude to meet the personal whims of the user. The slider of the balance control is taken to the final half of the LM3900, IC25C, the gain of which is arranged so that the output is fairly heavily clipped. This output is then rectified and a small degree of smoothing applied via C54. This capacitor is somewhat arbitrary in value and could be changed, if required, to suit personal preferences.

Having obtained this audio derived chain of pulses, the signal is routed as follows: a three way electronic switch similar to the routing bank described earlier comprises ICs 44, 45 and 46. The first two are quad NAND gates, and the third, because a three input gate is required to produce the reset pulse, is a 74LS10 (triple three input NAND gate). Unused inputs are tied to supply positive. The audio signal is taken to two gates of IC45 and the other gates taken to the outputs of the chase and hait flip-flops not connected to the I.e.d. indicators. When a particular function is selected that output will be high, and, when the audio signal is also high, the appropriate gate will give a low output. For the chase effect, the output of IC45a pulls down, through D15, the enable input of the second section of IC11, advancing the count rate and eventually the sequence. Since the audio...
derived signal is not heavily smoothed, the rapidity of pulses from that circuit causes the 4520 to be clocked often and the sequence then advances with the music.

Earlier it was mentioned that some good effects may be obtained using the chase function. This is because, although the sequence is advanced in this manner, the number of pulses at the OE input of the sequence memory is unchanged and thus clever manipulation of the speed and attack controls will decide whether the chase effect is sharp and positive, or more gentle and relaxed. When the audio halt function is selected, IC45d operates, producing an active low signal which is then inverted by IC45b and applied to the clock input of the same 4520 counter via the blocking diode D16. R33 and C18 (see Fig. 4) provide a time constant, without which the effect of the train of pulses would not be cumulative and would not therefore produce any noticeable effect.

When the 'off' button is depressed, the outputs of each of the gates IC45a and IC45d are held high and any audio effect is cancelled.

CONSTRUCTION
With the exception of the suppressor chokes, which are too heavy to be mounted and are instead encapsulated in a tray behind the board, the whole mixer, including power supply and output stage, is assembled on one double sided p.c.b. To avoid the possibility of shorts, and bridges, bearing in mind the close proximity of components, both sides of the board on the author's unit were printed with solder resist. The board offered by the supplier in the parts list is also prepared in this manner. The saving in time spent finding shorts and the like well exceeds the small cost involved in this process.

As far as the case is concerned, whilst it is certainly possible for the constructor to make his own, if he has the tools at hand, cutouts are specialised, particularly for the switches, which have rectangular pads with rounded corners. Thus the ready-made and printed panel and case are recommended.

Fig. 11 shows the component layout, looking at the top side of the board. Not all of the components are topside mounted owing to the dictates of space and also because of the height of certain components. Amongst the components that are rear-mounted are C3, C6 and C59. C6 is not only rear-mounted, but rear-soldered as well so the leads will have to be left a little longer to facilitate this. If a lot of vibration is anticipated, C6 may be taped to C3.

In the underside layout one value of slider is used, explaining the use of a buffer transistor on the crossfade control, and the need for a Darlington buffer on the effects master, when a lower value control would have done away with the first transistor. In the same manner, because the rotary controls used are of the 'through-board' variety and not freely available, only two types, 2k2 and 470k, were used. Hence the need for an extra resistor on the attack control. All the triacs used are 8A rated and must have isolated tabs, since they are mounted to a small subchassis cum heatsink which is in turn bolted to the case proper.

When assembling the board, it is a good idea to insert and solder the terminal pins in the output stage first, since these are a tight fit. Fitting these first will preclude the gnashing of teeth when other components are inadvertently broken. Start with the lowest profile components, such as resistors and diodes first. Next fit the medium height components such as transistors and then the i.c.s. Note that R54 has one end terminating under IC33.

The layout of the transistors shows the emitter, base and collector connections clearly. The shape of the case is only an indication and will not necessarily agree with the device package obtained. All i.c.s, with the exception only of the
and neutral inputs and connect to the mains, via an isolating transformer if at all possible, if not take care.

It is a good idea to have the front panel at hand to identify the controls. Check immediately for SV on the output of the 7805, and 10V on the cathode of D16. If these voltages are not in evidence you must find out why before proceeding. If all is well check that the supply positive and ground terminals of all the ICs are at the correct potentials. Now, assuming all is still well, observe which ICs are lit. The black marking is on the cathode of D11, and some operation of the unit shows from this pair of gates, any malfunction here should be investigated first. Check the operation of the ‘Mixers on’ and ‘Blackout’ switches back and forth. Next, the programme routing group of switches. The ‘Off’ I.E.D. should be flashing. If it is not, check the ‘Sequence speed’ control to see if it is stuck in maximum. The output stage section is setting the ‘Off’ lamp will stay off for long periods. The ‘Off’ lamp should flash. Now check the operation of the other eight buttons, paying no attention to what the rest of the unit does. If all is in order press the ‘Off’ button again. The Audio ‘off’ I.E.D. should be alright. Check operation of the two audio affect switches and again return that section to the ‘Off’ mode. The programme select I.E.D. should be lit, as should one of the eight programme selected I.E.D. Check that the programme indicator advances one position with each one of the eight programme selected I.E.D.s. Check that the mode. The programme select I.E.D. should be lit, as should the solder joints for the capacitors are under the triacs. For that matter, it is a good idea to leave the fitting of the triacs until the board is actually in the case, since the soldering of the leads after the triacs have been screwed down will obliterate soldering and realigning later and possible damage through stress and strain.

The keyboard switch sets come in three pieces plus, of course, the I.E.D. These are the switch proper, a I.E.D. holder into which the switch fits, and a push on rectangular key. For ease of assembly and to avoid possible error, the board layout is such that the switch I.E.D. is always mounted the same way, i.e. with the anode to the right. The anode is usually the longer of the leads, but this should not be assumed. The cathode is usually easily recognizable as it is the standard and can be very annoying to some finding of all or all of the I.E.D. inserted incorrectly when the unit is turned on, apart from flashing I.E.D.s and switch lights with no further one attempts to reverse the diode. To check, look into the I.E.D. above the cathode, it is usually a small, triangular end to it. All diodes on the layout diagram are shown with the cathode marked >. This corresponds to the banded end on the 1N4548, 1N4000 and Zener and to the short lead on the I.E.D.s. It does not indicate the +ve terminal for the I.E.D.

HOLE ROLES

Note the three sets of ‘10 in line’ holes: one set on the far left, one set to the right and one set directly to the left of the A/B crossfade slider and the third, running horizontally, immediately below the A/B and effects master sliders. These were included in the board layout for the convenience of the author, and are in order to provide for a feed to a slave unit from the driver transistors TR27-34. Holes are already in the board layout for the fitting of a duplicated output stage. The resistor should be 330 ohms, assuming that the slave unit, which should have its own 12V supply, has no indicator I.E.D.s if these are to be included, the resistor should be lowered to 270 ohms.

Sliding covers for holes are a convenient test point for the output of the sequencer section and are also useful for possible expansion of the desk. The third set have the first three holes obscured with board connections, but in total comprise the essential information for the bilateral switches, plus the outputs of the routing memory, IC24. Again, these are simple to be added as future points. In the event of the desk being expanded, these latter two sets of holes would be fitted with Molex p.c. connectors, which would also act as through board connectors where required.

The four large holes in the p.c.b. in the region of the mains inputs are for 18 or 25mm M6 bolts which should be fitted with washers both sides of the board to encourage current distribution away from the thin copper strips towards the main lines, neutral and earth connections. The board neutral track should be reinforced with a 16g length of tinned copper wire. The board is well insulated from the housing, thus the soldering should be liberal, and should encapsulate the wire, which should extend to the earth terminal input. The idea of this is to provide the correct current handling possible for the feed to the triacs. At full power on a resistive load, the right hand end of the black wire could get quite hot. It is therefore advisable to arrange a power feed to the unit; a 13A wall socket is only good for 250 watts per channel!

The output stage section is set at one kilowatt per channel of resistive load. Having said that, this figure should be derated to 750 watts per channel if using tungsten halogen lamps, which although they have high operating temperatures, and consequently a very low cold resistance. This does not matter so much when using the static section since the changes in the output to lamp tend to be gradual, but is important when using the sequencer section, since the low cold resistance means greater surge currents on turn-on and thus a far greater ignition loss in both the triacs and along the track to them.

The mains transformer, which should be the last item fitted, apart from the triacs, is in place, the constructor may then like to observe his or her handiwork and decide whether to test the unit before fitting it in its case. Bear in mind that although the output stage cannot be checked at this point, some tests may be performed on the duplicated areas of the board are rather more accessible when the board is not in the case. In fact, once the desk is tested and any gremlins dealt with, it could be that some constructors may decide to test the effect switches, plus the outputs of the routing section where the board is probably better off free on the bench. Do please remember that the top portion of the board is live on both sides regardless of the absence of the completed case assembly offered in the parts list, and that the case assembly offered in the parts list, will have a tray behind the front panel into which the chokes locate. At this stage it is a good idea to put these into position using a polyester resin, or if you are feeling rich, silicon rubber compound. The author used polyester resin and considered it quite acceptable. The suppression chokes comprise, basically, as many turns as possible of heavy gauge wire wound into a cardboard, or plastic, form. If you fancy yourself if the laminations and suitable wire (at least 0.8mm) are to hand, but in the long run it makes for a considerable saving in the cost of materials and you ever tried to wind heavy gauge copper wire to use the ready made ones available as shown in the parts list. These have self soldering leadouts and therefore scraping is not required.

TESTING

Assuming that both memories have not been fitted and completing assembly, start by checking for shorts on the three supply lines. Also, since the board is not yet in the case, assuming it has been correctly fitted, you may then like to observe his or her handiwork and decide whether to test the unit before fitting it in its case. Bear in mind that although the output stage cannot be checked at this point, some tests may be performed on the duplicated areas of the board are rather more accessible when the board is not in the case. In fact, once the desk is tested and any gremlins dealt with, it could be that some constructors may decide to test the effect switches, plus the outputs of the routing section where the board is probably better off free on the bench. Do please remember that the top portion of the board is live on both sides regardless of the absence of the completed case assembly offered in the parts list, will have a tray behind the front panel into which the chokes locate. At this stage it is a good idea to put these into position using a polyester resin, or if you are feeling rich, silicon rubber compound. The author used polyester resin and considered it quite acceptable. The suppression chokes comprise, basically, as many turns as possible of heavy gauge wire wound into a cardboard, or plastic, form. If you fancy yourself if the laminations and suitable wire (at least 0.8mm) are to hand, but in the long run it makes for a considerable saving in the cost of materials and you ever tried to wind heavy gauge copper wire to use the ready made ones available as shown in the parts list. These have self soldering leadouts and therefore scraping is not required.
basically correct in operation. Furthermore, do not be concerned that the I.e.d.s illuminate quite brightly early on in the raising of the slider. The important matter is the proper operation of the output stage and to get a true representation of output stage condition via a I.e.d. would necessitate much more circuity, since the illumina of it is dependent only on the current passing through and thus tends towards being linear. The load on the output however is receiving power that increases on a square law basis, ignoring lamp ballistics etc. If the I.e.d.s do not illuminate, or come on immediately, check the ramp waveform at the emitter of TR2 and that it is arriving at the op-amps. When doing this the scope should be set on d.c. to check the position of the ramp relative to zero volts. Gradually move the A/B slider to the 'B' position and observe that all channels dim to zero uniformly, then advance the 'B' sliders to maximum and check for correct operation. Leaving both sets of sliders at full, press the 'Blackout' button. All eight I.e.d.s should extinguish and the independent circuit I.e.d.s should dim, showing those channels to be in the standby mode also.

Switch the mixer on again and press the second button in the programme routing group. This button routes the sequence to channels 1–4 and the dimmers on those four channels should now be disabled, whatever their setting, and instead a sequential effect will be displayed. This is best checked initially with the speed and attack controls at maximum. Select each of the eight programmes in turn, using the 'Manual' button and then press the 'Auto' button. The programmes should now cycle through automatically. The dimmers should still be functional on channels 5–8. As well, check the next four switches, shifting the four channel programme to channels 2–5, 3–6, 4–7, 5–8 in turn, and finally operate the seventh switch, marked 1–8, which should disable all the dimmers and put in instead an eight channel sequence. It is worthwhile, at a later time, when all the rest of the basic functions have been checked, to check each and every programme in each and every mode of operation, since they are all in different sections of the memory e.g. just because programme No. 4 is correct on channels 1–4 does not automatically mean that it will be correct on channels 5–8, or for that matter in the strobe mode. And so indeed to the strobe button on the far right. Depress this, and all the dimmers should be disabled. Similarly the independent circuits should be seen to be on standby by virtue of the reduced brilliance of the indicator I.e.d.s.

The selected programme should now be indicated on the strobe I.e.d.s, and the display will take the form of flashes owing to the differentiating effect of the resistor capacitor combination on each output of IC23. Fill and empty routines are pointless for strobes, and the effect of the strobe circuitry is to reduce all such programmes to straightforward chase effects. This results in similarity between some strobe sequence programmes which could only be avoided by having yet another set of programmes. This was felt to be unnecessary.

At this stage check that the pulses appear at the output DIN socket at the back top edge of the board. The pin connections are given in Fig. 7.

Operate the 'Blackout' switch and check that the strobe function is disabled along with the other facilities.

Switch the mixer back on and select the programme route 1–8. Adjust the sequence speed to about one change every 5 seconds and then gradually reduce the setting of the attack control, noting the fading up and down of the I.e.d.s.

Switch the programme routing off, and return the speed and attack controls to maximum. All eight channel I.e.d.s should now be on fully, since both sets of sliders are at the top of their travel. Set the 'Flash level' control to minimum and press each flash button in turn. The appropriate I.e.d. should extinguish. Now, depressing and releasing any button continuously, rotate the 'Flash level' control gradually, noting the increasing level of brilliance of the I.e.d. in question. It is not really necessary to repeat this on the other seven channels, since you have already confirmed that each channel is receiving the 'flash' signal.

Set the programme routing to 1–8 again, and apply an audio input which is in keeping with whether the wire link is in position or not. Initially it will be best to choose a level somewhere in the middle of the operating range. Set the 'Sequence speed' fairly slow, and with preferably a signal input having some 'light and dark'. Press the 'Audio chase' button and note the chase effect. Raise the speed to maximum and now operate the 'Audio halt' control, again finding the optimum setting using the 'Audio balance' control. The sequence will temporarily halt with the beat of, or with crescendos in, the music. If the setting of the balance control is too high the sequence will tend to stop for excessively long periods.

**TIMED CROSSFADE CHECK**

All that remains now, before the final assembly is done, is to make a final check of the static section. First though, check the operation of the timed crossfade by advancing the timer control to maximum, and then performing an A/B crossfade at normal speed. The A and B indicator I.e.d.s should undergo the A/B transition in 10 seconds or so. To ensure that any variation in timing due to component tolerances errs on the high side the calculations for the timing components were generously on the upper side of 10 seconds and it will probably be found that for a 95% crossfade, 15 seconds will be achieved. Rotate the timer control back to the minimum setting and, taking each channel in turn, perform the following checks. Reduce the 'A' and 'B' sliders to zero, with the crossfade in the 'B' position. Connect the scope to pin 2 of the appropriate MOC3020, and set as before, and confirm that it is switched to d.c. operation. If a scope is not available, the tests will have to wait until final assembly has taken place. The only signal observable should be the ripple on the supply, at about 13-5V. The signal should not change until the 'B' slider is advanced about 5% of its travel. This is to allow a margin at each end of the track. As the slider is advanced a narrow rectangular wave will appear, increasing in width until, at approximately 5% from the top of the track, it has disappeared, showing the output of the op-amp and driver transistor to be completely switched. Return the 'B' slider to zero, move the crossfade control to the 'A' position and repeat with the 'A' slider. Remember that any adjustment of the presets must start with the 'B' preset, and not the 'A' preset, since the 'B' preset defines the range of voltage scan initially. Having done this, set both controls at halfway and move the crossfade back and forth, making an adjustment to one or the other slider to achieve the same mark space ratios for both 'A' and 'B' controls. During the transition there should now be no, or negligible, dip or reduction in the width of the waveform when the crossfade is central. It is possible that when the two sliders are set very near the bottom end, say 10% of travel, that a small amount of dip may be noticed. This can be ironed out with an amount of playing around, but in practice such cheese-paring adjustments are not necessary.

This all sounds rather long winded, but having set the first channel up correctly, which in fact only takes a minute or so,
it only remains to check that the other channels are in fact operating in the same manner. If one is not, suspect a wiring or component fault rather than faulty operation due to tolerances. As a final check, which need not be made on all channels, ensure that advancing the timer control to maximum whilst a fader is up full does not prevent the output from fully switching. A few seconds will need to be allowed for the timer circuit to settle to make this check, and if any small spikes do appear (this is unlikely) the ‘B’ and ‘A’ presets will have to be readjusted.

The only test left now is that of the output stage, and this can be done as soon as the board is dropped into the case from the front, bolted in position and the triacs and regulator affixed, using heatsink compound. When screwing the board into the case, note that there is not a lot of clearance on the fixing nearest IC1. It may be necessary to use an insulating washer under the screw head. The aluminium bracket that the triacs screw into must be spaced from the board with a fibreglass insulator such as supplied in the kit of parts to prevent the neutral rail shorting to ground.

Connection of the board is by push-on receptacles, except for the mains input, which connection is made onto terminal bolts via crimp connectors as mentioned previously. The choke wires connect to two terminal pins. One pin is immediately behind and just above the top end of each of the ‘A’ sliders and the other pin about 20mm from its respective output spade terminal, which in turn nestles between the suppression capacitors. When all the wiring is completed and checked over, connect 12 lamps to the output terminals, with the common neutral line going to one of the four spade terminals by the neutral input terminal. All push-on connectors used should be either the ready insulated type or should have ‘boots’ fitted. Do not forget to take an earth line from the input earth terminal to the case.

If a scope was available and the previous tests have been carried out, it only remains to check that the output stages work correctly and that the independent switching functions correctly when the desk is switched to ‘Blackout’. If you wish to monitor the signal on the load, use a dropper arrangement comprising a 2M2 resistor from the load to the scope input, a 220k resistor across the input and a 220k resistor from the scope ground terminal back to the desk neutral terminal. Remove the mains earth to the scope temporarily, and take care! Even better use an isolating transformer.

For those without a scope, measure the incoming mains as accurately as possible, and carry out the checks described previously measuring the voltage obtained across the load. A digital multimeter is ideal for this task; the author is not fond of digital meters for the majority of applications, preferring the ability of the analogue instrument to show trends in fluctuating values to the greater accuracy of its digital counterpart, but in this case both maximum output across the load can be checked, and also the lower end voltages, without the changing of ranges and the ensuing risk of wrapping a pointer around its end-stop. As for the scope tests the zero and maximum outputs should be obtained at 5% and 95% of the slider travel. Once this is all completed, the desk is ready to add that extra something to your performance or show.

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IMPROVED STEREO TV

European patent application 0082205 from Sanyo of Japan, suggests ways of improving the multiplex stereo system already used on a limited scale for TV transmissions in Germany, and proposed for the rest of Europe. The patent application is particularly interesting because it gives a useful run down on the existing service technology and some of the problems being encountered. Although the Germans are keeping very quiet about these problems, it is surely significant that the service has expanded far less than promised when it was introduced at the Berlin Funkausstellung three years ago. At last year's show, for instance, there was virtually no emphasis on TV stereo sound.

Whereas in Japan, two sound channels are multiplexed on a single sound carrier, in Germany two separate carriers are used. The Germans say this is because there is less risk of breakthrough between channels, but the Japanese system seems to work very well. More likely Germany wants to deter Japanese imports by using a different system. There have been attempts by the Germans at patenting what is essentially well known technology. The Sanyo patent gives a brief run down on this technology.

The normal sound carrier has, in Germany, a frequency 5.5MHz higher than the video carrier. The second sound carrier has a frequency of 5.7MHz above the video carrier, and is set at a level 7dB below the main audio. For stereo music right plus left channels are sent on the main carrier and right only on the auxiliary carrier. For bilingual operation one language is sent on the main carrier and the other on the auxiliary. This give compatibility with existing receivers. But stereo receivers must have a switched matrix to cope either with stereo or bilingual. The matrix is switched by tone signals sent with the programme (which, incidentally, can cause "birdie" interference, Fig. 1 shows the present circuit layout. Tuner 1 sends i.f. signal to amplifier 3 through filter 2. Detector 4 separates audio and video. Video is amplified at 5 and audio sent to bandpass filters 6 and 10. The main sound carrier is passed at 6, amplified at 7 and detected at 8. Auxiliary channel is passed at 10 to amplifier 13. Matrix 14 is switched in for stereo to decode left and right, but left out of circuit when there is a different language on each carrier. The problem in practice, we now learn from Sanyo, is buzz interference as caused by breakthrough from video into the audio circuits. This happens on most TV sets but becomes more noticeable in stereo if there is uneven buzz between channels.

Fig. 2 shows a new buzz balancing circuit and Fig. 3 shows the German stereo spectrum. (Note vision-sound carrier spacing is different in the UK.) Tuner 21 outputs to i.f. filters 22 and 31. Video detector 24 outputs the main sound carrier and auxiliary sound carrier to filter 27 which passes the auxiliary audio to detector 29 and matrix 37. Filter 31 passes both the main and auxiliary sound carriers to limiter 32 where the main carrier is separated at 34 and passed to matrix 37. The right channel signal, from the auxiliary carrier, contains buzz. The sum signal from the main carrier contains no buzz. So the matrix output contains equal, but reduced, buzz in each channel. For bilingual operation one channel contains more buzz than the other, but this does not matter because they are not heard together.
MONITORS... for Home Computers

MICHAEL TOOLEY BA  DAVID WHITFIELD MA MSc CEng MIEE  PART ONE

Britain is a world-leader in terms of the number of home computers per head of population. So much so, in fact, that the accusation of being 'square-eyed' can now as easily refer to being a computer addict, as it can to being a television addict. A factor common to both of these conditions, however, is 'the box' itself. The growth of home computing would have been severely restricted but for widespread television ownership. After all, would have been severely restricted but for widespread television ownership. After all, it is one thing to spend around £90 on a computer, which could turn out to be just a passing fancy, but quite a different matter to spend a further £200 to £300 for a special display unit just to be able to use it. Without a home television, therefore, many people would never even consider buying a home computer, or would rule it out as too expensive. The benefits of the computer have to become clear before adding a special-purpose display (known as a monitor) is usually even considered.

Part 1 of this article describes the various types of monitors which are now available for home computers at reasonable prices. If you are becoming dissatisfied with the quality of the display from your computer, or you are being forced to compute only during off-peak television time, then this article will help you to select a monitor to overcome these problems. Two current production monitors will be reviewed in Part 2 and a buying guide is included here to help in choosing a monitor which will suit both your needs and your pocket.

As a first step, however, we need to be able to make sense of the manufacturers' specifications, and of the facilities provided by monitors. It is useful, therefore, to start by looking at the ways in which computers generate their displays. We will then be in a position to appreciate what it is that a monitor must do with the signal from the computer.

COMPUTER DISPLAYS

In most medium and large computer systems, the tasks of working out the contents of a display, and of actually 'drawing' the image, are kept quite separate. For example, the main computer usually works out what is to be put onto the screen, outputs it to a display terminal (usually a VDU), and then forgets about it. The VDU, on the other hand, remembers the information from the computer, and looks after drawing the result onto the screen. Subsequent commands from the computer may cause changes to the information to be displayed, and this new information is again remembered in the VDU's memory, and displayed. Such VDUs must thus be able to communicate with the computer, must have a memory in which to hold the information to be displayed, and must be able to turn the memory's contents into a visual display. This usually means that there is a processor and some memory in both the computer and the terminal. Fig. 1 illustrates a typical arrangement.

A VDU of the type described above could be used in a small computer system, but it would probably cost two or three times as much as the computer itself. Most of the VDU functions are therefore usually performed by the computer, as shown in Fig. 2. The only function not then performed by the computer is actually 'drawing' the image onto the cathode ray tube; instead, a video signal is generated by the computer to drive a separate monitor. As we shall see, this video signal can take many different forms, but its essential purpose is to provide a convenient way of representing the final image. The most popular method, available on all small computers, is to generate a standard television signal suitable for driving a domestic television. However, this is not the only method, or even necessarily the best, but it is initially the most convenient approach.

GENERATING VIDEO SIGNALS

The majority of home computers now produce colour displays, and Fig. 3 shows a typical arrangement for the video section of such a computer. Basically, the same memory is shared by the programs and the display. Specific regions of this memory, however, are allocated exclusively for programs and for the display in any particular graphics/display mode. The memory area used for the display is often referred to as 'video RAM', while that reserved for programs is referred to as 'user RAM'.

This sharing of memory between the display and user programs allows very efficient utilisation of memory, and also minimises the hardware required to support the computing and display functions. A further benefit of this...
approach is that the division of memory between display and programs can be varied depending on the requirements of the selected graphics/display mode. The actual amount of video RAM required depends on the number of display colours, the maximum number of characters on a screen, and the resolution of any graphics. The remaining memory is then free for programs; large programs can thus be made to fit by judicious selection of the display mode used.

In such shared-memory systems, the CPU writes suitably coded information into the video RAM, either directly or via a language such as BASIC. This is usually done by running a program, but it can also be done directly from the keyboard. The video processor reads this display information, and converts it into a signal suitable for driving the display (monitor or television). Both of these operations appear to occur at the same time, although in fact the CPU and the video processor time-share the system bus and the memory. The exact details vary from one computer to another, but the general principles apply to most small computers. Having read the coded information from the video RAM, the next step is to look at how the various types of video signal are produced.

**R-G-B-SYNC**

The standard UK method of producing a colour picture uses 625 lines to build up each picture frame. In order to produce a stable picture, these frames are repeated at a rate of 25 per second: a technique known as raster scanning. In practice, each of the 625-line frames is usually drawn in two stages: the odd-numbered lines on the first scan, and the even-numbered lines on the second scan. This technique, known as interlacing, avoids visible flicker on the picture, and results in each scan lasting one-fiftieth of a second.

The video processor output must give a colour for every possible display position (pixel) in each picture line, even if this is only to indicate that there is no colour (black). The overall picture is thus represented by a 2-dimensional coloured matrix which is built up from lines of coloured pixels. The actual number of pixels in each line depends on the resolution of the computer; the more pixels, the finer the detail which can be displayed, but the greater the amount of video RAM required. The colours available are usually simple combinations of the primary colours, red, green and blue.

When any of these appears in a pixel, it is at maximum brightness, giving a total of eight possible colours; black (no colour), red, green, blue, yellow (red and green), magenta (red and blue), cyan (blue and green), and white (all colours), as illustrated in Fig. 4.

Fig. 5. R-G-B-Sync signals

The pixel colour information on its own is not enough, however, to be able to recreate an image. Some additional control information is necessary to show where each line and frame starts. The signal for each line therefore starts with a line synchronisation pulse ('sync'), and is followed by the colour information for the pixels in that line; the whole line lasts 1/15625th of a second. In practice, not all of the 625 lines are actually used to display 'picture' information. A few lines in each frame are used to allow the picture spot to move from the bottom of the screen back up to the top during the frame sync pulse. This is similar to the way in which the spot moves back to the start of each line during the line sync pulse interval.

A typical display line is shown in Fig. 5 in terms of the four video processor outputs: red, green, blue and sync. On many computers this R-G-B-Sync signal is made available to drive
Practical Electronics

The individual red, green, blue and sync signals. There are outputs from numerous small clusters of the three primary colours. The electron beam from each gun is aligned to illuminate only the appropriately coloured phosphor dots on the screen, as illustrated in Fig. 6. Thus the image is built up by a very narrow band centred on 6MHz, and the remaining bandwidth is used to provide separation from adjacent channels. Black-and-white sets are able to use PAL signals because they are only concerned with the luminance information.

The PAL encoder takes the computer's red, green, blue and sync signals, and combines them into a composite signal. This PAL signal is sometimes available as an output, and is particularly suitable for driving the VCR or CTV input provided on some colour television sets. The usual purpose of producing the PAL signal, however, is for modulating a suitable UHF carrier so that it can be used with a domestic television receiver.

**UHF TELEVISION**

The broadcasting services use sophisticated high power transmission equipment to modulate PAL signals onto UHF carriers, but more modest techniques suffice in small computers. A compact UHF modulator is used (invariably tuned at or around channel 36) which accepts a PAL input and produces a modulated low-power UHF signal which can be applied directly to the television's aerial socket.

The UHF modulator is designed to produce an output whose characteristics are as shown in Fig. 7. This implies that the luminance information must not exceed around 4MHz if interference with the chrominance information is to be avoided. With fine picture details, however, problems can arise because closely-spaced picture changes are represented by high luminance frequencies. This effect is demonstrated by clothing with close checks or stripes when seen on television: the fine patterns take on unexpected bursts of colour. An additional limitation on the maximum resolution (finest detail) of the UHF signal is imposed by the UHF modulator itself, which typically has a bandwidth of around 6MHz.

The final point to note about the modulators used in small computers is that their carrier frequency tends to drift slightly as they warm up. Depending on the television, this may necessitate adjustment of the (usually small) tuning controls to maintain the sharpest possible picture. Modern sets, however, are increasingly tolerant of such drift due to their automatic frequency control circuitry, but beware of the effect on older sets!

The UHF signal is probably the most useful output for the newcomer to home computing since it allows the computer to be used immediately with an unmodified television set. The use of this output does, however, bring with it some limitations in the achievable image quality. In many cases, however, these limitations will not be important, and a domestic television will provide a perfectly adequate level of performance.

**MONOCHROME**

There are many applications where a colour display is not really necessary or even desirable. Perhaps the best example of this is in word processing, where it is much more important that the display is as clear, sharp and stable as possible. In order for 80-column text to be easily readable, the monitor should have a high resolution. Typical 80-column text is composed of characters which are 8 pixels across. This gives 640 pixels on each line, and requires a monitor with a bandwidth of around 10-12MHz in order to produce a satisfactory picture. This performance is, however, usually well beyond the capabilities of a standard colour television, and for this reason a monochrome monitor (or a modified black-and-white television) is usually preferred for high resolution displays where colour is not essential.

Using the PAL signal to drive a monochrome monitor will
work, but it results in the loss of the very resolution which we are striving to retain. The best method of generating a suitable monochrome signal is to combine the red, green, and blue signals (rather than encode them as for PAL) to produce a monochrome signal which shows different colours as shades of grey, but which retains the highest possible resolution. The sync information is then added to what is by now a purely luminance signal, and a composite monochrome signal is then available.

CHOOSING A MONITOR

Having looked at the various ways in which a computer may output a signal representing the image to be displayed, which type of monitor do we choose? Before starting to decide, however, it is well worth looking at the image on your television, and deciding what you feel is wrong (or not quite right) with it. Then think carefully about the types of image that you would use a monitor to display, and decide on the performance improvements required.

Among the factors to consider next, price inevitably comes high on the list. Other considerations include whether colour is required, and whether a custom-designed monitor is required, or will a monitor/television suffice? The outputs available from the computer itself may also limit the choice somewhat, although it may be possible to obtain an additional interface to provide any missing outputs. Only when all of these factors have been considered will the necessary information be available to allow a start to be made in choosing a monitor.

When looking at a monitor, there are some general points worth noting. The first is to try out the monitor on the highest resolution display possible, and in particular see if text is readable at your expected viewing distance. Next, fill the whole screen with plus signs and look to see if they vary in shape or size across the height and width of the display; they shouldn't! With the same display, look for any signs of picture shimmer caused by poor power supply design. Next, try producing as white a display as possible (e.g. lines of white blocks), since this represents the most severe type of load on the power supply; the brightness should be constant across the screen. Finally, always try out any monitor on an image which is typical of your most exacting requirements, and then compare the results with at least one other monitor.

RGB MONITORS

An RGB monitor is without doubt the ideal type for colour displays since such a monitor makes the best possible use of the information provided by the computer. The major decisions to make in choosing an RGB monitor relate to the screen size and the bandwidth required. Choice of screen size is a matter of personal preference, and is usually limited by what is actually available; most RGB monitors have 14" screens. Choice of bandwidth is, however, a rather more involved matter.

A useful guide for good displays (colour or monochrome), is that a monitor should have a bandwidth which is approximately 1MHz for every 60 pixels in each display line. Thus, for 80-column text from a computer whose characters are each 10 pixels wide (i.e. 800 pixels per line), a bandwidth of 12-14MHz will produce a good picture. A lower bandwidth will produce quite acceptable results, but this will depend on the degree of image sharpness and resolution required. The minimum bandwidth to be able to distinguish between adjacent pixels, however, is around 1MHz for every 120 pixels in each line, and in the example above this represents a 6-7MHz bandwidth. Bandwidths below the minimum will cause adjacent pixels to merge into one another, and the picture will begin to noticeably lack sharpness. By comparison, the usable bandwidth of a colour television is typically in the region of 5MHz maximum. As a guide, the finest lines on the test card are at 5-25MHz.

A point to note in relation to the bandwidth of RGB monitors is the size of the phosphor dots which make up the picture. Colour televisions are designed to be viewed from a distance, whereas many monitors are used less than a metre from the operator. When used for very high resolution work, the size of the phosphor dots becomes comparable with size of the pixels. The dots can actually be distinguished from very close-up on larger television tubes. Many monitors use tubes which are similar to those used in televisions, and it is advisable, therefore, to check that the spot size of the tube will allow the number of pixels required to be clearly displayed (often quoted in terms of pixels per line). This limitation does not apply to monochrome monitors (at least not as far as is visible to the naked eye), and for this reason monochrome monitors are usually preferred for word processing and similar applications.

In most literature, RGB monitors are referred to as medium/standard or high resolution; typically these have bandwidths of 10-12MHz, and 14MHz, respectively. RGB monitors of lower bandwidths are also available, typically around 7MHz. The bandwidth figure should, however, always be studied in conjunction with the horizontal resolution figure in order to determine the usable definition of the display.

The ultimate test as to whether a monitor has adequate bandwidth for your purpose is to try it out. Putting up 80-column text, for example, usually provides one of the most severe tests. The safest choice with colour monitors is to select a purpose-built RGB monitor with a bandwidth of 12-14MHz or more; this should cope with even the highest resolution displays currently available from small computers.

MONITOR/TELEVISIONS

Monitor/televisions represent an ideal compromise for many computer owners. Ideally such a set should have an R-G-B-Sync input, rather than the PAL colour input associated with video recorders. By choosing such a set, the problems associated with PAL encoding, limited modulator bandwidth, and the infuriating drift off channel caused by the modulator warming up, are avoided. The set is still also usable as a conventional television, although in some cases this may be considered a disadvantage! It should be borne in mind that such sets have usually been designed primarily as televisions, but the bandwidth is still usually adequate for all but the most exacting requirements.

MONOCHROME MONITORS

When selecting a monochrome monitor, there are a number of colours from which to choose. The usual phosphor colours are white (as in the conventional black-and-white television), green and amber. The colour chosen is purely a matter of personal taste, although green is considered to minimise the strain associated with long periods of use. Many people, however, still greatly prefer to see white text on a black background.

Most monochrome monitors have much higher bandwidths than comparable RGB monitors, with 24MHz models readily available at little or no extra cost. Finding a monochrome monitor with adequate bandwidth is therefore not usually a problem. Portable black-and-white televisions make quite acceptable monitors for many purposes, e.g. 40-column text is usually quite acceptable. For higher resolution work, however, a model with a direct video input is to be greatly preferred. In all cases the improvement provided by direct video input is quite dramatic.
Buyer's Guide

Two of the biggest problems often encountered after deciding to buy a product, especially in electronics, is finding out exactly what models are available in your price range and from where.

To help you overcome these problems when choosing a monitor we have listed 30 currently available models from a wide variety of manufacturers. Although it has not been possible to list all the models of every manufacturer we have tried to produce a balanced guide covering the six main specification areas.

Most of the models given in our Table are dedicated monitors with the exception of the three marked †† which can also be used as television receivers.

The prices shown are intended only as a guide and current prices including VAT and carriage together with further details and specification sheets on the models listed can be obtained from the quoted suppliers.

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>MODEL</th>
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†† Monitor/receiver model
* Not known
### PRICE GUIDE

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**All prices ex VAT and carriage**
This Temperature Controller uses a single m.o.s. integrated circuit to make temperature measurements and provide a controlled output which may be used to switch on or off any appliance.

The operating range is \(-39.9\) to \(+39.9^\circ\text{C}\). The accuracy is better than \(\pm 0.5^\circ\text{C}\) over the range 0 to \(+39.9^\circ\text{C}\) when using a thermistor as the sensor; the response time when using this type of sensor is very fast indeed.

Two control outputs are provided, one which operates when the temperature is greater than that which has been set, and one which operates when the temperature is lower. Additionally, adjustable hysteresis can also be preset which then provides a margin either side of the critical temperature.

The i.c. used also features leading zero blanking, power failure detection, overrange indication and direct drive of either I.e.d. or I.c.d. displays.

**BLOCK DIAGRAM**

A block diagram of the system is shown in Fig. 2.

Consider the case where the temperature being measured is positive. The input circuitry within the dotted line can be considered as a bridge network designed to balance at \(0^\circ\text{C}\). In this situation the output from the two comparators is zero (actually Vref). When the temperature rises positively the output from the comparators changes, i.e. a voltage difference is produced. A non-linear ramp is produced by the system controller, the time taken for the ramp voltage to change from one comparator input voltage to the other gives the temperature. The measurement/read cycle diagram of Fig. 1 shows this more clearly. It can also be seen from the diagram how a temperature which is negative can also be measured in this way. The part shown as 'system cycles' allows the input to be auto-zeroed.

Connected to the system controller are the adjustable Set Temperature switches and the presettable hysteresis switches. Together these set the limits to the required temperature. Inside the system controller are further comparators which compare the measured temperature with the set temperature. Two switched outputs are provided, one which operates when the temperature is at the set point plus the hysteresis, and the other which operates when at set point minus the hysteresis. The appropriate output is selected by the mode switch and passed to the alarm and relay.

**CIRCUIT DESCRIPTION**

The full circuit diagram for the Temperature Controller is shown in Fig. 3.

The main i.c. is IC1, type AY-3-1270 and the pin-outs for this are shown in Fig. 5. The set temperature switches are three binary-coded decimal thumbwheel switches S6-S8. The ten's are set by S6, only the figures 0,1,2,3, should be set otherwise inaccurate readings will result. The unit's switch is S7 and is set to any number 0-9. Likewise with the 0-1's. The sign switch, S1 is used to set the sign of the temperature; in its normal position it is set to plus. The hysteresis set switches are S2-S4, S5 being the I.e.d. select switch and is normally in the off position. These four switches are contained in a single d.i.l. package mounted on the p.c.b. Consequently, the hysteresis must be decided on before final construction. The code for the hysteresis is not b.c.d.; the switch positions are given in Table 1.

There are 7 presettable hysteresis levels, ranging from \(\pm 0.2^\circ\text{C}\) to \(\pm 8^\circ\text{C}\). Additionally there is a \(0.05^\circ\text{C}\) hysteresis.
already set within the i.c. to prevent display and control output jitter. This figure should be borne in mind when setting the unit.

The clock components C1, R1 and R2 provide a clock frequency of about 560kHz. For most applications this type of R/C clock is quite suitable although minor variations may be noticed if the power supply voltage should drop by an appreciable amount. For this reason the clock is also designed to be used with a much more stable ceramic resonator. The circuit for this is shown in Fig. 4. Ideally the resonator should be 560kHz, although any type within the range 300 to 800kHz should work.

The reset switch S9 together with C2 form the power failure detection circuit. Normally S9 is in the open position at switch on. When the unit is switched on, the circuit will operate normally, displaying the actual temperature for
about 2–3 seconds. After this time the circuit will store the last measurement and flash the display at about 1 flash every two seconds. In this condition the circuit will still operate normally, making real time measurements and switching the outputs as appropriate. Operation of the reset switch will restore the display to normal.

If there is a short power failure, of say two or three seconds’ duration, the circuit will ignore it, and once power is restored will operate normally. If however, the power failure lasts longer, then on restoration of the power, the display will commence to flash as before. The display will also flash if an overrange situation occurs.

The bridge components are VR1, R3, TH1, R4 and R5. The preset is used to balance the bridge such that the display reads zero. The last components associated with the i.c. are C3 and VR2 and together they form the ramp. VR2 sets the f.s.d. of the unit.

The remaining parts of the circuit are the alarm generator and the power supply. The power supply is conventional, supplying a stabilised voltage of 9V to the i.c. and an unstabilised voltage of about 18V to the remainder of the circuit.

The mode switch S10 selects the required output. In the position shown in the diagram the relay will turn on and the alarm will sound when the temperature falls below the set temperature. In its second position, the relay will turn on when the output is above the set temperature.

The alarm circuit consists of IC2 and the ceramic buzzer to form a very effective pulsed output. The alarm may be turned off by S11 without affecting the normal operation of the controlled outputs.
CONSTRUCTION
The Temperature Controller is built on three printed circuit boards designed to fit inside the recommended case. The fit inside the case is quite tight and some constructors may wish to mount the boards etc, in a larger case. For this reason no case drilling details have been given, besides which a great deal depends on the display bezel and b.c.d. switches used.

Figs. 6 and 7 show the display board details. The size given is appropriate for the type of bezel specified and should of course be varied if other types are used. The l.c.d. should be soldered direct to the board and not mounted in sockets.

The power supply board is shown in Figs. 8 and 9. The relay and transformer are very much standard items so changes in the layout should not be required. The final board is the main board and this is shown in Figs. 10 and 11. Here once again all the components are standard, except perhaps for the d.i.l. switch. It would be wise to check this component before finally drilling the board.

Because of the lack of space in the prototype, the ceramic buzzer (WD1) was mounted on the back-side of the Main board, as can be seen in Fig. 11.

FINAL WIRING
Fig. 12 shows the final wiring between the three p.c.b.s. The majority of the wiring was done with multi-coloured ribbon cable, with the exception of the mains switch, socket and the reset switch, for which a twisted-pair was used.

Connections to the display board are made direct to the pads on the copper side using single stranded wire. Note that the connections to the main board are in reverse order (see Fig. 12). Ribbon cable may be used here, but it would be an advantage if the wires are kept, say, to five per cable. This will make it easier when fitting the front panel.

Note carefully the correct orientation of the diodes D6–D15 which are mounted on the b.c.d. switches. Fig. 12 shows the sign switch (S1) where the spare tag is used to mount the diode (D5), as shown, the toggle of this switch
will normally be up when the sign required is positive.
Finally, remember to use sockets for IC1 and IC2.

ADJUSTMENT
There are only four adjustments to be made, the first is setting the power supply to 9V. This should be done with both i.c.s removed from their sockets, and checked again once the i.c.s are plugged in.

Before applying power, set VR1 and VR2 to about mid-position, connect the supply and observe the display. Using an accurate thermometer, adjust VR2 to give the same temperature in free air. This adjustment can conveniently be done at room temperature. Next the Set-Zero preset should be adjusted. This may be done by carefully placing the thermistor in a cube of ice, having previously prepared the ice cube with a suitable hollow, and adjusting the preset as the ice melts.

As a final check on the accuracy, the previous adjustment can be repeated until no further improvement can be made.

Table 1. (Hysteresis programming). X=switch to be on. If using an i.c.d. S5 must be ‘off’. Note: These are nominal values, variations of ±0.1°C to ±0.9°C can be expected
The last adjustment is to set the required hysteresis, i.e. the margin allowable before the control outputs turn on. There are seven levels: 0, ±0.2, ±0.4, ±0.8, ±2, ±4 and ±8, and one particular level should be decided on before the front panel is fitted. Table 1 gives the required switch settings. In the prototype the level was set at ±0.4° i.e. just S3 was on. Remember that S5 should always be turned off.

After the above adjustments have been made the unit is then ready for use.

Alternatively an I.E.D. display may be used. The display should of course not be multiplexed, and current limiting resistors should be inserted between all connections. If an I.E.D. display is used S5 should be switched on, inhibiting the I.C.D. back plane signal.

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the principles of image-processing and feedback. Much interest has been shown here by industry. One example is the recognition and orientation of items in confectionery production. One is almost tempted to say that sweet are the rewards of technological innovation.

Another Colne venture—described in detail in the January issue (News and Market Place)—is a computer numerically-controlled latch. "We maintain," says John Reekie, "that the price, which includes tools, accessories and handbooks, is realistic and that the product itself meets the needs of those educational establishments which seek to teach tomorrow's engineers the skills required to gain maximum benefit from this extension to computer technology."

Getting down to soild financial practicalities, Colne has been fortunate enough not to have operated in isolation. Prute—technology investment arm of Prudential Assurance—which was no touchstone when it comes to recognising a winner, have consistently supported the company with encouragement, ideas and finance to the extent, to date, of £350,000.

It says something for Prute's enlightened approach to the philosophy of a modern undertaking that they have not been put off by the easy informality, the strictly non-City working hours and other contemporary and unconventional aspects of the Colne venture. In fact, the relationship has been eminently productive on a number of working fronts.

Looking at the social implications of the spread of robotics, John Reekie is honest and realistic. "Of course, there are going to be problems, serious problems. They're constantly being pointed out to us and we're all familiar with them. Widespread reductions in workforces, the need to share working time and all the rest of it."

"But in my view it would be utterly wrong to adopt the policy that because these problems exist—and they won't go away—we should opt out and abandon all our activity in the field of robotic advance. Believe me, others won't."

John Reekie is not the only one whose dreams revolve about a robotic future. Hoover, according to newspaper reports, is working on a remotely-controlled version of the vacuum cleaner invented more than 70 years ago. They claim it will whisk over the carpets while the housewife guzzles her coffee, operated by a joystick like a game of Star Wars. Eventually it could embody a programming facility, enabling the machine to find its way around all the items in a large, unaided by human hand. But that, at probably three times the cost of a hand-operated version, could be many years ahead.

There is someone else who shares John Reekie's philosophy. Indeed, his sentiments were echoed with an economy of words, rare in a Parliamentarian, by ex-Premier Harold Macmillan justifiably dubbed Supermac in a TV interview on the eve of the opening of his 90th year. A witty bird, as full of wit and wisdom as of years, he said: "We must realise that the only object of work is leisure," and added, "the only object of work is not to go on working."

Those of us who would say Amen to that must be legion.
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AT LAST THE BLACK HOLE

The Director of TDRS for NASA, stated that experience was also gained in the operation of TDRS. The signals reaching TDRS are only 4-5dB. Practical Electronics have been studying NGC 4151 since 1978. In the centre of a galaxy (Fig. 1), the team "weighed" the centre of a galaxy using the S-band aerials for ground operation. There are several S-band aerials aboard the Shuttle's dish aerial was quite successful in the field of ultra-violet astronomy. The team investigated the gas clouds very close to the Galaxy's core. In a crucial new step they obtained the distances of the clouds from the core. They found that the clouds were moving at speeds of up to 14 thousand km/second. These figures were ascertained by finding the time taken for the core to 'light-up' the clouds. It was calculated that the slower moving clouds were those furthest from the core and were thus slowing in a way similar to the planets of our Sun. This means that the centre of the galaxy is a very massive object. Calculations show that the weight is 100 million times that of the Sun; only a Black Hole could have the mass and yet be as small as NGC 4151.

Professor D. Lyndon-Bell of the Institute of Astronomy at Cambridge proposed in 1969 that quasars were caused by black holes at the centres of galaxies—gas from the galaxy spirals inwards under the influence of the black hole's gravity, in the process the clouds become hot and produce radiation. The powerful quasars would have a black hole some 500 million times heavier than the Sun, these however being far away at the edge of the Universe. Many more galaxies would have smaller central black holes 50 to 100 times as massive as the Sun. There would thus arise mini-quasars at the centre of a small yet otherwise normal galaxy. NGC 4151 fits this description exactly. It is a spiral galaxy similar to our own but it has a tiny mini-quasar. It is some 50 million light years from Earth in the direction of the constellation Canes Venatici. It is a Seyfert Galaxy, so called after the first astronomer to study them, Carl Seyfert.

After studying ultra-violet emissions from a nearby galaxy an International research team with leading members from the Royal Greenwich Observatory "weighed" a Black Hole. They came to the conclusion that the quasar like object NGC 4151 is powered by a black hole which is about 100 million times heavier than the Sun. The Sun though shedding its mass has a weight of 2 times 10^37 tonnes. The relationship gives some idea of the magnitude of the matter involved.

This is the first time that astronomers have 'weighed' the centre of a quasar and the discovery now strengthens the theory that the immense and concentrated energy of a quasar is due to gas that is revolving round a black hole in the centre of a galaxy (Fig. 1). The team have been studying NGC 4151 since 1978. In order to 'weigh' the centre they investigated the gas clouds very close to the Galaxy's core. In a crucial new step they obtained the distances of the clouds from the core. They found that the clouds were moving at speeds of up to 14 thousand km/second. These figures were ascertained by finding the time taken for the core to 'light-up' the clouds. It was calculated that the slower moving clouds were those furthest from the core and were thus slowing in a way similar to the planets of our Sun. This means that the centre of the galaxy is a very massive object. Calculations show that the weight is 100 million times that of the Sun; only a Black Hole could have the mass and yet be as small as NGC 4151.
In any other than the most elementary of logic circuits, we sooner or later realise the need for a device which can remember a logic state. Such a device should possess the ability to remember a transitory logical condition and thus constitutes a simple form of electronic memory, the most fundamental form of which is the bistable. (The name simply indicates that the device has two stable states corresponding to outputs of either 1 or 0.) Another word synonymous with bistable is "latch". To explain the significance of this term let us consider the difference between two commonly available types of switch: "momentary" and "latching".

A momentary switch is one in which the switch contacts make (or break if it is a normally closed, rather than normally open, type) only when the switch is being operated. This is, for example, the case with a bell-push. We only want the bell to sound when the button is actually being pushed. It should not be possible for callers to walk away leaving the bell ringing!

A latching switch is one in which the contacts make (or changeover) whenever the switch is operated and, once operated, the mechanical design of the switch ensures that it remains biased in that state until operated again. A word sometimes used to describe this action is "toggle". In simple terms this means: operate once for 'on' and again for 'off'. An example of a switch with a mechanical latching action is that associated with a normal room light. Once the switch is operated, the room light must stay 'on' allowing one to move away from the switch!

In the previous example, sharp eyed readers might have noticed that we were careful to use the term "mechanical latching". It is, of course, eminently possible for a momentary switch (such as a push-button) to be coupled with an electronic circuit such that the combination forms an "electrically latching" switch. Fortunately, we don't have to look very far for an example of such a device. Just such an arrangement is incorporated in the PE Logic Tutor!

At this point, and to make absolutely certain that we can distinguish between the two types of switch, it is recommended that readers take a brief look at the way in which the Logic Tutor switches operate. Press S1 (or S2) and notice that the associated I.e.d. lights only when the switch is actually depressed. Press S3 (or S4) and notice that its I.e.d. stays 'on' when the button is released, and remains 'on' until the switch is pressed for a second time. All this may appear to be labouring the point. It is, however, quite crucial since we must make a very clear distinction between logic devices which operate on a momentary basis, and those which operate on a latching basis.

**BISTABLE LATCH USING INVERTERS**

The simplest form of bistable arrangement uses two inverters, as shown in Fig. 5.1. We should, by now, be quite familiar with the way in which an inverter operates: a 1 input produces a 0 output, and vice versa. The logical state of the outputs of the two gates in Fig. 5.1 must, therefore, always be complementary. If the first gate is producing a 1, the second gate must produce a 0. If the first gate produces a 0, this must result in a 1 from the second gate. If we were to assemble such a circuit the state of its outputs would, initially at least, be indeterminate. It would be impossible to say which of the outputs would assume a logic 1 state and which would assume a logic 0 state. Worse than that, there is no obvious method of changing the state other than by shorting one, or other, of the outputs to logic 0 in order to force the logical state at that particular point to become a 0. Such an arrangement is not considered good design practice but, don't worry, we shall show how this problem can be overcome later.

The time has now come to introduce a first practical example of the use of a bistable. Let's imagine that we require a logic system to control the operation of a pump. We wish to use two push-buttons to control the pump; one to switch it on (Pump On) and one to switch it off (Pump Off). The arrangement in Fig. 5.2 shows how these switches can be added to the simple bistable latch of Fig. 5.1. We simply pull-down the input of one, or other, gate to 0V momentarily whenever the
appropriate switch is operated. If this all sounds too simple, check it out using the Logic Tutor as shown below!

Insert a 7404 hex-inverter into socket A of the Logic Tutor, checking as usual that pin 1 aligns correctly with the connection marked ‘A1’. Now make the following links:

A1 to S1 (S1 is the Pump Off switch)
A2 to A3
A3 to S2 (S2 is the Pump On switch)
A4 to A1
A4 to D1 (D1 indicates that the pump is running)
A7 to 0V (0V)
A16 to +5V (positive supply)

Note that, when the power is first applied, D1 may either be in the illuminated or extinguished state. Disconnecting the power supply and then reconnecting it again may sometimes effect a change of state but this cannot be relied upon. It will, therefore, be necessary to re-set the bistable latch into the inactive condition by first pressing S1 (Pump Off) as soon as the supply has been connected. (On real logic systems there are, of course, quite simple methods of achieving this automatically!) Then momentarily depress S2 (Pump On) and check that D1 becomes illuminated. Depressing S2 for a second time should have no further effect on the logical state of the circuit. Now momentarily depress S1 (Pump Off) and check that D1 is extinguished again.

By now, the perceptive reader may have counted three quite different logical input conditions. These may be summarised briefly as:

(a) S1 ‘off’ and S2 ‘off’.
(b) S1 ‘on’ momentarily whilst S2 remains ‘off’.
(c) S2 ‘on’ momentarily whilst S1 remains ‘off’.

There is, of course, one further possible input condition. This occurs when S1 and S2 are both ‘on’. This condition would arise if we were foolhardy enough to operate both push-buttons at the same time (i.e. operating Pump On and Pump Off simultaneously). Such a condition is clearly one which should, if at all possible, be forbidden or prevented. But what happens if you actually try it?

**SWITCH BOUNCE**

Before continuing with a discussion of improved bistable arrangements, we shall digress a little to mention a topic which must, at some time or other, have been or will be of concern to nearly every designer of digital logic circuits. This involves a gremlin known as “switch bounce”. We mentioned, right at the start of Part One, that one of the pitfalls of overlooking the differences between ‘perfect’ paper devices and their real-life counterparts was that we sometimes produce circuits which should work, but don’t. Switch bounce is a classic example of this. We all too often regard switches as perfect devices which are either ‘on’ or ‘off’. What we overlook in this particular case is what happens at the instant of changing over from the ‘off’ to the ‘on’ state, and vice-versa. Most switches are far from perfect in this respect; they just don’t change over cleanly. When the switch is operated, its contacts bounce and make repeated contact, ‘on’ and ‘off’, until they settle to their final condition. Admittedly, this takes a very short time. In TTL terms, however, this interval is quite considerable and thus the circuit reacts to each and every one of the bounces just as if the switch were being manually operated.

Fortunately, the problem of switch bounce can be very easily solved. The simple bistable latch which we met earlier changes its logical output condition whenever the relevant input connection is briefly taken to OV. It then blissfully ignores any further changes on that particular input, only reverting back to its original state when the other input is taken to logic 0. Hence, all we need is a simple changeover switch arrangement, as shown in Fig. 5.3. This is all fairly straightforward; a change of state. It should also be obvious that the gates we choose must be inverting; a non-inverting gate will not produce the complementary state that we require in order to latch the bistable. It thus remains to choose between two-input NOR or two-input NAND gates but, happily, we can use either and thus we shall describe bistables using both types. The bistable constructed from NOR gates is slightly easier to describe and we will therefore start with this type.

Fig. 5.4 shows how a bistable can be constructed from two two-input NOR gates. We have labelled the inputs ‘SET’ and ‘RESET’. The reason for the choice of these terms is that a 1 on the SET input produces a 1 at the output. We would say that it “sets the output” (to logic 1). Conversely, a 0 on the RESET input produces a 0 at the output. It can thus be said to “reset the output” (to logic 0). The output is labelled ‘Q’. There is no particular significance in the choice of this letter other than that it satisfies the convention adopted for bistable elements generally.

Since the inputs are named RESET and SET, this simple form of bistable is called an ‘R–S bistable’. We now continue with a practical investigation of an R–S bistable using two-input NOR gates.

**R–S BISTABLE USING A 7402**

The 7402 is a quad two-input NOR gate which we met in Part Three and thus only half of the i.c. needs to be used in the R–S bistable investigation. As usual, the 7402 should be inserted into socket A of the Logic Tutor ensuring, of course, that pin 1 aligns with the connection marked ‘A1’. The following links are required:

A1 to D1 (D1 indicates the output state, Q)
A2 to S4 (S4 is the RESET input)
A3 to A4
A5 to S3 (S3 is the SET input)
A6 to A1
A7 to 0V (OV)
A16 to +5V (positive supply)
Set up S3 and S4 to produce logic 0 outputs. Ensure that D1 is 'off', i.e. the Q output is a logic 0. Now press S3 (leaving S4 at logic 0). This produces a logic 1 at the SET input. D1 should immediately come 'on' indicating that the Q output has changed state to logic 1. Press S3 again to produce a logic 0 (leaving S4 at logic 0). D1 should remain 'on' and no further change should be evident; the bistable has 'remembered' that it has been set. Now press S4 (leaving S3 at logic 0). D1 should go 'off' and the Q output should immediately revert to logic 0. Pressing S4 again (leaving S3 unchanged at logic 0) should have no further effect; the bistable 'remembers' that it has been reset.

In Part Two we learned how useful truth tables could be for describing the logical function of a gate. Let's now take a look at the truth table for the R-S bistable which is shown in Table 5.1. Note that we started the previous exercise with a Q output of logic 0 when both SET and RESET were also at logic 0. A 1 on the SET input made the Q output change to 1; a 1 on the RESET input made the Q output change to 0.

Another way of drawing the bistable arrangement using NOR gates is shown in Fig. 5.5. This symmetrical circuit shows clearly how the gate outputs are cross-coupled to the inputs. It also shows that we are only using one of two possible outputs. It would be a very simple matter to obtain a complementary, Q, output from the gate, which may be useful in a more complex logic circuit. To adapt our earlier arrangement all we need is the following additional link on the Logic Tutor:

### Table 5.1. Partial truth table for the NOR gate R-S bistable

<table>
<thead>
<tr>
<th>RESET</th>
<th>SET</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 5.2. Complete truth table for the NOR gate R-S bistable

<table>
<thead>
<tr>
<th>RESET</th>
<th>SET</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Fig. 5.5. Another way of drawing the NOR bistable**

A4 to D2 (D2 indicates the Q output state)

It is worthwhile repeating the previous exercise and noting the effect on the Q output. The truth table should be the same as that obtained in Table 5.2. But, wait a minute, didn't we say earlier that the state of the Q and Q outputs would always be complementary? This is obviously not the case for one particular combination of the inputs, i.e. SET = 1, RESET = 1. This is somewhat disconcerting since it clearly contravenes the rules which we have established. In future we shall refer to this particular input condition as "disallowed" and, whilst not wishing to pretend that such a condition cannot arise, we should take active steps to ensure that it is prevented. Or, at the very least, if it does occur we should be aware and not place any reliance on the output.

**R-S BISTABLES USING NAND GATES**

Simple R-S bistables can also be constructed using two-input NAND gates, such as the 7400. A typical arrangement is shown in Fig. 5.6. The important difference between this arrangement and that of the NOR gate equivalent is that the SET and RESET inputs are logically inverted, i.e. they are active when they are at logic 0 rather than when they are at logic 1. This is an important point and one which we shall come across later in Part Six. Sometimes these inputs are referred to as "active low" (on some logic diagrams a circle is used at the input of more complex logic gates to indicate this); however we shall simply refer to them as NOT SET, S, and NOT RESET, R. If it is essential to have conventional SET and RESET inputs to the bistable it is, of course, a relatively simple matter to invert these signals prior to the bistable stage. With a 7400 quad two-input NAND we could, for example, achieve this by bringing into service the remaining two unused gates in an arrangement like that shown in Fig. 5.7. The operation of the bistable is then identical to that of the NOR gate bistable which we met earlier.

**Fig. 5.7. NAND gate R-S bistable comparable with the NOR gate version**

### CLOCKED BISTABLES

Whilst the simple R-S bistable element is useful in a number of applications, it does have significant disadvantages when several such stages are to be incorporated in a complex logic system. The problems arise from the way in which controls of state occur in the system. Earlier, we demonstrated how the R-S bistable changed state immediately the correct SET and RESET inputs are received. At first this may sound quite acceptable; after all one of our chief aims with the design of most circuits is to produce the fastest possible speed of operation.

The difficulty with R-S bistables is that such rapid changes are not very predictable. In many cases we have what is known as a "race condition", in which the logical output from a system may well be determined by the speed at which individual gates operate rather than the logical rules which they should obey. What we really need is a system in which the changes occur in a controlled fashion. In such a system we can accurately predict the output states, and all we need is a means of synchronising the changes within the system. This leads us to the very important concept of "clocked logic": a logic system which employs a clock signal to control the transfer of logical information from one stage to the next.

### CLOCKING THE R-S BISTABLE

When we talk about clocked logic circuits, we always assume the
presence of a clock signal. At this stage it is useful to have some idea of the type of signal involved. The most common clock signal is one where the level varies between 0 and 1 at a constant rate, and spends an equal amount of time at each level before changing. This is a so-called square wave clock signal, and the rate at which the changes occur affects the speed at which information can pass through the system. Now for how such clock signals are used in logic circuits.

The simplest way of constructing a clocked bistable is to add two AND gates ahead of the bistable stage, as shown in Fig. 5.8. The CLOCK and SET inputs are required on the Logic Tutor:

$$\text{SET} \rightarrow \text{CLOCK} \rightarrow \text{AND gates} \rightarrow \text{to SET input of bistable}$$

$$\text{RESET} \rightarrow \text{CLOCK} \rightarrow \text{AND gates} \rightarrow \text{to RESET input of bistable}$$

Fig. 5.8. Input gates of a clocked R-S bistable

SET signals are applied to one of these gates, and the resulting signal is then passed on to the bistable's SET input. Similarly, CLOCK and RESET signals are applied to the other AND gate, and the resultant output is passed on to the bistable’s RESET input.

In this way, a logic 1 only appears at the SET and RESET inputs of the bistable stage when both input and clock are at a logic 1. In effect, this means that data, in the form of 1’s and 0’s, can only pass into the bistable when the clock is at a logic 1. When the clock signal is at a 0, no changes can occur on the SET and RESET inputs of the bistable stage. Each time the clock is at a 1, changes can occur.

We will now move on to combine the logic arrangements in Fig. 5.4 and Fig. 5.8 in order to construct a complete, clocked R-S bistable.

CLOCKED R–S BISTABLE USING 7402 AND 7408

A clocked R–S bistable can be made using 7408 quad two-input AND and 7402 quad two-input NOR gates, as shown in Fig. 5.9. Two gates of each device are employed: the 7408 providing the input gating, whilst the 7402 forms the bistable element. The 7408 should be placed in socket A of the Logic Tutor whilst the 7402 should be inserted in socket B. Care should be taken to ensure the correct orientation with pin 1 of both devices aligning with 'A1' and 'B1' respectively. The following links are required on the Logic Tutor:

- A1 to S4 (S4 will act as the RESET input)
- A2 to A5
- A3 to B2
- A4 to S3 (S3 will act as the SET input)
- A5 to S1 (S1 will provide the CLOCK input)
- A6 to B6
- A7 to OV (OV)
- A16 to +5V (positive supply)
- B1 to D1 (D1 indicates the Q output)
- B3 to B4
- B4 to D2 (D2 indicates the Q output)
- B5 to B1
- B7 to OV (OV)
- B16 to +5V (positive supply)

The procedure for testing the bistable is fairly complex and readers are advised to follow the stages carefully, repeating the whole exercise until they become thoroughly familiar with the way in which the circuit operates. The six stages are as follows:

**Stage 1.** Apply power to the Logic Tutor and note the output state of S3 and S4 by examining their respective I.E.D. indicators. If either, or both, of these I.E.D.s are illuminated this indicates a logic 1 output from the switch. We need to start the investigation with logic 0’s on both the SET and RESET inputs. Thus S3 and S4 may need some initial adjustment to ensure that this is the case.

**Stage 2.** Having ensured that the SET and RESET inputs are both at logic 0, note down the state of the Q and Q outputs by examining D1 and D2 respectively. Readers should be aware that it is not possible to predict the initial state of the Q and Q outputs, other than that they should, of course, be complementary! In any event, we need to know what their initial state is so that we can detect any subsequent change when we apply logic 1 to the SET and RESET inputs.

**Stage 3.** Press S1 in order to generate a momentary logic 1 at the CLOCK input. There should be no change in the state of the Q and Q outputs; the circuit "ignores" the CLOCK input when SET and RESET are both at logic 0.

**Stage 4.** Now press S3 to produce a logic 1 at the SET input leaving S4 at logic 0. Check that the Q and Q outputs are still the same as before, and then press S1 to produce another momentary logic 1 at the CLOCK input. The results of momentarily pressing S1 does not depend on the previous states of Q and Q. When S1 produces the next clock input, Q goes to a logic 1, and Q goes to a logic 0. The bistable has been SET.

**Stage 5.** Press S3 again in order to change its output state back to a logic 0. Press S4 to obtain a logic 1 on the RESET input. Check that the Q and Q outputs have remained unchanged during this operation. Now press S1 to produce a further momentary logic 1 at the CLOCK input. The Q and Q outputs should change state as soon as S1 is pressed and Q should become a logic 0 (and Q a logic 1). The bistable has now been RESET.

**Stage 6.** Now press S3 to produce a logic 1 on the SET input whilst the RESET input remains at logic 1. Check that the bistable remains in its previous RESET condition. Press S1 to generate a further momentary logic 1 at the CLOCK input. Note what happens to the Q and Q outputs, then press S3 again several times. The state of Q and Q should appear to be somewhat random; they are affected by the clock but change in an entirely unpredictable manner. This is, as you have probably guessed, a "disallowed" condition!

Pressing S1 repeatedly to generate a CLOCK "pulse" can be somewhat tedious and, since we have a built-in clock within the Logic Tutor, it seems sensible to use this instead of relying upon manual operation of the clock. The modification to the Logic Tutor wiring is simply that of removing the link from A5 to S1, and installing a link from 'A5' to 'CLOCK’. After a little further experimentation, it should become very obvious that "data", in the form of SET and RESET inputs, is transferred into the bistable whenever the clock input goes to logic 1.
TRUTH TABLE FOR THE CLOCKED R-S BISTABLE

Earlier we looked at the truth table for a simple R-S bistable. Now let's see what effect the CLOCK input has on this. Table 5.3 shows the truth table for a clocked R-S bistable. At first sight this may look very similar to that for the simple R-S bistable but note that the output states in the truth table all assume that a clock pulse has just been received, i.e. after the clock input changes from 0 to 1. The main points to note are:

(a) There are two inputs, SET and RESET, and two outputs, Q_{n+1} and Q_n. An extra column has been incorporated for "comments" to explain what happens to the outputs after the clock input changes.

(b) A subscript notation has been adopted in conjunction with the Q and Q̅ outputs. This is simply a means of abbreviation: Q₀ merely denotes the state of the Q output before the clock changes whereas Q_{n+1} denotes the state of the Q output after the clock transition.

(c) With SET and RESET inputs both at logic 0, the next Q output (Q_{n+1}) is the same as the previous output (Q_n). The same is true for the complementary output, Q̅. There is thus no change in the state of the bistable outputs.

(d) With both SET and RESET inputs at logic 1 a disallowed state exists and the output state, after the clock pulse, is indeterminate.

(e) With SET at logic 1 and RESET at logic 0 the bistable is set after the clock pulse, i.e. Q_{n+1} \rightarrow 1.

(f) With RESET at logic 1 and SET at logic 0 the bistable is reset after the clock pulse, i.e. Q_{n+1} \rightarrow 0.

LEVEL VERSUS EDGE CLOCKING

In the clocked bistable which we have just considered, a logic level of 1 at the clock input caused the SET and RESET inputs to the bistable to become active. It may thus be referred to as a "level-clocked" bistable. This is satisfactory for a number of applications, but is still far from ideal since, during the period in which the clock is at logic 1, changes which occur on the SET and RESET inputs will affect the state of the output. In practical logic systems this can cause problems. A much better bistable element would be one in which the condition on the SET and RESET inputs could be changed at any time with the certain knowledge that the bistable would only react at the instant of time when the clock next changed from a logic 0 to a logic 1 (or from logic 1 to logic 0). Such a bistable is referred to as an "edge-clocked" bistable and is ideal for use in logic systems where a number of bistables are connected in tandem. Data is then transferred, from one stage to the next, on each rising (or falling) clock transition.

D-TYPE BISTABLES

A further improvement on the R-S bistable can be obtained by adding an additional input which determines the state of the outputs at the instant the clock changes. This, edge-triggered, bistable is referred to as a "D-type". The "D" stands for "data" which is effectively loaded into the bistable stage when the clock transition occurs. The symbol for a D-type is shown in Fig. 5.10. This has four inputs and, as usual, two outputs. The inputs are: SET, CLEAR, CLOCK, and D. The outputs are our old friends, Q and Q̅.

The D-type is rather difficult to construct using individual logic gates (one can be constructed from no less than six three-input NAND gates) and thus a purpose-designed integrated circuit version is preferred. We shall, therefore, not concern ourselves with the internal arrangement of the device which, for most applications, would be considered a purely academic exercise. Instead, we will concentrate on the characteristics and applications of the D-type.

7474 D-TYPE BISTABLE

The 7474 is a dual D-type bistable contained in a 14-pin d.i.l. package.

The internal arrangement and pin connections for the 7474 are shown in Fig. 5.11. As mentioned earlier, the small circles which appear on the SET and CLEAR inputs indicate that they are active low inputs. The following links are required in order to investigate the operation of the D-type in the circuit of Fig. 5.12:

Fig. 5.10. Symbol for a D-type bistable

Fig. 5.11. Internal arrangement and pin connections for a dual D-type bistable

Fig. 5.12. 7474 D-type bistable circuit

A1 to S4 (S4 is the CLEAR input)
A2 to S1 (S1 will provide the DATA)
A3 to CLOCK
A4 to S3 (S3 is the SET input)
A5 to D1 (D1 indicates the Q output)
A6 to D2 (D2 indicates the Q̅ output)
A7 to OV (OV)
A16 to +5V (positive supply)

The 7474 should be placed in socket A with pin 1 in position 'A1', as usual. The following steps should be followed in order to confirm that the D-type operates correctly:

Step 1. Adjust S3 and S4 to give logic 0 on both the SET and RESET inputs. (Remember that this device uses active low inputs and thus, in this condition, we are trying to SET and CLEAR the bistable at the same time!). Q and Q̅ will both go immediately to logic 1 in this normally disallowed state, although the behaviour is actually quite predictable for this particular bistable.

Step 2. Adjust S3 to produce a logic 0 on the SET input, and S4 to produce a...
logic 1 on the CLEAR input. Q now immediately changes to (or remains at) logic 1 regardless of the state of the CLOCK input. The bistable is set.

**Step 3.** Adjust S3 and S4 to produce a logic 1 on the SET input and a logic 0 on the CLEAR input. Q now immediately changes to (or remains at) logic 0 regardless of the state of the CLOCK input. The bistable is cleared.

**Step 4.** (and this is the important one!) Adjust S3 and S4 so that both SET and CLEAR are at logic 1. Q should be at logic 0 initially whilst Q is at logic 1 as a result of the previous step. Wait until the clock i.e.d. goes off, press S1 and hold the switch down. This places a logic 1 on the DATA input. Nothing should happen, however, until the clock goes to logic 1. When this happens, Q should change to logic 1 (whilst Q changes to logic 0). When the clock i.e.d. goes off again, release S1 to place a logic 0 on the DATA input. Nothing should happen until the clock again goes to logic 1, at which point Q should revert to logic 0 (whilst Q reverts to logic 1).

Readers should repeat the above exercise until they are absolutely familiar with the way in which the D-type operates. To summarise, you should revert to the bistable, which changes of state occur. To demonstrate just how useful timing diagrams can be, let us consider the timing diagram for the previous circuit constructed around the 7474 D-type bistable. We have assumed that the SET and CLEAR inputs are both set to logic 1 and that we are following through 'Step 4' of the investigation. Readers may like to work through this step again whilst looking at the timing diagrams.

The timing diagram is shown in Fig. 5.13 and it illustrates the logic states at four points in the circuit: the CLOCK and DATA inputs, and the Q and Q outputs. The most important point on the clock waveform is the rising (positive-going) edge and you will notice that the changes at the Q and Q outputs are always synchronised with this edge. The falling (negative-going) edge is unimportant, as is the precise moment at which the data input changes.

**TIMING DIAGRAMS**

As we are now entering the world of clocked operation of bistables, it is important to have a simple and unambiguous means of describing the sequence of logical events in a circuit. This is achieved by constructing a "timing diagram". Such a diagram is simply a graph showing the logic states at various points in the circuit, plotted against a common scale of time. By referring to the diagram we can, not only accurately predict the logic states within the circuit at any instant of time, but we also identify the crucial times at which changes of state occur.

To understand how this works, imagine that the Q and Q outputs of the bistable are initially at logic 0 and logic 1 respectively. When the clock next changes from logic 0 to logic 1 (assuming that the device is positive edge triggered), the logic 1 at the Q output will be transferred into the bistable such that the Q output changes to logic 1 whilst the Q output becomes logic 0. The bistable remains in this state until the next positive clock edge occurs at which point the bistable again changes state with the Q output reverting to logic 0 whilst the Q output becomes logic 1 again. Notice that the Q output has changed from logic 0 to logic 1 and back to logic 0 in the same time that the clock has changed from logic 0 to logic 1 and back twice. It has taken two cycles of the clock to produce only one cycle at the output. This is binary division and we now have a device at our disposal which produces, in any given time interval, half as many output pulses as clock input pulses.

**BINARY DIVIDERS**

If the Q output of a D-type bistable is fed-back to its DATA input, the bistable can effectively be made to divide by two. To understand how this works, imagine that the Q and Q outputs of the bistable are initially at logic 0 and logic 1 respectively. When the clock next changes from logic 0 to logic 1 (assuming that the device is positive edge triggered), the logic 1 at the Q output will be transferred into the bistable such that the Q output changes to logic 1 whilst the Q output becomes logic 0. The bistable remains in this state until the next positive clock edge occurs at which point the bistable again changes state with the Q output reverting to logic 0 whilst the Q output becomes logic 1 again. Notice that the Q output has changed from logic 0 to logic 1 and back to logic 0 in the same time that the clock has changed from logic 0 to logic 1 and back twice. It has taken two cycles of the clock to produce only one cycle at the output. This is binary division and we now have a device at our disposal which produces, in any given time interval, half as many output pulses as clock input pulses.

**7474 BINARY DIVIDER**

Fig. 5.14 shows how the 7474 D-type bistable can be connected to form a single stage binary divider. The

![Fig. 5.13. Timing diagram for the 7474 D-type bistable](image-url)
This consists of four binary digits, or "bits" and can thus be referred to as a "four-bit number". The left-most bit carries the position, as shown below:

\[
\begin{array}{c|c|c|c}
\text{Binary 1010} & 2^3 &= 8 & 2^2 &= 4 & 2^1 &= 2 & 2^0 &= 1 \\
1 & 0 & 1 & 0 & & & & \\
\end{array}
\]

The denary number 174 is the result of adding the individual weighted values, i.e. \((1 \times 100) + (7 \times 10) + (4 \times 1)\) or \((100 + 70 + 4)\). The binary number 1010 is, therefore, the result of adding its individual weighted values, i.e. \((1 \times 8) + (0 \times 4) + (1 \times 2) + (0 \times 1)\) or \((8 + 2)\) which is 10 on the denary scale. To reinforce the point, let's take another example. The eight bit binary number 01001011 is equivalent to \((0 \times 128) + (1 \times 64) + (0 \times 32) + (0 \times 16) + (1 \times 8) + (0 \times 4) + (1 \times 2) + (1 \times 1) = (64 + 8 + 2 + 1) = 75\).

So much for converting from binary to denary. Now let's consider the reverse process, i.e. converting from denary to binary. There are two commonly used methods, one involves finding the set of binary weighted values whose sum is equal to the denary number, and the other involves successive division of the number by two and noting down the remainders. We shall consider each of these methods in turn.

Starting with the decimal number 13 we must first examine it to find the highest power of two contained in it. We then subtract that number, and examine the remainder, repeating the process until we are left with a 1 or a 0. In effect, we are determining a set of binary weighted values which, when added together, are the same as the number which we started with. This may all sound rather complex so, to show how easy it all is, let's take decimal 13 as an example:

\[
\begin{align*}
13 & = (8 + 4 + 1) = (2^3 + 2^2 + 2^0) \\
\end{align*}
\]

Now place a 1 in the appropriate weight positions and 0 in the remaining position, as shown below:

\[
\begin{array}{c|c|c|c}
\text{Denary 174} & 10^2 &= 100 & 10^1 &= 10 & 10^0 &= 1 \\
\text{(hundreds)} & 7 & 4 & \\
\end{array}
\]

Thus decimal 13 is equivalent to binary 1101. Unfortunately, this method becomes somewhat cumbersome when we are dealing with very large numbers (say, greater than 64 or 2^6) and the alternative method may then be preferred. This method involves repeated division by 2, leaving whole numbers only, and noting down all the remainders produced. The values of the remainders (which will be either 0 or 1) are assembled, in reverse order, to give the binary number.

### HEXADECIMAL NUMBERS

Many digital systems process groups of signals being used to represent numbers of one sort or another. Binary numbers are passed around as groups of digital signals, but continually referring to long numbers by strings of 0's and 1's becomes tedious to say the least! The hexadecimal (base 16) number system is a shorthand way of representing such numbers. The binary 0/1 string is split up into groups of 4 bits, starting with the least significant end. Each 'nibble' (as it is called) is then converted into a single hex digit according to Table 5.4. Thus 1010

<table>
<thead>
<tr>
<th>DECIMAL</th>
<th>BINARY</th>
<th>HEXADECIMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>1010</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>1011</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>1100</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>1101</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>1110</td>
<td>E</td>
</tr>
<tr>
<td>15</td>
<td>1111</td>
<td>F</td>
</tr>
</tbody>
</table>

Table 5.4. HexadeacIMAL numbers

0011 1111 is represented by A3F, while EF35 is shorthand for 1110 1111 0011 0101. The result is an economical representation which is easily remembered, and which is widely used.

### NEXT MONTH: 3 and 4 input gates and JK flip-flops.
 Appearing every month, Micro-Bus now presents ideas, applications and programs for the most popular micro-computers and all micro-related projects so far published in PE. Ideas must be original, and payment will be made for any contribution featured.

This month's Micro-Bus features a 6809 Call Utility, submitted by R. G. Strange of Loughborough.

6809 CALL UTILITY

The 6809 processor offers two forms of subroutine call. JSR jumps to a direct address, resulting in programs which are easy to code and read, but which are position dependent. BSR produces position independent code, but requires relative jump calculations, and results in code which is difficult to read.

Often programs do not need to be relocated by an arbitrary number of bytes, but are simply shifted by a whole number of K, for example, when transferring a RAM based program to EPROM.

The CALL routine listed in Fig. 1 utilises the 6809 software-interrupt SWI (op code 3F) to create an alternative instruction which branches relative to the next lowest 2K boundary (since the writer's programs are currently based in 2K EPROMs). This results in a relocatable program in which each subroutine has a unique and meaningful jump vector. For example, in the 2K block $9800-$F8FF, a routine at $9950 has jump vector $0150 and is called by the instruction 3F 01 50

The routine can reside anywhere in memory, and the SWI vector at $FFFF, $FFFB must point to it.

There is an inherent time penalty of 70 cycles, but in programs where execution time is not critical the CALL routine can speed program development considerably.

The operation of the routine can be understood with the help of Fig. 2, the 6809 stacking order.

Fig. 1. CALL routine

```
9A00 3F 01 50 CALL $9950
```

Fig. 2. 6809 stack during execution of CALL $9950

Using USR with the PSG

Sir—Currently to set up a register and its contents on the PSG, it is necessary to use two POKEs, i.e. POKE R, REG : POKE C, CON, where R and C are the register and content addresses on the PSG and REG and CON is the register number and its value. This method is rather long winded and cumbersome especially where large numbers of registers need to be set up. However, with the machine code routine shown below, and having first set the USR address to $0222 (POKE 11, 34:POKE 12, 2), X = USR(REG*256+CON) gives register number REG the value of CON. Furthermore, to set up a number of registers use:—

```
X = USR(RREG+CON) = USR(RREG+CON) = USR(RREG+CON)
```

The values inside the brackets can, of course, be calculated beforehand, for instance X = USR(255) = USR(1039) = USR(1022) outputs a single tone, and is far shorter and more convenient than its equivalent POKEs.

PSG routine

; ORG $0222 relocatable
0222 20 01 AE JSR $AE01
0225 A5 AE LDA $AE
0227 8D 70 F 1 STA $F170
022A A5 AF STA $AF
022C 8D 71 F1 STA $F171
022F 60 RTS

Fig. 2. 6809 stack during execution of CALL $9950

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Published on approximately the 7th of each month by IPC Magazines Limited, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Printed in England by Chapel River Press, Andover, Hants. sole Agents for Australia and New Zealand: Gordon and Cotchin (Asia) Ltd, South Africa: Central News Agency Ltd, Subscribers INLAND £13 and OVERSEAS £14 payable to IPC Magazines Ltd. "Practical Electronics" Subscription Department, Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given by them, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be first, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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