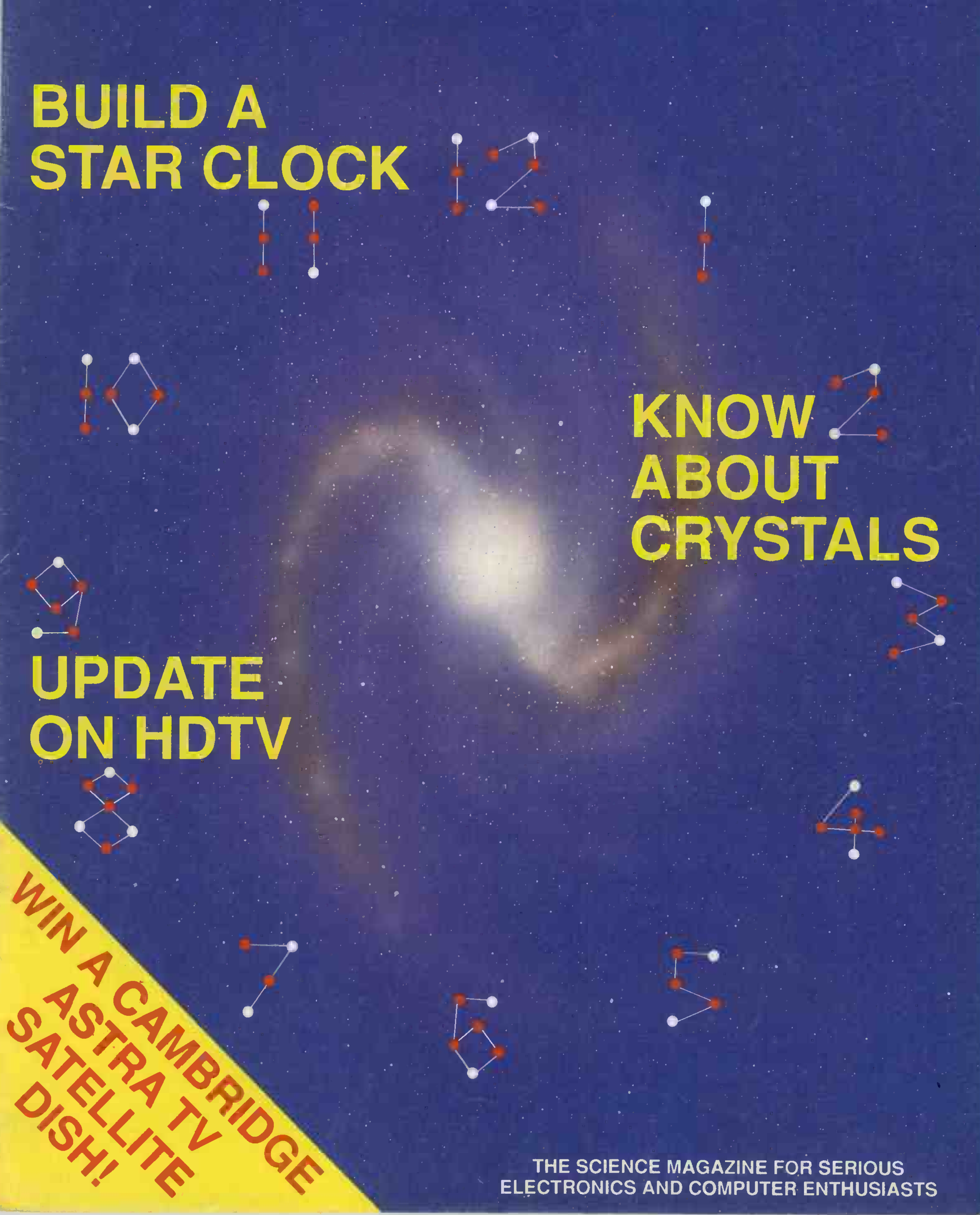
PRACTICAL

ELECTRONICS

FEBRUARY 1989 • £1.25

SCIENCE & TECHNOLOGY



BUILD A STAR CLOCK

KNOW ABOUT CRYSTALS

UPDATE ON HDTV

WIN A CAMBRIDGE ASTRA TV SATELLITE DISH!

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

New REALISTIC®
PORTABLE SCANNING RECEIVER

- **Frequency Synthesized - No Crystals To Buy**
- **68-88 MHz VHF-Lo**
- **108-136 MHz (AM) Aircraft**
- **136.005-174 MHz VHF-Hi**
- **380-512 MHz UHF**
- **806-960 MHz**

Realistic Pro-34. Catch all the action on this hand-held programmable scanner. Features extended frequency coverage, including the new 800 MHz band! Scan up to 200 channels in 10 bands or search for new bands. Store frequencies in a special monitor band for one-key transfer to permanent memory. Lock-out key temporarily bypasses unwanted channels.

The Key To Better Listening

Also features large LCD display showing channels and frequencies being scanned, monitored or programmed and has a switchable backlight for night viewing. Squelch control, built-in speaker, 1/8" earphone socket, flexible aerial and belt-clip. Includes BNC jack for adding external aerial.

Realistic PRO-34 £249.95.
Cat. No. 20-9135

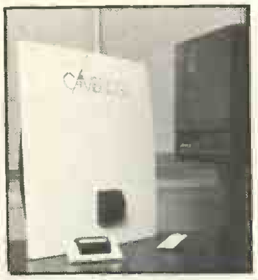
Tandy®

Tune in to Tandy TODAY!

Over 400 Stores
And Dealers Nationwide
Prices may vary at Dealers. Offers subject to availability.
Tandy, Tandy Centre, Leamore Lane,
Walsall, West Midlands. WS2 7PS

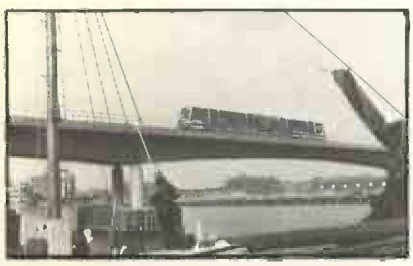
PRACTICAL ELECTRONICS

PE VOL 25 NO 2 **FEBRUARY 1989**



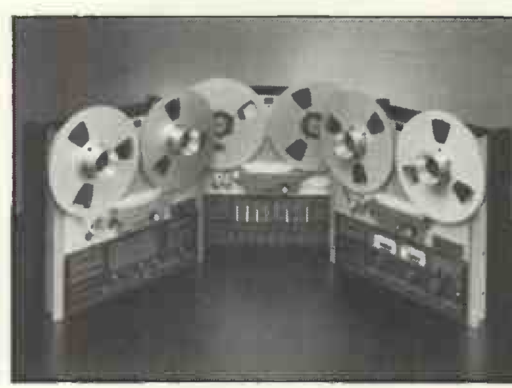
COMPETITION

CONSTRUCTIONAL PROJECTS



SPECIAL FEATURES

REGULAR FEATURES

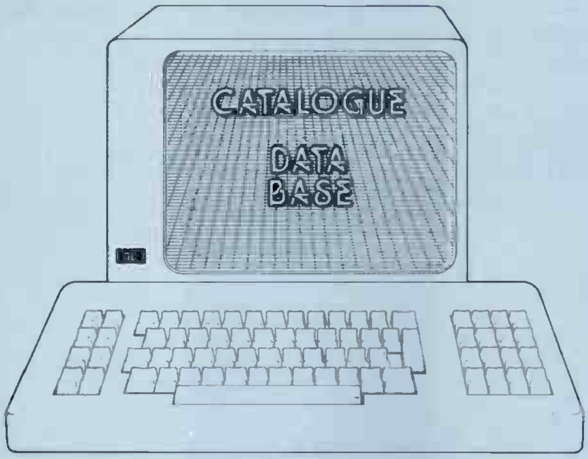


NEXT MONTH . . .

☆ IN PARTICULAR ROBERT PENFOLD TELLS YOU HOW TO BUILD A PRECISION CAMERA SHUTTER TIMER ☆ AND MICHAEL STRASSEN STEERS A COURSE THROUGH THE AUTOGUIDE SYSTEM ☆ AND OF COURSE THERE'LL BE NO SPACE UNFILLED – WE'LL BRING YOU LOTS MORE TIMELY INTEREST WITH OUR REGULAR SERIES OF TOP FEATURES ☆

SO START THE COUNTDOWN FOR OUR MARCH 1989 ISSUE ON SALE FROM FRIDAY FEBRUARY 3RD

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS



We have recently received the following literature:

OK's new electronic production catalogue has 150 pages in full colour format covering **pcb assembly equipment,** including smd, soldering, desoldering, tools, static control etc. **OK Industries UK Ltd,** Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants, SO5 5RR. 0703 619841.

The Modern Book Company's computer catalogue contains listings of hundreds of **books on computers,** computer technology, software languages, artificial intelligence and allied subjects. It is claimed to be the **most extensive and up to date** list of books on computing available. **The Modern Book Co,** 19-21 Praed Street, London, W2 1NP. 01-402 9176.

Brian Price has 30 years experience of importing **Bohm** musicical instrument diy kits. He has sent a comprehensive colour **catalogue of the Bohm range** which includes a very large selection of keyboard instruments, drum synths, amps, cassettes, tools, and music-related microprocessor technology. **Brian Price Bohm Organ Studios,** 389 Aspley Lane, Nottingham, NG8 5RR. 0602 296311.

Heinemann Newnes' 1989 complete **catalogue of technical books** is a good source of information about practically every aspect of technology. **Heinemann Professional Publishing,** Halley Court, Jordan Hill, Oxford, OX2 8EJ. 0865 311366.

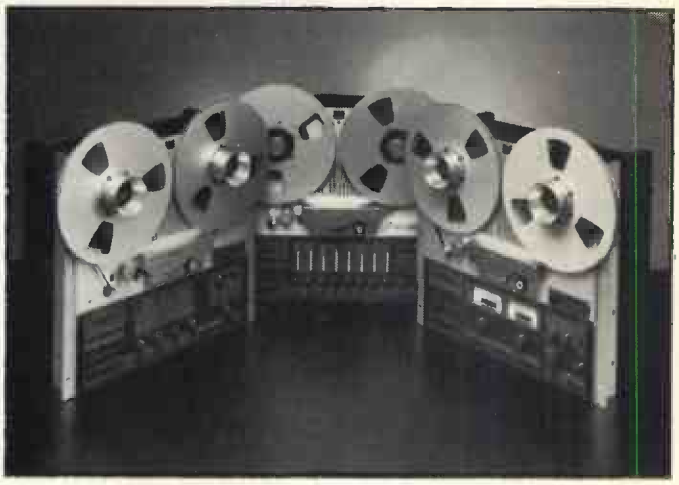
STC's full colour 6-page brochure on the Kemet range of **surface mounting capacitors** will mainly be of interest to PE's professional readers. The Capacitor Group, **STC Electronic Services,** Edinburgh Way, Harlow, Essex, CM20 2DF. 0279 626777.

Flight Electronics 7th Edition 1988-9 colourful catalogue has a wealth of information for those seeking **an excellent variety of microprocessor training systems,** pc control cards, breadboards and test instruments. **Flight Electronics Ltd,** Flight House, Ascupart Street, Southampton, SO1 1LU. 0703 227721.

Antex are renowned for the excellence of their soldering irons and related equipment. Their new 12 page colour brochure is entitled **Precision Soldering.** In addition to detailing products, the brochure includes a section on **how to choose the right soldering iron.** Several new products are introduced, including the option of having **burn-proof cable** on any of their equipment (seems an excellent idea to your Ed whose cables tend to become inartistically pock marked on crowded work benches – about time other tools become burn-resistant too!). **Antex (Electronics) Ltd,** Mayflower House, Plymouth, Devon. 0752 667377.

Mega Electronics are manufacturers and suppliers of equipment, tools and materials for **practically all your pcb requirements,** including design, processing and production. Their latest colour catalogue will be of interest to anyone involved in **any aspect relating to pcbs.** It also includes front panel and label production materials. **Mega Electronics Ltd,** The Grip Industrial Estate, Linton, Cambridge, CB11 6NR. 0223 893900.

WHAT'S NEW



C And Hear Hear

There are two new additions to the Revox "C" range of professional and industrial tape recorders.

The C274 and C278 are new four and eight channel recorders, the latter on 1/2" tape. In common with the C270 recorder, these new additions are loaded with features that are not available even as options on comparable machines from other manufacturers.

Available as standard:

- Dolby HX-PRO headroom extension
- Seamless gapless punch in punch out
- Integral scrape-flutter idler in head assembly
- Constant tension on both spooling motors
- One hand cueing under full servo control
- Front access to all audio electronics
- Plug in record and replay equalisers for easy speed pair change
- 3 peak led indicators, +6, +9, +12dB
- Adjustable mute to play 50 to 990 msec
- Built in vari-speed, -33% to +50%
- Selectable library wind and record habit
- Optical end of tape sensor
- Fader start circuitry and RS232 control of all machine functions
- Rack mounts as standard

Both machines are available with two speeds which can be field changed between 3 3/4, 7 1/2 and 15 ips and have a built-in time and date generator and reader with search capability, especially useful for the low speed logging versions available at the end of the year, with a choice of any two of 15/32, 15/16 and 1 7/8 ips.

For more information about Studer Revox Equipment please contact: FWO BAUCH LIMITED, 49 Theobold Street, Boreham Wood, Herts, WD6 4RZ. Tel: 01-953 0091.

P.S. I was recently shown round their premises – they have some beautiful equipment, and very helpful people.
Ed

New LCD CTV

Following the tremendously successful launch of the pocket sized PTV01 lcd colour television, (three of which featured as the prices in our Jan 1989 issue competition), Ferguson have introduced the PTV02/A.

Having pioneered the UK market with active matrix lcd technology, as distinct from the inferior, lower resolution passive matrix, Ferguson is again leading the way with larger 3.2 inch active matrix lcd screen on the PTV02/A. This represents the latest in flat screen lcd technology giving a high resolution, high contrast picture.

One-touch auto tuning buttons enable easy channel selection and there are also volume, brightness, colour and contrast controls. The set includes an audio only switch which allows you to listen without a picture, so extending battery life. With this feature, you could for example, watch Rugby live inside the ground at Twickenham whilst using the earphone socket to listen to the tv commentary, and then, at the flick of a switch, turn the tv screen on to watch an exciting replay.

CONTACT; Anne Waterman, Ferguson Ltd, Great Cambridge Road, Enfield, Middx, EN1 1UL. Tel: 01-363 5353.

Sir Clive's Flat Out

Sir Clive Sinclair is again at the forefront of innovation. His company, Cambridge Computer, has announced that it has entered the satellite broadcasting market. Its new receiver uses a technological breakthrough which will enable Cambridge to sell the 'dish' at a price considerably lower than any current offering, while maintaining high performance and top-quality manufacture.

The 'dish' is in fact a flat square which has a streamlined design. It measures just 60cms across, comes with a tuning unit that sits in the home, and will be available in three versions..

Commenting on the new product Sir Clive Sinclair said: "There is currently a lot of debate and uncertainty about satellite dishes. The entry of Cambridge's satellite receiver onto the market is significant because it offers a reliable, low-cost answer."

The basic package at £149.95 includes the receiver and tuning unit. For £179.95 Cambridge also supplies a remote control unit for armchair channel changing (It's this dish that's our prize in this month's competion). The top of the range model, which costs only £229.95, includes stereo reception, graphic equalizer, channel selector, remote control and stereo sound output.

The outer casing of the Cambridge receiver is made of highly durable weather-proof plastic. A major benefit of the flat design is that it will not collect snow which can build up and prevent a conventional bowl-shaped system from working.

The receiver is an entirely British design manufactured in the UK, and marketed by Cambridge Computer, whose current product range includes the successful Z88 lightweight portable computer.

CONTACT: Helen Darbishire, Countrywide Communications (London) Ltd, Bowater House East, 68 Knightsbridge, London SW1X 7LH. Tel: 01-225 0311

Eight Metre Dishes

Two eight metre diameter aerial dishes are now in position for the Independent Broadcasting Authority's (IBA's) satellite up-link, located at Chilworth, Southampton. At the time of going to press, acceptance tests were imminently due to start.

This is an important step in the provision of high power direct-to-home television via satellite, which will start this year. British Satellite Broadcasting hold the franchise to supply three television channels.

Patio Astra Dish

Satellite supplies, the London based home satellite television distributors have moved into manufacturing.

After three years of building up a solid customer base throughout Europe, in the embryo satellite television market, they are ideally placed to exploit the explosion in the market following the Astra launch.

Their first product is a 60cm Astra compatable antenna. Having been fully tested on the signals from the French satellite, the company are confident that the antenna will be ideal for use throughout mainland Britain.

In its basic form a universal patio or wall fixing bracket is supplied, but can also be supplied with customised mounts.

CONTACT: Dan Hornby, Satellite Supplies Ltd, 234 High Street, London NW10. Tel: 01 961 1346.

PER ARIANE AD ASTRA

This is the Ariane rocket used to launch the Astra Satellite. Photo kindly supplied by Simon Vermeer of the European Space Agency.

COUNTDOWN

If you are organising any event to do with electronics, big or small, drop us a line – we shall be glad to include it here.

Please note: Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

Jan. 25-26. Instrumentation Southampton. Fleming Park, Eastleigh. 0822 614671.

Feb. 7-9. Smartex – Surface Mounting Technology Exhibition. Wembley Exhibition Hall. 01-302 8585.

Feb. 22-23. Instrumentation Harrowgate. Harrowgate Exhibition Centre. 0822 614671.

Mar. 21-22. Instrumentation Bristol. Crest Hotel, Filton, Bristol. 0822 614671.

Apr. 5-6. Laboratory Science and Technology Show, Kelsey Kerridge, Cambridge. 0799 26699.

Apr. 25-27. British Electronics Week. Olympia. 0799 26699.

May 8-10. Eurobus 89 – German Conference. Munich Sheraton Hotel, Munich. 01-940 4625.

Jun. 5-9. Lasers, Optoelectronics, Microwaves. 9th International Trade Fair and Congress. Munich Fair Centre. 01-948 5166.

Jun. 14-15. Instrumentation Scotland. The Forum, Livingstone. 0822 614671.

Jul. 10-13. EWEC '89. European wind energy conference and exhibition. Scottish Conference and Exhibition Centre, Glasgow. No reference tel. known.

Sep. 4-6. Eurobus 89 – UK Conference. Novotel Hotel, London. 01-940 4625.

Oct. 16-20. Systems, Computers and Communications. 11th International Trade Fair and Congress. Munich Trade Fair Centre. 01-948 5166.

Oct. 24-26. Sensors and Systems – International Transducer Exhibition and Conference. Wembley Conference Centre. 0822 614671.

Nov. 7-11. Productronica. 8th International Trade Fair for Electronics Production. Munich Trade Fair Centre. 01-948 5166.

BTEC CONTINUING EDUCATION CERTIFICATE COURSES. Starting dates Jan11 and Apr 26 – each course 2 days per week Wed/Fri for 13 weeks. London Electronics College, 20 Penywern Road, London SW5 9SU. 01-373 8721.

RACKS CABINETS & FANS | SURPLUS BOUGHT & SOLD | ELECTRONIC COMPONENTS & OBSOLETE IC'S | MONITORS VDU'S & PLOTTERS | 1000'S OF ITEMS IN STOCK | COMPUTER SYSTEMS & PERIPHERALS | RELAYS MOTORS & STEPPERS | POWER SUPPLIES & INVERTORS | ALL TYPES OF TEST EQUIPMENT | PRINTERS DISK DRIVES & KEYBOARDS | VIDEO EQUIPMENT & CAMERAS

THE 'ALADDINS' CAVE OF ELECTRONIC & COMPUTER EQUIPMENT

COLOUR MONITORS

16" Decca, 80 series budget range, colour monitors, features include: PIL tube, attractive teak style case, **guaranteed 80 column resolution**, only seen on monitors costing 3 times our price, ready to connect to a host of computer or video outputs. Manufacturers fully tested surplus, sold in little or hardly used condition with 90 day full RTB guarantee. **1000's Sold to date.**
DECCA 80 RGB - TTL + SYNC input for BBC type interface etc.
DECCA 80 COMP 75 Ω composite video input with integral audio amp & speaker ideal for use with video recorder or TELEBOX ST or any other audio visual use. **Only £99.00 (E)**

HIGH DEFINITION COLOUR

BRAND NEW **CENTRONIC 14"** monitors in attractive style moulded case featuring **hi res** Mitsubishi 0.42 dot pitch tube with 669 x 507 pixels, 28Mhz bandwidth. Full 90 day guarantee.
Order as **1004-N2** for TTL + sync RGB for BBC etc £159.00 (E)
1003-N1 for IBM PC etc fully CGA equiv £189.00 (E)
1005-N2 RGB interface for QL 85 columns. £169.00 (E)

20" & 22" AV Specials

Superbly made, UK manufacture, PIL tube, all solid state colour monitors, complete with composite video and sound inputs, attractive teak style case, ideal for a host of applications including Schools, Shops, Disco's, Clubs etc. Supplied in EXCELLENT little used condition with 90 day guarantee.
20" Monitor £165.00 (F) 22" Monitor £185.00 (F)

MONOCHROME

MOTOROLA M1000-100 5" CRT black & white compact chassis monitor measuring only cm 11.6h, 12w, 22d, ideal for CCTV or computer applications. Accepts standard Composite video or individual H & V syncs. Operates from 12v DC at apprx 0.8a. Some units may have minor screen marks, but still in very usable condition. Fully tested with 30 day guarantee & full data **Only £29.00 (C)**
Fully cased as above, with attractive moulded, desk standing swivel and tilt case Dim. cm 12h, 14.5w, 26d. £39.00 (C)
JVC type 751-7 5" ultra compact black & white chassis monitor for 12v 0.7a DC operation Dim cm 11h, 14w, 18d. Simple DIY circuit data included to convert data and separate sync input to composite video input. Ideal portable equipment etc, Supplied with full data. **Brand New £65.00 (B)**
KGM 324 9" Green Screen, Little used fully cased, mains powered high res monitors with standard composite video input. Fully tested and in excellent condition £49.00 (E)
20" Black & White monitors by **AZTEK, COTRON & NATIONAL** All solid state, fully cased monitors, ideal for all types of AV or CCTV applications. Units have standard composite video inputs with integral audio amp and speaker. Sold in good, used condition- fully tested with 90 day guarantee. **Only £85.00 (F)**

FLOPPY DRIVE SCOOP Drives from Only £39.95

A MASSIVE purchase of standard 5.25" disk drives enables us to offer you prime product at all time super low prices. All units unless stated are removed from often **BRAND NEW** equipment, **fully tested** and shipped to you with a full **120 day guarantee**. All units offered operate from +5 and +12 volts DC, are of standard size and accept the common standard 34 way interface connector.
TANDON TM100-2A IBM compatible 40 track FH double sided **Only £39.95 (B)**
TANDON TM101-4 FH 80 track double sided **Only £49.95 (B)**
JAPANESE Half Height double sided drives by **Canon, Tec, Toshiba etc.** Specify 40 or 80 track **Only £75.00 (B)**
TEAC FD55-F 40-80 track double sided Half Height **Brand New £115.00 (B)**

DISK DRIVE ACCESSORIES

34 Way interface cable and connector single **£5.50, Dual £8.50 (A)**
5.25" DC power cable **£1.75**. Fully cased PSU for 2 x 5.25" Drives £19.50 (A) Chassis PSU for 2 x 8" drives £39.95 (B)

8" DISK DRIVES

SUGART 800/801 single sided refurbished £175.00 (E)
SUGART 851 double sided refurbished £260.00 (E)
MITSUBISHI M2894-63 Double sided switchable Hard or Soft sector **BRAND NEW £275.00 (E)**
SPECIAL OFFER Dual 8" drives with 2mb capacity in smart case with integral PSU **ONLY £499.00 (F)**

COMPUTER SYSTEMS

TATUNG PC2000. Big brother of the famous **EINSTEIN**, the **TPC2000** professional 3 piece system comprises: Quality high res **GREEN** 12" monitor, Sculptured **92 key keyboard** and plinth unit containing the **Z80A CPU** and all control electronics **PLUS 2 integral TEAC 5.25" 80 track double sided disk drives.** Many other features include **Dual 8" IBM format** disk drive support, Serial and parallel outputs, full expansion port, 64k ram and ready to run software. Supplied complete with **CPM, WORDSTAR, BASIC** and accounts package. **BRAND NEW**
Full 90 day guarantee.
Original price **OVER £1400** **Only £299(E)**

EQUINOX (IMS) S100 system capable of running either **TURBO** or standard **CPM**. Unit features heavy duty box containing a powerful PSU, 12 slot **S100** backplane, & **dual 8" double sided disk drives.** Two individual **Z80** cpu boards with **192k of RAM** allow the use of multi user software with upto **4 RS232 serial interfaces**. Many other features include battery backed real time clock, all IC's socketed etc. Units in good condition and tested prior despatch, no documentation at present, hence price of only £245.00 (F)
S100 PCB's IMS A465 64K dynamic RAM. **£55.00 (B)** IMS A930 FDC controller **£85.00 (B)**. **IMS A862** CPU & i/o **£65.00 (B)**
SAE for full list of other S100 boards and accessories.

PRINTERS

Bulk purchase brings you incredible savings on a range of printers to suit all applications. Many other "one off bargains" can be seen at our South London Shop

HAZELTINE ESPRINT Small desktop **100 cps** print speed with both **RS232** and **CENTRONICS** interfaces. Full pin addressable graphics and 6 user selecable type fonts. Up to 9.5" single sheet and tractor paper handling **Brand New Only £199.00 (E)**
CENTRONICS 150 series. A real workhorse for continuous use with tractor feed paper, either in the office, home or factory, desk standing, 150 cps 4 type fonts and choice of interfaces. Supplied **BRAND NEW** Order as:
150-SN up to 9.5" paper handling £185.00 (E)
150-SW up to 14.5" paper handling £225.00 (E)
150-GR up to 14.5" paper plus full graphics £245.00 (E)
When ordering please specify RS232 or CENTRONICS interface.

Ultra Fast 240 cps NEWBURY DATA NDR 8840 High Speed Printers Only £449 !!

A special purchase from a now defunct Goverment Dept enables us to offer you this amazing British Made, quality printer at clearance prices, **SAVING YOU OVER £1500 !!** The **NDR8840** features **high speed 240 cps** print speed with integral, fully adjustable paper tractor, giving exceptional fast paper handling for multi part forms etc. The unit features **10 selectable type fonts giving up to 226 printable characters on a single line.** Many other features include Internal electronic vertical and horizontal tabs, Self test. 9 needle head, Up to 15.5" paper, 15 million character ribbon cartridge life and standard **RS232 serial interface**. Sold in **SUPERB** tested condition with 90 day guarantee **Only £449.00 (F)**
EPSON model 512 40 column 3.5" wide paper roll feed, high speed matrix (3 lines per second) printer mechanism for incorporation in point of sale terminals, ticket printers, data loggers etc. Unit features bi directional printhead and integral roll paper feed mech with tear bar. Requires DC volts and simple parallel external drive logic. Complete with data. RFE and tested **Only £49.95 (C)**
EPSON model 542 Same spec as above model, but designed to be used as a slip or flatbed printer. Ideal as label, card or ticket printer. Supplied fully cased in attractive, small, desk top metal housing. Complete with data. RFE and tested **Only £55.00 (D)**
PHILIPS P2000 Heavy duty **25 cps** bi directional daisy wheel printer. Fully **DIABLO, QUME, WORDSTAR** compatible. Many features include full width platten - up to 15" paper, host of available daisy wheels, single sheet paper handling, superb quality print. Supplied complete with user manual & 90 day guarantee **plus FREE** dust cover & daisy wheel. **BRAND NEW Only £225.00 (E)**

Most of the items in this Advert, plus a whole range of other electronic components and goodies can be seen or purchased at our

** South London Shop **

Located at **215 Whitehorse Lane, London SE25**. The shop is on the main **68 bus route** and only a few miles from the main A23 and South Circular roads. **Open Monday to Saturday from 9 to 5.30**, parking is unlimited and **browsers are most welcome.** Shop callers also save the cost of carriage.

MODEMS

Modems to suit all applications and budgets. Please contact our technical sales staff if you require more information or assistance.

SPECIAL PURCHASE V22 1200 baud MODEMS ONLY £149 !!

MASTER SYSTEMS type 2/12 microprocessor controlled **V22 full duplex 1200 baud**. This fully BT approved modem employs all the latest features for error free data comms at the staggering speed of 120 characters per second, **saving you 75% of your BT phone bills and data connect time !!** Add these facts to our give away price and you have a superb buy !! Ultra slim unit measures only 45 mm high with many integral features such as Auto answer, Full LED status indication, RS232 interface, Remote error diagnostics, SYNC or ASYNC use, SPEECH or DATA switching, integral mains PSU, 2 wire connection to BT line etc. Supplied fully tested, EXCELLENT slightly used condition with data and full 120 day guarantee.

LIMITED QUANTITY **Only £149 (D)**

CONCORD V22 1200 baud as new **£330.00(E)**
CONCORD V22 1200-2400 BIS **£399.00 (E)**
RIXON Ex BT Modem 27 V22 1200 **£225.00 (E)**
DATEL 4800 / RACAL MPS 4800 EX BT modem for 4800 baud sync use. **£295.00 (E)**
DATEL 2412 2780/3780 4 wire modem unit EX BT fully tested. **£199.00 (E)**
MODEM 20-1 75-1200 BAUD for use with PRESTEL etc EX BT fully tested. **£49.00 (E)**
TRANSDATA 307A 300 baud acoustic coupler with RS232 I/O **Brand New £49.00 (E)**
RS232 DATA CABLES 16 ft long 25w D plug to 25 way D socket. Brand New **Only £9.95 (A)**
As above but 2 metres long **£4.99 (A)**
BT plug & cable for new type socket **£2.95 (A)**

POWER SUPPLIES

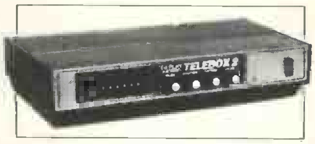
All power supplies operate from 220-240 v AC Many other types from 3v to 10Kv in stock. Contact sales office for more details.
PLESSEY PL12/2 Fully enclosed 12v DC 2 amp PSU. Regulated and protected. Dim cm 13.5 x 11 x 11 **New £16.95 (B)**
AC-DC Linear PSU outputs of +5v 5.5a, -5v 0.6a, +24v 5a. Fully regulated and short proof. Dim cm 28 x 12.5 x 7 **New £49.50 (C)**
POWER ONE PHC 24v DC 2 amps Linear PSU fully regulated **New £19.95 (B)**
BOSHERT 13088 switch mode supply ideal disk drives or complete system. +5v 6a, +12 2.5a, -12 0.5a, -5v 0.5a. Dim cm 5.6 x 21 x 10.8 **New £29.95 (B)**
BOSHERT 13090 same as above spec but outputs of +5v 6a, +24v 1.5a, +12v 0.5a, -12v 0.5a **New £39.95 (B)**
GREENDALE 19AB0E 60 Watt switch mode outputs +5v 6a, +12v 1a, -12v 1a, +15v 1a. D. 11 x 20 x 5.5 **RFE Tested £24.95 (B)**
CONVER AC130-3001 High grade **VDE spec** compact 130 watt switch mode PSU. Outputs give +5v 15a, -5v 1a, +&-12v 6a. Dim 6.5 x 27 x 12.5 Current list price £190. Our price **New £59.95.00 (C)**
FARNELL G6/40A Compact 5v 40 amp switch mode fully enclosed **New £140.00 (C)**
FARNELL G24 5S Compact 24v 5 amp switch mode fully enclosed **New £95.00 (C)**

Special Offer EXPERIMENTORS PSU — ONLY £16.95 (C)

Made to the highest spec for **BT** this unit gives several fully protected DC outputs most suited to the **Electronics Hobbyist.** +5v 2a, +&-12v 1a, +24v 1a and +5v fully floating at 50ma. Ideal for school labs etc. Quantity discount available.
Fully tested with data RFE = Removed From Equipment

The AMAZING TELEBOX Converts your monitor into a QUALITY COLOUR TELEVISION

Brand new high quality, fully cased, 7 channel UHF PAL TV tuner system. Unit simply connects to your TV aerial socket and video monitor turning same into a fabulous colour TV. Dont worry if your monitor doesn't have sound, the **TELEBOX** even has an integral audio amp for driving a speaker plus an auxillary output for Headphones or Hi Fi system etc. Many other features: LED Status indicator, Smart moulded case, Mains powered, Built to BS safety specs. Many other uses for TV sound or video etc. Supplied BRAND NEW with full 1 year guarantee. **Carriage code (B)**



TV SOUND & VIDEO TUNER ONLY **£29.95**

TELEBOX ST for monitors with composite video input **£29.95**
TELEBOX STL as ST- but fitted with integral speaker **£34.95**
TELEBOX RGB for use with analogue RGB monitors **£59.95**
Colour when used with colour CRT. RGB version NOT suitable for IBM-CLONE type colour monitors. DATA sheet on request. PAL overseas versions CALL.

RECHARGEABLE BATTERIES

Maintenance free, sealed longife **LEAD ACID**
A300 12v 3 Ah **£13.95 (A)**
A300 6v 3 Ah **£9.95 (A)**
A300 6-0-6 v 1.8 Ah **RFE £5.99 (A)**

NICKEL CADMIUM

Quality 12 v 4 Ah cell pack. Originally made for the **TECHNICOLOUR** video company, this unit contains 10 high quality **GE nicad, D** type cells, configured in a smart robust moulded case with DC output connector. Dim cm 19.5 x 4.5 x 12.5. Ideal portable equipment etc **BRAND NEW £24.95 (B)**
12v 17 Ah Ultra rugged, all weather, virtually indestructable **refillable NICAD** stack by **ALCAD**. Unit features 10 x individual type **XL1.5** cells in wooden crate. Supplied to the **MOD** and made to deliver exceptionally high output currents & withstand long periods of storage in discharged state. Dim cm 61 x 14 x 22 **Cost over £250 Supplied unused & tested** complete with instructions **£95.00 (E)**
EX EQUIPMENT NICAD cells by GE Removed from equipment and believed in good, but used condition. **'F'** size 7Ah 6 for £8 (B) Also **'D'** size 4Ah 4 for £5 (B)

BRAND NEW 85 Mb Disk Drives ONLY £399

End of line purchase enables this brand new unit to be offered at an all time super low price. The **NEC D2246 8" 80 Mb** disk drive features full CPU control and industry standard **SMD interface**, Ultra high speed data transfer and access times leave the good old ST506 interface standing. Supplied **BRAND NEW** with full manual. **Only £399.00 (E)**
Dual drive, plug in **135 Mb** sub system for **IBM** AT unit in case with PSU etc. **£1499.00 (F)**
Interface cards for **upto 4 dives** on IBM AT etc available **Brand new at £395.00**

COOLING FANS

Keep your hot parts COOL and RELIABLE with our range of BRAND NEW cooling fans.
AC FANS Specify 240 or 110 v
3" Fan dim 80 x 80 x 38 **£8.50 (B)**
3.5" ETRI slimline 92 x 92 x 25 **£9.95 (B)**
4" Fan Dim 120 x 120 x 38 **£9.95 (B)**
As above - TESTED RFE **Only £4.95 (C)**
10" round x 3.5" Rotron 10v **£10.95 (B)**
DC FANS
Papst Miniature DC fans 62x62x25 mm
Order 812 6-12v or 814 24v **£15.95 (A)**
4" 12v DC 12w 120 x 120 x 38 **£12.50 (B)**
4" 24v DC 8w 120 x 120 x 25 **£14.50 (B)**
BUHLER 12v DC 62 mm **£12.95 (A)**
1000's of other fans and blowers in stock CALL or SAE for more details

SPECIAL INTEREST

Please call for availability or further info.
RACAL-REDAC real time, colour drafting **PCB** layout system **£3950**
DEC VAX11/750 inc 2 Mb Ram DZ, and full doc etc. **Brand New £8500**
HP7580A 8 pen digital A1 drum plotter with IEEE interface **As New £4750**
CHEETAH Telex machine **£995**
1.5 kw 115v 60 Hz power source **£950**
500 watt INVERTER 24v DC to 240v AC sine wave 50 Hz output **£275**
SOLDER SYSTEMS tin lead roller tinning machine for PCB manufacture **£350**
CALLAN DATA SYSTEMS multi user **INTEL** based **UNIX** system complete with software and 40 Mb winchester disk drive. **£2750**
WAYNE KERR RA200 Audio, real time frequency response analyzer **£3000**
TEKTRONIX 1411/R PAL TV test signal standard. **£6900**
TEKTRONIX R140 NTSC TV test signal standard. **£875**
HP 3271A Correlator system **£350**
PLESSEY portable Microwave speech / data link, 12v DC, 70 mile range. The pair **£275.00**
19" Rack cabinets 100's in stock **from £15.00**

DISPLAY -ELECTRONICS-

All prices for UK Mainland. UK Customers must **ADD 15% VAT to total order value. Minimum order, cash £5, Credit Card £10.** Official account orders from Government Depts, Universities, Schools & Local Authorities welcome – **minimum account order value £25.** Carriage charges **(A)** £1.50, **(B)** £3.50, **(C)** £6.50, **(D)** £8.50, **(E)** £10.00, **(F)** £15, **(G)** Call. All goods are supplied subject to our standard conditions of sale. All guarantees given on a return to base basis. We reserve the right to change prices & specifications without prior notice. Bulk trade & export enquines most welcome.

MAIL ORDER & OFFICES
Open Mon-Fri 9.30-5.30
32 Biggin Way,
Upper Norwood,
London SE19 3XF

LONDON SHOP
1000's of Bargains for callers
Open Mon-Sat 9-5.30
215 Whitehorse Lane,
South Norwood, London SE25

DISTEL © The ORIGINAL
FREE of charge dial up data base
1000's of items + Info **ON LINE NOW!!**
300 baud 01 679 1888, 1200/75 01 679 6183. 1200 FDX 01 679 8769

ALL ENQUIRIES
01 679 4414
FAX 01 679 1927
TELEX 894502

VISA

Prize Drill

Daniel Dalton, from Hook, near Basingstoke in Hampshire, is one of the five winners in the 14-16 year old age group of the 1988 Schools Design Prize competition, organised by the Design Council and sponsored by British Aerospace plc. Daniel was a pupil at Robert May's School, Odiham, when he designed a computer-controlled precision drilling machine for his school.

Daniel has won a prize of £200 and a certificate, and also £200 for his school. The winners were presented with their prizes by John Butcher MP Under-Secretary of State for Education and Science in a recent ceremony at the Design Centre, London.

Current school workshop technology makes drilling large numbers of printed circuit boards very time-consuming. Daniel decided to design a more efficient machine as part of two of his GCSE courses, CDT Design and Realisation, and CDT Technology, and felt he could achieve this using computer technology.

The drill runs on a BBC Master Computer, with a program written in Basic. Machine code is used where Basic is too slow. Daniel used 12 volt dc motors to power the machine; to avoid a gradual build up of error, the terminals of the motors are earthed when switched off. This enables the machine to be accurate to 1/100 of an inch. The computer provides visual confirmation of the status of the machine to the user. There is no comparable machine available presently at a price schools can easily afford.

For further information contact: Mr A Dee, CDT Department, Robert May's School, West Street, Odiham, Nr Basingstoke, Hants, RG25 1NA. Tel: 025 671 2700.

POINTS ARISING

PANNING MIXER (Dec 88)
Fig.4 page 14, C15 should have its positive end on the +15V line – the pcb is correct. Fig.6 page 15, the second IC3 should be marked as IC5.
DUAL BEAM SCOPE (Dec 88)
Fig.20 page 27, C15 should be across the + 5V lines – the pcb is correct. Page 29, C91 in the parts list should read as C9.

CHIP COUNT!

This month we highlight some recently received information on transputers:

NEW TDS

INMOS has announced that it has commenced shipments of a new version of its Transputer Development System (TDS), the IMS D700D. The TDS is a fully integrated development tool for the production of systems written in Occam. The major new feature of this improved TDS is the Symbolic Network Debugger which will provide the developer with essential network error detection facilities. This enhanced development system is one of the first components of INMOS' strategy to provide transputer users with a wide choice of software development options supporting single users or teams working in a variety of languages.

The IMS D700D provides a fully integrated development system including the INMOS folding editor. This editor allows text to be organised and displayed efficiently in a hierarchial manner which reflects the structure of the application under development. The IMS D700D can be run on transputer add-in boards for the IBM PC XT or AT or the NEC PC-9081, which allows users to design, edit, compile and debug occam applications to run on transputer networks of any size.

TRANSPUTING NUCLEAR PSU

CGEE-Alsthom, a member of the CGE group of France, has developed an industrial control system based on transputers.

The first system, Controbloc P20, is currently being tested prior to installation in a French nuclear power station by July 1989. The company expects to install similar transputer based systems at two other industrial sites in the near future.

According to CGEE-Alsthom, the transputer family has been chosen for its raw processing power and intrinsic communication advantages that allow transputers to be directly linked together to form a powerful parallel processing network.

CHEAPER TRANSPUTERS

A further reduction in Transputer family prices has been announced. These movements, like previous reductions, reflect the progressive decline in unit production costs as volume shipments to customers increase. They will also assist INMOS' strategy of increasing penetration of the volume markets of embedded control, PC sub-systems, workstations and communications markets.

In the 32-bit range for example, the IMS T800 20MHz Transputer has had the price reduced by 30%, giving a 1000-off price of £227, and the IMS T414 20 MHz integer processor is now priced at £126 for 1000-off quantities.

The IMS T222 enhanced version of the T212 16-bit Transputer with 4Kbytes of on-chip sram and faster serial links is now in full production in 17 and 20 MHz versions. The 17 MHz version sells for £48 in 1000-off quantities.

INMOS

Founded in 1978, INMOS supplies advanced semiconductor products for performance driven applications in the US, Japan and Europe. In addition to the transputer product family, INMOS manufactures and markets a range of high performance static rams, colour graphics devices (including the industry-standard device used in the IBM PS/2) and digital signal processors.

Contact: INMOS International, 1000 Aztec West, Almondsbury, Bristol, BS12 4SQ. Tel: 0454 616616.

Active Passive Security

Riscomp have an exciting addition to their range of security products. Known as the CPU 9000 the unit contains all the necessary components of an alarm system in a single compact steel case, which will monitor an area of 500 square feet or more.

Protection of a chosen area is achieved merely by sitting the unit in a convenient position and switching on. In the event of an intrusion within the protected area a penetrating 103dB built-in siren will sound. The unit uses the latest in detection technology incorporating a passive infra-red sensor.

The system operates either from 240V ac or 12V dc with provision for the use of a re-chargeable battery being included, together with the possibility of extending the coverage by the use of additional sensors.

The unit is supplied with two keys, comprehensive instructions, and is fully guaranteed for 12 months.
CONTACT; Riscomp Ltd, 51 Poppy Road, Princes Risborough, Bucks, HP17 9DB. Tel: 084 446326.

Phase-Locked Counting

An updated version of the Model 6002D 1.3 GHz frequency counter is now available from Global Specialities.

The inclusion of a unique phase-lock loop means that low frequencies up to 10kHz can be measured to an accuracy within 0.01Hz in a time of one second.

Two frequency modes are featured, and two inputs respectively accept signals from 5Hz to 100MHz, and 80MHz to 1.3GHz. A 10MHz oven crystal oscillator timebase ensures good temperature stability.

Designed and manufactured in the UK, the counter is enhanced by a completely re-styled front panel with increased use of graphics for simplicity of use. The 6002D is ideally suited for applications such as audio, communications, quality control and data processing.
CONTACT; Global Specialities, 2nd Floor, 2-10 St. Johns Street, Bedford, MK42 0DH.

FLAT AERIALS

BY BARRY FOX
Winner of the UK Technology Press Award

ALL MOD CONS, TO VIEW

Once again the satellite broadcasting industry is making promises which some signs say it can't keep

Like the first cuckoo of spring, the promise of a flat aerial for satellite television comes round with the seasons. The latest rash of publicity stems from the announcement, by British Satellite Broadcasting, that it had signed an exclusive deal with a company called Fortel, to sell a "Squarial". The squarial is a 25 centimetre plastic diamond-shaped flat plate aerial for receiving BSB signals when the service launches late in 1989.

BSB unveiled the Squarial at a press conference in London on August 2nd. BSB told the press that the "revolutionary" squarial was "smaller than a conventional dish, easier to install and cheaper" because "a new production process means that they (flat satellite antennae) are now simpler to manufacture, bringing the price down to a level below that for a conventional dish". The aerial, said BSB "had been verified by ERA Consultants who are amongst the foremost antenna experts".

Up against pressing deadlines, most of the journalists present had to run off and write or broadcast stories which enthused over the squarial. So they never had time to find out that what they had seen was in fact a dummy, non-working mock-up.

Wondering why Fortel were not at the press conference, I asked BSB to put me in touch with the company and squarial inventor John Collins. BSB refused. So I pursued ERA Consultants of Leatherhead, who were willing to talk after I reminded them that BSB had put ERA's name on the line as verifiers of the technology. It turned out that although ERA had tested similar types of flat aerial from Fortel, they had not tested the 25 centimetre plastic squarial.

At this point it is worth recapping on how flat aerials work. A conventional dish aerial uses a metal or metalised plastics parabola to focus incoming microwave radiation onto a feed horn and low noise block converter. This amplifies the signal, and down-converts it from dbs frequencies of around 12GHz to around 1GHz, so that the signal can be routed by conventional coaxial cable to a tv set.

Whereas a dish aerial is a single aerial, a flat aerial is a combination of many small aerials spread over a flat surface - the more the better. Outputs from all these mini aerials are summed together. Care must be taken to make the path lengths match so that the signals are all in phase and thus add rather than subtract. This is made difficult because the wavelength of the signal is only around 2.5cms.

Because it is impractical to build a frequency converter into each tiny aerial, the signals have to travel at 12GHz across the aerial surface to the summing point. At these frequencies, conventional insulators conduct electricity and lose signal. The military solves the problem by using laminated plastics which are less lossy but cost literally hundreds of pounds per square foot.

The BBC has for years been working on flat aerials, and recently decided to "end direct involvement" because of the high cost of materials needed to make them work anywhere near as efficiently as dish aerials of the same size.

Thanks to ERA, and no thanks to BSB, I finally spoke with inventor John Collins. He told me about his aerial and also why he had not been present at the BSB press conference. Quite simply he had not known that there was going to be one, even though he had been negotiating with BSB through the night and finally signed a deal at 5.30 am that morning.

The clear implication is that if the inventor had known about the mounting pressure of time on BSB, he would have been able to strike a better deal.

John Collins acknowledged that there was no working model yet of the squarial as unveiled by BSB. But he confidently promised demonstrations by Christmas.

The plate, explained Collins, is made from metalised plastics, moulded with resonant cavities. A conductive copper network connects probes in the cavities with a common lnb which Plessey will probably supply. The conductors are mainly suspended in air, to reduce signal loss.

"It is a mechanical achievement built round existing knowledge", says Collins. "There is nothing new. It's a mechanical approach. We haven't re-invented the wheel".

He is working with GE Plastics of Warrington, subsidiary of GE in the US, on suitable materials for moulding.

"I am confident that we can match the price of a 30cms pressed metal dish", says Collins.

Three weeks later, BSB finally found a tongue to talk. The aerial, they told me, will have 144 separate elements, each with a copper probe. All 144 elements are combined in a copper network which is suspended in air to reduce signal loss through the metalised plastics from which the body of the aerial will be moulded.

It all sounds fine in theory, but engineers are highly dubious about the practice.

"They are promising to sell something which hasn't yet been engineered for production", said one.

Using a suspended strip line will cut down on signal loss, but it raises the question of rigidity. Will the components stay precisely in their intended positions, both during transport and in a high wind on a roof?

And there is a world of difference between producing a few one-off prototypes, and mass producing at cost low enough to let BSB honour its promise of a full satellite receiver system, including tuner, D-MAC chips and de-encryption circuitry, for £250.

Engineers also question the directional characteristics. The smaller an aerial, the wider its beam of reception. Domestic dishes have a beam width of around one degree or two degrees, but a 25cm flat plate will probably pick up signals from around 6 degrees. This is why BSB promises that the squarial will be "far easier to manoeuvre and aim".

This may be good news now, when there are relatively few high power direct broadcasting satellites in orbit, but in the future when there are more satellites operating on the same frequencies within a few degrees of each other, a wide beam

Continued on page 47

PE SCIENCE AND TECHNOLOGY
VOLUME 25 NO. 2
FEBRUARY 1989
ISSN 0332 – 6372

Editor:
John Becker
Sub-Editor:
Helen Armstrong
Technical Illustrator:
Derek Gooding
Advertisement Sales:
Sarah Holtham
Business Manager:
Mary-Ann Hubers
Circulation:
David Hewett
Publisher:
Angelo Zgorelec
Editorial and Advertising Address:
Practical Electronics,
Intra House, 193 Uxbridge Road,
London W12 9RA
Tel: 01-743 8888
Telecom Gold: 87: SQQ567
Fax: 01-743 3062

Advertisements
All correspondence relating to advertisements, including classified ads, should be addressed to: **The advertisement department, Practical Electronics, at the above address and telephone number.**

Readers' Enquiries
All editorial correspondence should be addressed to the editor and any letters requiring a reply should be accompanied by a stamped addressed envelope, or equivalent payment.
We regret that lengthy technical enquiries cannot be answered over the phone.

Subscription Address:
Practical Electronics, Subscription Dept., P.O. Box 500, Leicester LE99 0AA.

Annual Subscription Rates:
U.K. £15.00 Overseas £18.00

Cover Illustration
Paul Doherty.

© Intra Press 1989. Copyright in all drawings, photographs and articles published in PRACTICAL ELECTRONICS is fully protected, and reproduction or imitations in whole or in part are expressly forbidden. All reasonable precautions are taken by PRACTICAL ELECTRONICS to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it, and we cannot accept legal responsibility for it. Prices quoted are those current as we go to press. All material is accepted for publication on the express understanding that the contributor has the authority to permit us to do so.

DRIVING TRANSMISSON

The Queen, in her speech at the opening of Parliament in November said, "A Bill will be brought forward .... to provide for new systems of route guidance for drivers".

These few words refer to proposed legislation that, if adopted, could have profound significance for vehicle drivers. The route guidance system will comprise a network of data transceiving beacons placed at strategic locations throughout Britain. In essence, they will transmit data to computerised receivers built in to vehicles and give information on the best routes to driver-selected destinations. The system, known as Autoguide, will be run by licensed operators who will be responsible for ensuring that the data is constantly updated to meet changing road and traffic conditions. It is expected that participating drivers will have to pay for access to the coded data, probably by means of a rental or license fee.

A trial scheme is already operating in West London, and it is expected that Autoguide will become commercially available by the early 1990s. Britain is already one of the leading nations in terms of traffic control automation and Autoguide should reinforce our position in this field. We hope to bring a fuller report on the scheme in next month's issue.

At the Munich Electronica 88 exhibition (reviewed on page 28) it was interesting to look for other information on how automation is becoming increasingly vital to the automobile market, both at manufacturing and consumer levels.

Globally, we are growing more aware of environmental considerations so that lower fuel consumption, lower exhaust pollution and improved safety have become significant factors. Electronic control systems are now widely used in road vehicles to achieve these ends. As yet Europe has not fully woken up to these considerations, but exhibitions like Electronica should convince more manufacturers that the technology exists to satisfy increasing public pressure for environmentally safe products - and that it can often be implemented at a reasonable cost.

One interesting fact quoted at the exhibition is that around $800 of the retail price of a large American car is accounted for by in-built electronics of various sorts. This value is expected to rise to $1100 by 1991. A further comparison reported that whereas an average American car may have $44 of chips in it, a Japanese car has $30 but a European car only has $17. Though these values are expected to double by 1992 it is possible that US cars may continue to have more electronics due to heavier American legal emphasis on exhaust emissions and fuel consumption, plus the fact that Americans love luxury features such as navigation computers and car phones. Nonetheless, the world car market as whole is expected to become more dependent on electronic control over the next decade, quadrupling its current value to $60 billion by the end of the century. By then most new cars will be expected to have digital dashboard instrumentation, projected data displays, computer controlled gear changing, intelligent suspension systems, anti-slip and anti-collision systems and numerous other electronic controls via wires or fibre optics.

It's an exciting road ahead.

THE EDITOR

Published on 1st Friday of each month by Intrapress, 193 Uxbridge Road, London W12 9RA. Typesetting, artwork and film by Gilfillan Ltd. Mitcham, Surrey and printed in England by McCorquodale Magazines Ltd. Andover, Hants. Distributed by Seymour Press 01-773 4444. 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, 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 lent, 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.

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Computer & Econet Referral Centre

AMB15 BBC MASTER £346 (a) — AMB12 BBC MASTER Econet £315 (a)
AMC06 Turbo (65C – 02) Expansion Module — £99 (b)

ADC08	512 Processor	£195 (b)	**ADJ24**	Advanced Ref Manual	£19.50 (c)
ADF14	Rom Cartridge	£13 (b)	**ADF10**	Econet Module	£41 (c)
ADJ22	Ref Manual Part 1	£14 (c)	**ADJ23**	Ref Manual Part II	£14 (c)
				BBC Master Dust Cover	£4.75 (d)

BBC MASTER COMPACT
A free packet of ten 3.5" DS discs with each Compact
SYSTEM 1 128K Single 640K Drive and bundled software £385 (a)
SYSTEM 2 System 1 with a 12" Hi Res RGB Monitor £469 (a)
SYSTEM 3 System 1 with a 14" Med Res RGB Monitor £599 (a)
Second Drive Kit £99 (c) Extension Cable for ext 5.25" drive £12.50 (d)

View 3.0 User Guide £10 (d) — Viewsheet User Guide £10 (d)
BBC Dust Cover £4.50 (d) — 1770 DFS Upgrade for Model B £43.50 (d)
ADFS ROM (for B with 1770 DFS & B Plus) £26 (d) — 1.2 OS ROM £15 (d)
ACORN Z80 2nd Processors £329 (a) — ACORN 6502 2nd Processor £173 (b)
MULTIFORM Z80 2nd Processor £289 (b) — ACORN IEEE Interface £269 (a)
TORCH Z80 2nd Processor ZEP 100 — £229 (a)
TZDP 240: ZEP 100 with Technomatic PD800P dual drive with built-in monitor stand — £439 (a)

META Version III – The only package available in the micro market that will assemble 27 different processors at the price offered. Supplied on two 16K roms and two discs and fully compatible with all BBC models. Please phone for comprehensive leaflet **£145 (b).**

We stock the full range of ACORN hardware and firmware and a very wide range of other peripherals for the BBC. For detailed specifications and pricing please send for our leaflet.

PRINTERS & PLOTTERS

EPSON
EPSON LX86 — £189 (a)
Optional Tractor Feed LX80/86 — £20 (c)
Sheet Feeder LX80/86 — £49 (c)
FX800 — £319 (a)
FX1000 — £449 (a)
EX800 — £409 (a)
LQ800 (80 col) — £439 (a)
LQ1000 — £589 (a)

TAXAN
KP815 (160 cps) — £249 (a)
KP915 (180 cps) — £369 (a)

JUKI
6100 (Daisy Wheel) — £259 (a)

NATIONAL PANASONIC
KX P1080 (80 col) — £149 (a)

STAR NL10 (Parallel Interface) — £209 (a)
STAR NL10 (Serial Interface) — £279 (a)
STAR Power Type — £229 (a)

BROTHER HR20 — £329 (a)

COLOUR PRINTERS

Dotprint Plus NLQ Rom for Epson versions for FX, RX, MX and GLP (BBC only) — £28 (d)

PLOTTERS
Hitachi 672 — £459 (a)
Graphics Workstation (A3 Plotter) — £599 (a)
Plotmate A4SM — £450 (a)

PRINTER ACCESSORIES

We hold a wide range of printer attachments (sheet feeders, tractor feeds etc) in stock. Serial, parallel, IEEE and other interfaces also available. Ribbons available for all above plotters. Pens with a variety of tips and colours also available. Please phone for details and prices.
Plain Fanfold Paper with extra fine perforation (Clean Edge):
2000 sheets 9.5" × 11" £13(b) 2000 sheets 14.5" × 11" £18.50(b)
Labels per 1000s: Single Row 3½" × 1 7/16" £5.25(d) Triple Row 2-7/16" × 1 7/16" £5.00(d)

MODEMS

All modems carry a full BT approval

MIRACLE TECHNOLOGY WS Range

WS4000 V21/23 (Hayes Compatible, Intelligent, Auto Dial/Auto Answer) — **£149 (b)**

WS3000 V21/23 Professional As WS4000 and with BELL standards and battery back up for memory — **£245 (b)**

WS3000 V22 Professional As WS300 V21/23 but with 1200 baud full duplex — **£450 (a)**

WS3000 V22 bis Professional As V22 and 2400 baud full duplex — **£595 (a)**

WS3022 V22 Professional As WS3000 but with only 1200/1200 — **£350 (a)**

WS3024 V22 Professional As WS3000 but with only 2400/2400 — **£450 (b)**

WS2000 V21/V23 Manual Modem — **£95 (b)**

DATA Cable for WS series/PC or XT — **£10 (d)**

DATATALK Comms Package
* If purchased with any of the above modems * — *£70 (c)

PACE Nightingale Modem V21/V23 Manual — **£75 (b)**

(Offer limited to current stocks)

RT256 3 PORT SWITCHOVER SERIAL INTERFACE
3 input/1 output or 1 input/3 output manual channel selection. Input/output baud rates, independently selectable 7 bit/8 bit, odd/even/none parity. Hardware or software handshake. 256K buffer, mains powered — £375 (b)

PB BUFFER
Internal buffer for most Epson printers. Easy to install. Inst. supplied.
PB128 128K — £99 (c)

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II — £195.00 (b)
Adaptor for 2764/2564 — £25.00

PLEASE TELEPHONE FOR CURRENT PRICES

DISC DRIVES

5.25" Single Drives 40/80 switchable:
TS400 400K/640K — £114 (b)
PS400 400K/640K with integral mains power supply — £129 (b)
5.25" Dual Drives 40/80 switchable:
TD800 800K/1280K — £199 (a)
PD800 800K/1280K with integral mains power supply — £229 (a)
PD800P 800K/1280K with integral mains power supply and monitor stand — £249 (a)
3.5" 80T DS Drives:
TS351 Single 400K/640K — £99 (b)
PS351 Single 400K/640K with integral mains power supply — £119 (b)
TD352 Dual 800K/1280K — £170 (b)
PD352 Dual 800K/1280K with integral mains power supply — £187 (b)
PD853 Combo Dual 5.25"/3.5" drive with p.s.u. — £229 (a)

3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee. Discs in packs of 10

5¼" Discs				3½" Discs	
40 T SS DD	£10.00 (d)	40 T DS DD	£12.00 (d)	80 T SS DD	£20.00 (d)
80 T SS DD	£14.50 (d)	80 T DS DD	£15.50 (d)	80 T DS DD	£25.00 (d)

FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. 5¼" **£12.50 (d)** 3½" **£14.00 (d)**

DRIVE ACCESSORIES

Single Disc Cable £6 (d) — Dual Disc Cable £8.50 (d)
10 Disc Library Case £1.80 (d) — 30 × 5½" Disc Storage Box £6 (c)
50 × 5½" Disc Lockable Box £9.00 (c) — 100 × 5½" Disc Lockable Box £13 (c)

MONITORS

RGB 14"
1431 Std Res — £179 (a)
1451 Med Res — £225 (a)
1441 Hi Res — £365 (a)

MICROVITEC 14" RGB/PAL/Audio
1431AP Std Res — £199 (a)
1451AP Std Res — £259 (a)
All above monitors available in plastic or metal case.

TAXAN SUPERVISION II
12" – Hi Res with amber/green options. IBM compatible — £279 (a)
Taxan Supervision III — £319 (a)

MITSUBISHI
XC1404 14" Med Res RGB, IBM & BBC compatible — £219 (a)

MONOCHROME
TAXAN 12" HI-RES
KX1201G green screen — £90 (a)
KX1203A amber screen — £95 (a)

PHILIPS 12" HI-RES
BM7502 green screen — £75 (a)
BM7522 amber screen — £79 (a)
8501 RGB Std Res — £139 (a)

ACCESSORIES
Microvitec Swivel Base — £20 (c)
Taxan Mono Swivel Base with clock — £22 (c)
Philips Swivel Base — £14 (c)
BBC RGB Cable — £5 (d)
Microvitec — £3.50 (d)
Taxan £5 (d). Monochrome £3.50 (d)
Touchtec – 501 — £239 (b)

UVERASERS

UV1T Eraser with built-in timer and mains indicator. Built-in safety interlock to avoid accidental exposure to the harmful UV rays. It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. £59 + £2 p&p.
UV1 as above but without the timer £47 + £2 p&p.
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms. UV141 has a built in timer. Both offer full built in safety features UV140 £69, UV141 £85, p&p £2.50.

EXT SERIAL/PARALLEL CONVERTERS

Mains powered converters
Serial to Parallel — £48 (c)
Parallel to Serial — £48 (c)
Bidirectional Converter — £105 (b)

Serial Test Cable

Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end — making it possible to produce almost any cable configuration on site.
Available as M/M or M/F — £24.75 (d)

Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without rewiring the cable assay. Jumpers can be used and reused. — £22 (d)

Serial Mini Test

Monitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines. Connects in Line. — £22.50 (d)

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	—
St Hood	90	95	100	120
Screw Lock	130	150	175	—

TEXTOOL ZIF

SOCKETS — 24-pin £7.50
28-pin £9.10 — 40 pin £12:10

EDGE CONNECTORS

	0.1	0.156
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12 way (vic 20)	—	350p
2 × 18 way	—	140p
2 × 23 way (ZX81)	175p	220p
2 × 25 way	225p	220p
2 × 28 way (Spectrum)	200p	—
2 × 36 way	250p	—
1 × 43 way	260p	—
2 × 22 way	190p	—
2 × 43-way	395p	—
1 × 77 way	400p	500p
2 × 50 way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612	Plug	Skt
2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B	400p	
IDC Skt A + C	400p	

For 2 × 32 way please specify spacing (A + B, A + C).

MISC CONNS

21 pin Scart Connector 200p
8 pin Video Connector 200p

AMPHENOL CONNECTORS

36 way plug Centronics (solder 500p (IDC) 475p
36 way skt Centronics (solder) 550p (IDC) 500p
24 way plug IEEE (solder) 475p (IDC) 475p
24 way skt IEEE (solder) 500p (IDC) 500p
PCB Mtg Skt Ang Pin
24 way 700p 36 way 750p

GENDER CHANGERS

25 way D type

Male to Male — £10
Male to Female — £10
Female to Female — £10

RS 232 JUMPERS

(25 way D)

24" Single end Male — £5.00
24" Single end Female — £5.25
24" Female Female — £10.00
24" Male Male — £9.50
24" Male Female — £9.50

DIL SWITCHES

4-way 90p 6-way 105p
8-way 120p 10-way 150p

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	—
20 pin	75p	—
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

ATTENTION

All prices in this double page advertisement are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows: (a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TECHNOLINE VIEWDATA SYSTEM. TEL: 01-450 9764

Using 'Prestel' type protocols. For information and orders — 24 hour service, 7 days a week

74 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	0.70
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.90
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.55
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.70
74154	1.40
74155	0.80
74156	0.90
74159	2.25
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	3.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.15
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
74221	1.10
74251	1.00
74259	1.50
74265	0.80
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74284	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES

74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.26
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS48	0.90
74LS49	1.00
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	0.80
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.55
74LS136	0.45
74LS138	0.55
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.40
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.65
74LS160A	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166A	1.50
74LS168	1.30
74LS169	1.00
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.70
74LS245	0.90
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS257A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	14.00
74LS293	0.80
74LS295	1.40
74LS297	14.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.70
74LS374	0.70
74LS375	0.75
74LS377	1.30
74LS378	0.95
74LS379	1.30
74LS381	4.50
74LS385	3.25
74LS390	0.60
74LS393	1.00
74LS395A	1.00
74LS399	1.40
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	25.00
74LS612	25.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.25
74LS640	2.00
74LS640-1	3.00
74LS641	1.50
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS645-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.70
74LS682	2.50
74LS683	3.00
74LS684	3.50
74LS687	3.50
74LS688	3.50
74LS783	16.00

74S SERIES

74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	0.50
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.60
74S40	0.50
74S51	0.60
74S64	0.45
74S74	0.70
74S85	5.50
74S86	1.00
74S112	0.90
74S113	1.20
74S114	1.20
74S124	3.00
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.00
74S158	2.00
74S163	3.00
74S169	5.50
74S174	3.00
74S175	3.20
74S188	1.80
74S189	1.80
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	3.00
74S241	4.00
74S244	4.00
74S251	3.00
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	4.50
74S373	4.00
74S374	4.00
74S387	2.25

Special offer to PE readers only – 10% off on all TTLS and CMOS

74ALS SERIES

74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.50
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

4000 SERIES

4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0.45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
4014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.80
4021	0.70
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.80
4055	0.80
4056	0.85
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.80
4095	0.95
4096	0.90
4097	2.70
4098	0.75
4099	0.99
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.90
4541	0.75
4543	0.70
4551	2.40
4553	2.40
4555	0.56
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.60
14490	4.20
14495	4.50
145000	6.50
14599	2.00
22100	3.50
22101	7.00
22102	7.00
40014	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.30
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	0.80
40110	2.25
40114	2.25
40107	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

LINEAR ICs

ADC0808	11.90
AM7910DC	12.00
AN103	2.00
AN1-5050	1.00
AY-3-1350	5.00
AY-3-8910	4.90
AY-3-8912	5.00
CA3019A	1.00
CA3020	3.50
CA3028A	1.10
CA3046	0.70
CA3059	3.25
CA3060	3.50
CA3080E	0.70
CA3085	1.50
CA3086	0.80
CA3089E	2.50
CA3090AQ	3.75
CA3130E	0.90
CA3130T	1.30
CA3140E	0.45
CA3140T	1.00
CA3146	2.25
CA3160E	1.50
CA3161E	2.00
CA3162E	6.00
CA3189E	2.70
CA3240E	1.50
CA3280G	3.00
D7002	6.00
DAC1408-8	3.00
DAC0800	3.00
DAC0808	3.00
DG308	3.00
HA1366	1.90
ICL7106	6.75
ICL7611	0.95
ICL8038	4.00
ICM7555	0.90
ICM7556	1.40
LC7120	3.00
LC7130	3.00
LC7131	3.50
LC7137	3.50
LF347	1.20
LF351	0.60
LF353	0.90
LF355	0.90
LF356N	1.10
LF357	1.00
LF398	4.00
LM10CLH	4.50
LM301A	0.30
LM307	0.45
LM308CN	0.75
LM310	2.25
LM311	0.60
LM318	1.50
LM319	1.80
LM324	0.45
LM334Z	1.15
LM335Z	1.30
LM336	1.60
LM339	0.40
LM348	0.80
LM358P	0.50
LM377	3.00
LM380N-8	1.50
LM380N	1.50
LM383	3.25
LM384	2.20
LM386N-1	1.00
LM387	2.70
LM391	1.80
LM392N	1.10
LM393	0.85
LM394CH	4.00
LM709	0.35
LM710	0.48
LM711	1.00
LM723	0.60
LM725CN	3.00
LM733	0.65
LM741	0.22
LM747	0.70
LM748	0.30
LM1011	4.00
LM1014	1.50
LM1801	3.00
LM1830	2.50
LM1871	3.00
LM1872	3.00
LM1886	6.00
LM1889	4.50
LM2917	3.00
LM3302	0.90
LM3900	0.60
LM3909	1.40
LM3911	1.80
LM3914	3.50
LM3915	3.40
LM3916	3.40
LM13600	1.50
M51513L	2.30
M51516L	4.50
MB3712	2.00
MC1310P	1.50
1413	0.75
MC1458	0.45
MC1495	3.00
MC1496	0.70
MC3340P	2.00
MC3401	0.70
MC3404	0.65
MF10CN	4.10
MK50240	9.00
ML902	5.00
ML922	4.00
MM6221A	3.00
NE529	2.20
NE531	1.20
NE544	1.90
NE555	0.22
NE556	0.60
NE564	4.00
NE565	1.20
NE566	1.50
NE567	1.25
NE570	4.00
NE571	3.00
NE592	0.90
NE5532P	1.50
NE5533P	1.60
NE5534P	1.20
NE5534AP	1.50
OP-07EP	3.50
PLL02A	5.00
RC4136	0.55
RC4151	2.00
RC4195	1.50
RC4558	0.55
S50240	9.00
SN76013N	5.00
SN76033N	5.00
SPO256AL2	7.00
SP8515	7.50
TA7120	1.20
TA7130	1.40
TA7204	1.50
TA7205	0.90
TA7222	1.50
TA7310	1.50
TBA231	1.20
TBA800	0.80
TBA810	0.90
TBA20	0.80
TBA820M	0.75
TBA920	2.00
TBA950	2.25
TC9109	5.00
TCA270	3.50
TCA940	1.75
TDA1010	2.25
TDA1024	1.10
TDA1170S	3.00
TDA1170N	3.00
TDA2002	3.25
TDA2003	1.90
TDA2004	2.40
TDA2006	3.20
TDA2030	2.50
TDA2593	5.00
TDA2653	7.00
TDA3560	7.50
TDA3810	7.50
TDA7000	3.50
TEA1002	7.00
TL061CP	0.40
TL062	0.80
TL064	0.90
TL071	0.40
TL072	0.70
TL074	1.10
TL081	0.35
TL082	0.55
TL083	0.75
TL084	1.00
TL094	2.00
TL430C	1.20
UA759	3.20
UA2240	1.20
UCN5801A	6.00
ULN2001A	0.75
ULN2002A	0.75
ULN2003A	0.75
ULN2004A	0.75
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
UPC575	2.75
UPC592H	2.00
UPC1156H	3.00
UPC1185H	5.00
XR210	4.00
XR2206	4.50
XR2207	3.75
XR2211	5.75
XR2216	6.75
XR2240	1.20
ZN404	1.00
ZN414	0.80
ZN419P	1.75
ZN423E	1.30
ZN424E	1.30
ZN425E8	3.50
ZN426E8	3.00
ZN427E8	6.00
ZN428E8	4.50
ZN429E8	2.25
ZN447E	9.00
ZN448I	7.50
ZN449E	3.00
ZN450E	7.50
ZN459CP	3.00
ZN1034E	2.00
ZNA1040	6.60
ZNA134H	23.00
ZNA234E	8.50

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TP220

+ VE		– VE	
5V 7805	0.45	7905	0.50
6V 7806	0.50	7906	0.50
6V 7808	0.50	7908	0.50
12V 7812	0.45	7912	0.50
15V 7815	0.50	7915	0.50
18V 7818	0.50	7918	0.50
24V 7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V 78L05	0.30	5V 79L05	0.45
6V 78L06	0.30	12V 79L12	0.50
8V 78L08	0.30	15V 79L15	0.50
12V 78L12	0.30		
15V 78L15	0.30		

OTHER REGULATORS

FIXED REGULATORS

LM309K	1A 5V	1.40
LM323K	3A 5V	3.50
L78H05KC	5A 5V	7.50

VARIABLE REGULATORS

LM305AH		2.50
LM317T	TO-220	1.20
LM317K	TD3	2.40
LM337T		2.25
LM350T		4.00
LM723N		0.50

SWITCHING REGULATORS

ICL7660	2.50
SG3524	3.00
TL494	3.00
TL497	2.25
78S40	2.50
RC4195	1.50

COMPUTER COMPONENTS

CPUs

1802CE	6.50
2650A	10.50
6502	4.50
65C02-2MHz	12.00
6502A	6.50
6502B	8.00
6800	3.50
6802	3.50
6809	6.50
6809E	10.00
68B09	10.00
68B09E	12.00
68000-LB	36.00
8035	3.50
80C35	6.00
8039	4.20
80C39	7.00
8080A	9.50
8085A	3.00
80C85A	7.50
8086	22.00
8087-5	£120
8087-8	£160
8088	17.50
8741	15.00
8748	10.00
TMS1601	12.00
TMS9980	14.50
TMS9995	18.00
V20-8	12.00
V30-8	12.00
Z80	2.50
Z80A	2.90
Z80B	5.50
Z80H	7.50
TMS4500	14.00
TMS9901	5.00
TMS9902	5.00
TMS9914	14.00
Z80PIO	2.50
Z80APIO	2.75
Z80CTC	2.50
Z80ACTC	2.75
Z80DART	6.50
Z80ADART	7.00
Z80DMA	7.00
Z80ADMA	7.50
Z80ASIO-0/2/9	7.00
Z80BPIO	5.00
Z80BPID	5.00
Z80BCTC	5.00
Z80BDART	9.00

SUPPORT DEVICES

2651	12.00
3242	8.00
3245	4.50
6520	3.00
6522	3.50
6522A	5.50
6532	4.80
6551A	6.00
6821	1.60
68B21	2.50
68040	3.75
68B40	6.00
6850	1.80
68B50	2.50
6852	2.50
6854	6.50
68B54	8.00
8154	8.50
8155	3.80
8156	3.80
8205	2.25
8212	2.00
8216	1.60
8224	POA
8226	4.25
8228	5.50
8237	8.50
8243	2.60
8250	12.00
8251A	3.25
8253C-5	3.50
8255AC-5	3.20
8256	18.00
8257C-5	54.00
8259C-5	4.00
8275	29.00
8279C-5	4.80
8282	4.00
8284	4.60
8287	3.80
8288D	6.50
8755A	16.00

MEMORIES

2114-3	1.00
4116-2	1.50
4164-15	2.50
41256-15	7.00
41464-15	8.50
4416-15	3.00
5101-3	5.00
6116LP-1S	6.50
62256	12.00
6810	2.50

PROMS

28L22	4.00
74S188	1.80
74S287	2.25
74S288	1.80
74S387	2.25
82S23	1.50
82S123	1.50
82S129	1.75

IBM AMSTRAD UPGRADES

8087-5	£75
8087-8	£120
8087-10	£175
80287-5	£160
80287-8	£190
8087-10	£225

EPROMs

2716-45	4.50
2732-45	4.50
2764-25	4.00
27C64	4.50
27128-25	4.80
27C256	5.50
27512	9.00
27513	18.00
27C128	5.50
27256	5.50

RS232

MAX232	7.50

CRT CONTROLLER

CRT5037	12.00
CRT6545	9.00
EF9365	32.00
EF9366	32.00
EF9367	36.00
EF9369	12.00
MC6845	6.50
MC6845SP	6.50
MC6847	6.50
SFF96364	8.00

INTERFACE ICs

ADC0808	10.00
AD561J	20.00
AM25S10	3.50
AM25LS2521	3.50
AM25LS2538	3.50
AM26LS31	1.20
AM26LS32	1.20
AM7910DC	25.00
DM8131	6.00
DP8304	4.50
DS3691	4.50
DS8830	1.40
DS8831	1.50
DS8832	1.50
DS8833	2.25
DS8836	1.50
DS8838	2.25
D7002	6.00
MC1488	0.60
MC1489	0.60
MC3446	2.50
MC3459	4.50
MCS3470	4.75
MC3480	8.50
MC3486	2.25
MC3487	2.25
MC4024	5.50
MC4044	5.50
MC6883	16.00
MC14411	7.50
MC14412	7.50
75107	0.90
75108	0.90
75109	1.20
75110	0.90
75112	1.60
75113	1.20
75114	1.40
75115	1.40
75121	1.40
75122	1.40
75150P	1.20
75154	1.20
75159	2.20
75160	5.00
75161	8.50
75162	7.50
75172	4.00
75182	0.90
75188	0.60
75189	0.60
75365	1.50
75450	0.80
75451	0.50
75452	0.50
75453	0.70
75454	0.70
75480	1.50
75491	0.65
75492	0.65
8T26	1.20
8T28	1.20
8T95	1.20
8T96	1.20
8T97	1.20
8T98	1.20
81LS95	1.40
81LS96	1.40
81LS97	1.40
81LS98	1.40
88LS120	6.50
9602	3.00
9636A	1.80
9637AP	1.80
E	9.50
9638	1.80
9639	2.50

DISC CONTROLLER ICs

765A	10.00
6843	8.00
8272	10.00
FD1771	20.00
FD1791	20.00
FD1793	20.00
FD1797	22.00
WD1770	24.00
WD1691	15.00
WD2143	12.00
WD2793	27.00
WD2797	27.00

CHARACTER GENERATORS

RO32513UC	7.50
RO32513LC	7.00

TELETEXT DECODER

SAA5020	6.00
SAA5030	7.00
SAA5041	16.00
SAA5050	9.00

KEYBOARD DECODERS

74C922	5.00
74C923	5.00

BAUD RATE GENERATORS

MC14411	7.50
COM8116	8.50
4702B	7.50

UARTs

AY3 1015	3.00
AY51013P	3.00
COM8017	3.00
IM6402	4.50

MODULATORS

6MHz	3.75
8MHz	4.50

SOUND & VISION

12MHz	12.00

CRYSTALS

32.768KHz	1.00
1.6432MHz	2.25
2.00MHz	2.25
2.45760MHz(L)	2.00
2.45760MHz(S)	2.50
2.5MHz	2.50
3.276MHz	1.50
3.5795MHz	1.00
4.00MHz	1.50
4.194MHz	2.00
4.43MHz	1.00
4.9152MHz	2.50
5.00MHz	1.50
5.068MHz	1.75
6.00MHz	1.40
6.144MHz	1.40
7.00MHz	1.50
7.16MHz	1.75
8.00MHz	1.50
8.876MHz	1.75
10.0CMHz	1.75
10.50MHz	2.50
10.70MHz	1.50
11.00MHz	3.00
12.00MHz	1.50
14.00NHz	1.75
14.31MHz	1.80
14.756MHz	2.50
15.00MHz	2.00
16.00MHz	2.00
17.734MHz	1.50
18.00MHz	1.50
18.432MHz	1.50
19.969MHz	1.50
20.000MHz	1.50
24.000MHz	1.75
48.000MHz	1.75
116MHz	2.50
PXO1000	12.00

Please note:
All prices are subject to change without notice.
Only current prime grade components stocked.
We also stock a wide range of: Transistors, Diodes, Triacs Plastic, Bridge Rectifiers, Thyristors and Zenors.
Please phone for details.

OTHERS

BPX25	3.00
BPW21	3.00
ORP12	1.20
ORP60	1.20
ORP61	1.20
SFH205	1.00
TIL31B	1.20
TIL81	1.20

DISPLAYS

FND357	1.00
FND500/TIL370	1.00
FND507/TIL729	1.00
MAN71 DL707	1.00
MAN3640	1.75
MAN4640	2.00
MAN6610	2.00
NSB5881	5.70
TIL311	6.50
TIL728	1.00
TIL7300	1.00
MAN8910	1.50
MAN8940	2.50

LEDs

0.125"

RED TIL2090	0.12
GRN TIL211	0.16
YEL TIL212	0.20
Rect LEDs (R.G.Y)	0.30
CXO (Bi colour)	1.00
10 LED Bar Graph Red	2.25
Green	2.25

0.2"

TIL220	0.15
TIL222	0.18
TIL226	0.22

DISPLAY DRIVERS

9368	4.50
9370	4.50
9374	3.50

COUNTERS

74C925	6.50
74C926	9.50
74928	6.50
ZN1040	6.70
LM3914	3.50
LM3915	3.50
LM3916	3.50
UDN6118	3.20
UDN6184	3.20
ULN2003	0.90
ULN2004	0.90
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
75491	0.70
75492	0.70

OPTO-ELECTRONICS

BPX25	3.00
BPX34	3.00
BPW21	3.00
CQY21	3.00
FND357	1.00
MAN74 DL704	1.00
MAN71 DL707	1.00
MAN4640	2.00
MAN6610	2.00
MAN8910 0.8"	1.20
NSB5881	5.70
ORP12	1.20
SFH305	1.00
TIL31A	1.20
TIL32	1.20
TIL78	1.20
TIL81	1.20
TIL100	1.20
TIL311	6.50

OPTO ISOLATORS

ILD74	1.30
MCT26	1.00
MCS2400	1.90
MOC3020	1.50
ILQ74	2.20
TIL111	0.70
TIL112	0.70
TIL113	0.70
TIL116	0.70
6N137	3.00
6N139	1.75

LOW PROFILE SOCKETS BY TI

8pin	9p	18pin	16p	24pin	24p
14pin	10p	20pin	18p	28pin	26p
16pin	11p	22pin	20p	40pin	30p

WIRE WRAP SOCKETS BY TI

8pin	25p	18pin	50p	24pin	70p
14pin	35p	20pin	60p	28pin	80p
16pin	40p	22pin	65p	40pin	100p

TURNED PIN LOW PROFILE SKTS

18pin	25p	16pin	35p	20pin	450p	28pin	65p
14pin	30p	18pin	40p	24pin	55p	40pin	90p

TECHNOMATIC LTD

MAIL ORDERS TO: 17 BURNLEY ROAD, LONDON NW10 1ED
SHOPS AT: 17 BURNLEY ROAD, LONDON NW10
(Tel: 01 208 1177) Telex: 922800 Tel: 01-723 0233
305 EDGWARE ROAD, LONDON W2

PLEASE ADD 50p p&p & 15% VAT
(Export: no VAT, p&p at Cost)
Orders from Government Depts. & Colleges etc. welcome.
Detailed Price List on request.
Stock items are normally by return of post.

SIDEREAL CLOCK

BY JOHN BECKER

TEMPUS NEED NOT FUGIT WITH A MEAN SUN

The stars and planets go wandering across the celestial night. Do you know when to find them and keep them in your sight? With this sidereal clock on space-watch you'll time their orbits right!

Lately, in the letters pages of PE there has been correspondence about the role of electronics in astronomy. There have also been two main feature articles by professional astronomers who described the roles played by charge coupled devices (Aug. 88), and infra-red detecting arrays (Sep. 88).

The expense of the devices discussed in those two articles is too great for amateur astronomers to consider constructing their own electronic star image enhancers, but there are a few other areas in which the amateur can readily and cheaply assemble electronic aids. One such is a sidereal clock.

SIDEREAL TIME

For the benefit of those who have only a limited knowledge of astronomy, let us first look at what a sidereal clock is, and why it is needed.

Greenwich Mean Time (or GMT), and therefore the local civil time at any place is governed by the motion of the Sun. Roughly speaking, one solar day is the time between two successive passages of the Sun across the north-south line (the meridian) from any place; this usually occurs at around local noon. In fact the real Sun is not a very good timekeeper, because the Earth is tilted on its axis, and its path around the Sun is not perfectly circular. So, there is usually a difference between 'Sun' time and Greenwich Mean Time. For convenience, the real Sun is replaced by a fictitious mean Sun, which travels around the sky at a uniform rate, adjusted so that the real Sun and the mean Sun take exactly the same time to complete one circuit. Normal clocks show mean solar time.

Astronomers are generally not interested in the motion of the Sun, but in the other, more distant, stars visible in the night sky. They need to use a clock whose rate is such that any star will have returned to exactly the same position in the sky after exactly 24 hours have passed according to this clock. Such a clock is known as a sidereal clock, and its time, which is controlled by the apparent motion of the stars, is called sidereal time. Mean solar time is not the same as sidereal time, because during each solar day the Earth moves nearly 1/360 (about one degree) of its orbit around the Sun. So, the Sun progressively moves

against the background stars as seen from the Earth; or vice versa, the stars appear to move with respect to the Sun. The sidereal day, consisting of 24 sidereal hours is the time taken for the Earth to spin once on its axis relative to the stars.

There are 365.2564 mean solar days in a sidereal year, the time taken for the Sun to return to the same place in the sky against the distant stars. It is this odd 0.2564 days that necessitates adding an extra day to the calendar every four years to 'take up the slack' so it speak. A further day is added when the century year is divisible by 400 (eg 2000 AD) to additionally correct for the minor decimal places. During a sidereal year, the Earth spins about $366\frac{1}{4}$ times around its own axis. This means that each sidereal day is slightly shorter than a mean solar day – 24 hours of sidereal time correspond to only 23h 56m 4.091 of mean solar time. So, an astronomer's sidereal clock must gain 3m 55.909s per day (a gain of almost 10 seconds per hour) amounting to one day per year, on clocks keeping mean solar time. GMT and Greenwich Sidereal Time (or GST) agree at one instant every year, at the autumnal equinox on about September 21st or 22nd. Thereafter, sidereal time runs faster than mean solar time, and at the spring equinox, the difference between them is 12 hours.

If you go outside on a clear, dark night you will see that the stars (and the planets which wander among them) appear to be fixed to the inside of a huge hollow sphere with you at its centre. Astronomers call this the celestial sphere. As the Earth spins on its axis. so the celestial sphere will appear to move, with stars rising in the east and setting in the west. The position of every star on the celestial sphere is fixed by a system of co-ordinates just like the latitude and longitude we use on the Earth. Celestial latitude is called declination (how far a star is north or south of the celestial equator), and celestial longitude is called right ascension. The equivalent of the Greenwich meridian on the celestial sphere is called the First Point of Aries. The Local Sidereal Time (or LST) at any place is the hour of right ascension which lies on the meridian at that time. So, if your know your local sidereal time, you can tell exactly which stars will be visible in the sky, without even venturing outside your front door!

SIDEREAL TIME FORMULA

Constants: A = 0.065709
C = 1.002743

The factor B varies from year to year, as follows:

1989	B = 17.357573
1990	B = 17.373487
1991	B = 17.389402
1992	B = 17.405316

To find the Greenwich Sidereal Time (GST) for any particular Greenwich Mean Time (GMT):

$$GST = (GMT \times C) + (D \times A) - B$$

where D is number of full days passed during the year for the date required, and GMT is given in hours with fractions expressed as a decimal. If GST is greater than 24, then subtract 24. If GST is less than zero, then add 24.

To find your Local Sidereal Time (LST), for any particular Greenwich Sidereal Time (GST), first correct longitude difference in degrees to a difference in time, evaluating L = longitude difference in degrees divided by 15.

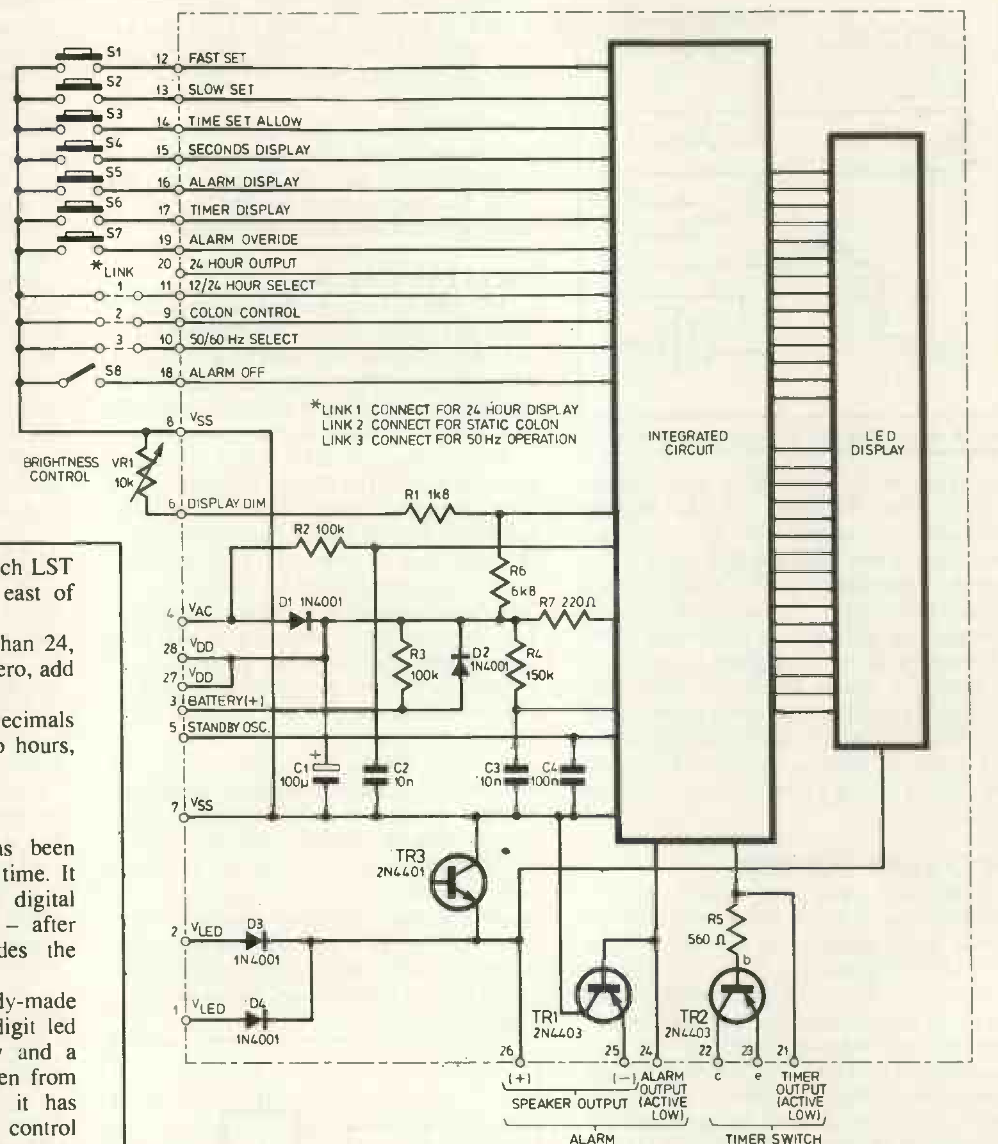


Fig.1. *Basic clock module circuit.*

For a longitude, west of Greenwich LST = GST - L, and for a longitude east of Greenwich, LST = GST + L.

Then if derived LST is greater than 24, subtract 24, or if LST is less than zero, add 24.

The value of LST in hours and decimals of hours may then be converted to hours, minutes and seconds.

FACING THE CLOCK

The clock I describe here has been designed to keep track or sidereal time. It may also be used as an ordinary digital clock, though not simultaneously – after switching between the two modes the appropriate time needs to be reset.

The basic clock consists of a ready-made digital clock module with a four-digit led readout. It needs a power supply and a 50Hz input clocking signal. As seen from its operational diagram in Fig.1, it has several control inputs and two control outputs. The latter enable it to be used as an alarm, as a timer and as the trigger source for an external timer or control circuit.

There are eight switches associated with the clock module itself, S1-S8. and their use will be described later.

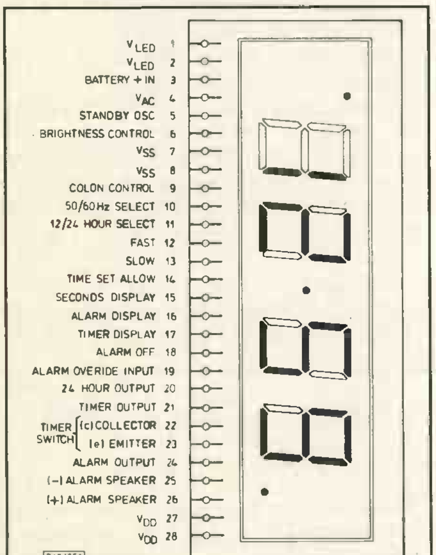


Fig.2. *Clock module pinouts*

VR1 is used to control the brilliance of the led display, a factor which also governs the total current required by the module. Fig.2 shows the module pinouts.

CONVENTIONAL CLOCK

In its simplest form the module can be used as an ordinary clock powered and supplied with its 50Hz signal direct from the mains supply via a suitable transformer. Fig.3 and Fig.4 show the connections.

The 7.75Vac winding is the source of the 50Hz signal and of the current for driving the module. Referring back to Fig.1, D1 rectifies the ac voltage which is then smoothed by C1. This dc voltage can be tapped at module pins 27 and 28 and used for powering other circuits. The 7.75Vac also goes through R2 and becomes the timing waveform required by the clock. C2 mops up any transients that might appear on the mains power line and undesirably be counted by the clock circuit.

The design of the module allows for the mains frequency to run at either 50Hz or 60Hz. This mode is determined by the status of pin 10. For 50Hz mode, as experienced by the majority of PE readers, particularly those in Britain, pin 10 is linked to the 0V line. For 60Hz mode, the pin is left unconnected.

The two 3.5Vac transformer secondaries supply the power needed to drive the led display. The voltage is push-pull rectified by D3 and D4, but does not require smoothing.

STANDBY MODE

The module has also been designed with a built-in oscillator which only comes into

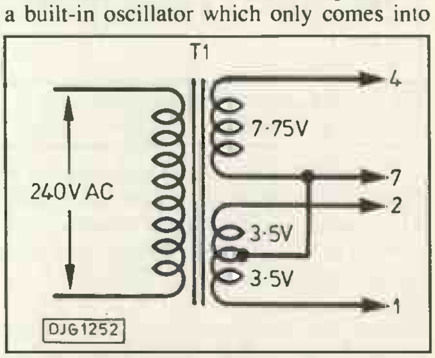


Fig.3. *Optional mains supply and control if using clock module as ordinary "Real" time clock.*

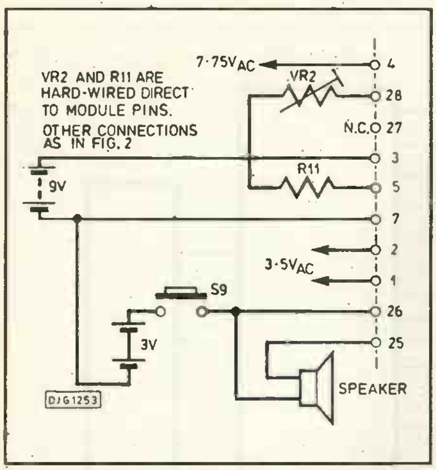


Fig.4. *Wiring for normal mains operation*

operation in the event of a mains power failure. The frequency of the standby oscillator is determined by the total resistance across VR2 and R11 in Fig.4. For standby operation, a 9V battery linked across pins 3 and 7 provides the control voltage, and a 3V battery across pins 7 and 26 supplies the led display voltage via S9.

During a power failure the clock will roughly keep the correct time according to the frequency of the standby oscillator, but the display will not be illuminated. To view the display during a power failure, S9 has to be pressed.

SPEAKER'S CORNER

Note that with the alarm speaker connected as in Fig.4, the speaker will not sound if the mains is off and can only be heard if S9 is pressed.

For those who, like the author, cannot wake on time without an alarm this wiring method as suggested by the module manufacturers is probably unacceptable. An alternative method is shown in Fig.5. Two extra diodes are needed, D5 from the 3V battery, and D6 from the junction of D3 and D4. Both can supply current to the speaker. When mains is present the higher voltage from D3 and D4 through D6 will inhibit the supply from the 3V battery through D5. Without a mains supply, the speaker will be powered from the battery via D5.

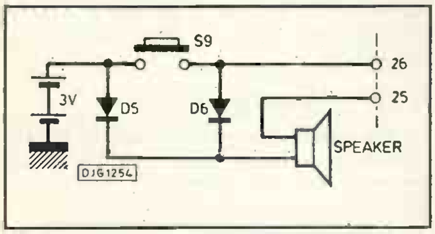


Fig.5. *Alternative wiring for alarm to sound in both mains on and off conditions.*

The signal that drives the speaker is an 800Hz pulse-waveform modulated at 2Hz. This signal can be tapped directly from module pin 24, but note that the voltage at this pin will be high when the alarm is not triggered. The speaker may be any between 8 ohms and 16 ohms, or alternatively be replaced by a high impedance audible warning device (awd), so minimising current consumption.

TIME OUT

The timer output from the module's control is available directly at pin 21, or via the interface transistor TR2. This is a pnp transistor with its collector (pin 22) and emitter (pin 23) unconnected. The connections are left to the user, depending on the application. The output at pin 21 is normally high, but will go low once the timer has been started. At the end of the timed period it will revert high again.

CRYSTAL GAZING

The unit so far described is complete in itself and can be used as an ordinary clock for any purpose to which a clock is normally put. The object of this article, though, is to describe a sidereal clock, one that runs faster than is normally acceptable.

Two methods of achieving a fast clock come to mind. The first is to make use of the module's own internal standby oscillator. Fine in theory, bad in practice – the oscillator is unstable. The manufacturer's data sheet quotes a stability of only 20%, and no doubt it is subject to temperature and voltage changes which will help make up this wide tolerance, or should I say intolerance? To be of any practical use, a clock's time keeping should be better than 20%!

A more stable oscillator has to be substituted. Crystal controlled oscillators are the obvious choice and the M706B1 divider chip is designed for use with a 3.2768MHz crystal to produce a precise 50Hz output signal. By substituting the output of this oscillator for the mains frequency we can use the module as an accurate conventional clock in which the power comes, not from the mains, but from a battery.

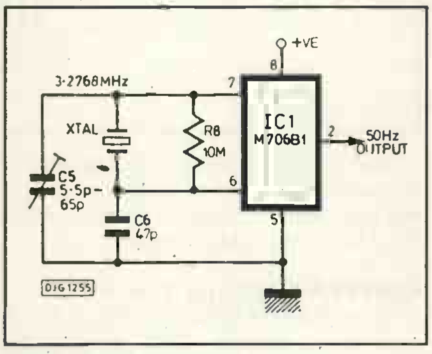


Fig.6. *50Hz timer circuit*

In Fig.6 the oscillator consists of IC1, the crystal, C5 and C6. The frequency at which the crystal oscillates is very precisely set in manufacture, but even so it has a quoted tolerance, or variation, of 12.5 parts per million across a temperature range of -20° and +70°C. In other words in a million seconds (about 11.5 days), the displayed time might vary by about 12.5 seconds.

Although a crystal wants to oscillate at its own predetermined frequency, it is possible to slightly vary its rate by changing the capacitance across it. I have been unable to establish from data sheets the variation that can be imposed on a crystal's frequency in this way. It is also too fractional to read on an oscilloscope, but it seems reasonable to suppose that by varying C5 between its 5.5pf and 65pf limits any normal tolerance variation can be corrected to full accuracy.

However, the sidereal clock has to display a count of 24 hours after only 23 hours 56 mins 4.091 seconds. We need a deviation of around 236 seconds – far too wide to achieve with a capacitively modified 3.2768MHz crystal oscillator. The desirable frequency at which the oscillator should run is roughly 3.2858MHz when used with the M706M1 divider chip. I could find no such crystal in my data books.

PULSE ADDING

The solution that appeared most practical was to mimic the leap year principle and add extra pulses at regular intervals so that the clock would show the correctly modified time.

Speeding the clock by 3 mins 56 secs requires an extra 11800 pulses to be added to a clock source basically running at 50Hz. Calculations showed that if I added an extra pulse for every 368 pulses from IC1, and then added a further pulse for every 128 blocks of 368 pulses the result would be near enough the correct answer. Then, within the range of the crystal's correctable frequency variation, the desired accuracy could be finely tuned.

PRACTICAL ADDING

Fig.7 shows the theoretical block diagram of the pulse adding circuit. In Fig.8 the basic frequency is taken from IC1 and through the OR gate IC5B. This is primary 50Hz that drives the clock. The 50Hz also goes via S10 to the binary counter IC2, four outputs of which, representing decimal 368, binary 101110000, are ANDed by gate IC3A. At each 368th pulse the output of IC3A goes high, resets IC2 back to zero and a pulse passes through OR gate IC5A to the first of two monostables, IC6A.

The positive-going edge of the pulse triggers IC6A and the output at its pin 7 goes low. After a period set by C8 and R9, the output reverts high, triggering monostable IC6B. Its output at pin 10 steps from low to high, remains so for the time set by C9 and R10, and then returns low. This pulse is also fed through the OR gate IC5B.

The timing sequence can be seen in Fig.9. IC2 is triggered by a negative-going clock edge, IC3A gates IC2's selected

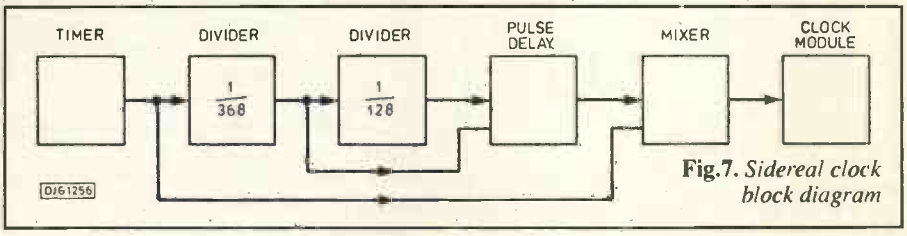


Fig.7. *Sidereal clock block diagram*

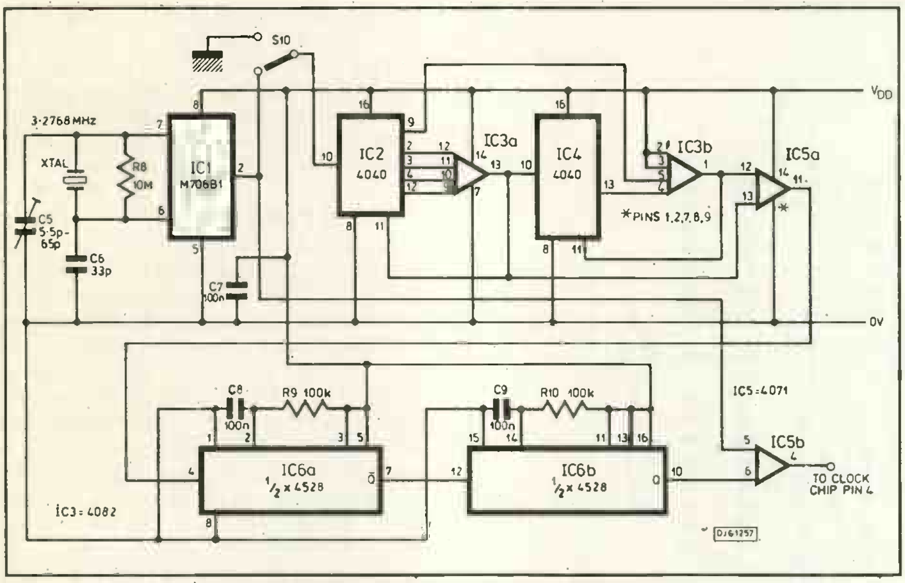


Fig.8. *Circuit diagram for the clock generator and pulse adding circuit*

outputs, IC6A delays the gated logic change, and IC6B produces a pulse long enough to be recognised by the clock module. The effect is that the extra pulse is slotted in between two clock pulses from IC1.

Additionally, each pulse from IC3B, representing a block of 368 clock pulses, triggers the counter IC4. Its output pin 13 goes high every 128th pulse (binary 10000000) and passes to the AND gate IC3B. If this output were to immediately trigger IC6A via IC5A, then the pulse would coincide with that from the first counter. A delay of one fiftieth of a second is thus introduced by enabling the gate IC3B on the first pulse from IC2 following reset, ie from pin 9, the Q1 output. Inputs 2 and 3 of IC3B are basically unused and so are tied high to Vdd. When IC3B opens, its output resets IC4, and the pulse triggers IC6A. Thus the required extra pulses are repeatedly added to the basic 50Hz.

For use as an ordinary clock, the additional pulses are inhibited by switching the input to IC2 to ground.

BATTERY POWERED

As a sidereal clock, the unit will probably be used away from a mains power supply. Consequently, it has been designed principally as a battery operated unit, but with the option to plug in a battery eliminator (mains adapter) if required.

In Fig.10 the clock pulses are brought to pin 4 of the module. The primary battery power of 9V is brought to pin 3. The 3V battery for the led display is brought via S9 into D3 at pin 2. In this configuration S9 is made a toggle switch so that the display can be left illuminated for brief periods of time, leaving hands free to do other things while watching the clock. To avoid unnecessary depletion of the 3V battery, S9 should only be switched on when really needed.

The speaker or awd is connected direct to the 3V battery so that the alarm can sound even if the display is switched of. The internal oscillator components VR2 and R11 are not required and so are omitted.

EXTERNAL SUPPLY

An external 9V battery, or 9V battery eliminator can be connected via the power input socket. C10 smooths the input voltage which is directed first to the module via D7. Provided the external voltage supply is slightly greater than that from the internal battery the module will take its supply from the external connection. To keep within the module's limits, the external supply must not exceed 12Vdc.

The external supply is additionally fed to the regulator chip IC7. This drops the input to 5V and is taken to D4 via pin 1. The module will accept led display voltages up to 6V, so the 5V at pin 1 is quite satisfactory. Since the regulated 5V is greater than the 3V battery supply, the leds will be powered from the external source, maximising battery life. S9 will not turn off the display when under external voltage control.

CURRENT AFFAIRS

The module circuit draws about 3.5mA and the timing interface takes a further 1mA. The led display can be current-thirsty – the data sheet states 315mA at full brightness, though on my unit I measured only 180mA max, and a minimum of 60mA. Consequently, the 3V battery will be depleted faster than the 9V one, so the use of an external supply is more desirable for display illumination than for clock control.

OTHER OPTIONS

Three connections not so far mentioned are those marked colon control, 12-24 hour select and 24 hour output, pins 9, 11 and 20 respectively. Pin 9 left unconnected allows the colon between the hours and minutes digits to flash at 1Hz. Linking pin 9 to 0V causes the colon to remain static. With pin 11 taken to 0V the clock counts on a 24 hour display basis, but left unconnected will display only up to 12 hours before recycling from zero. Astronomers always use a 24-hour clock.

When in the 12 hour mode the led in the top left hand corner of the display will light indicating pm time.

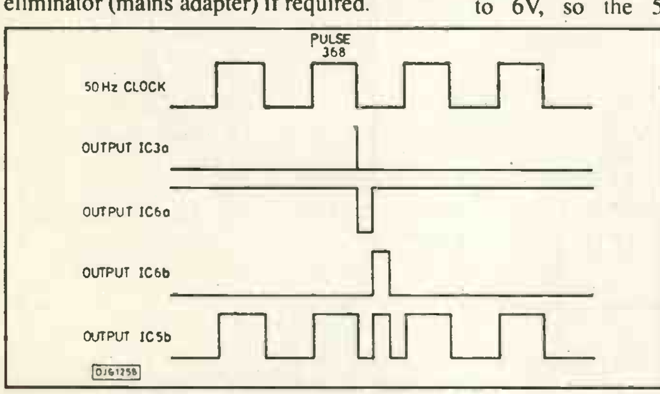
The 24 hour output produces a square wave having a 12 hour mark-space ratio – 12 hours on followed by 12 hours off. It could be used to drive other circuitry for counting days, or feeding into calendar logic circuitry.

ASSEMBLY

The layout and function connection points of the ready-built clock module were shown in Fig.2. Fig.11 shows the interface pcb layout, and a control wiring diagram is in Fig.12.

The push button pad for S1-S7 is a 3 x 4 miniature telephone-type of which five buttons remain unused. It could be replaced by a set of individual push switches if preferred, but probably not so cheaply.

The pcb, clock module, keypad, awd, controls and the interface pcb are all mounted on the lid of a plastic box measuring 60 x 110 x 190 mm. The width is just sufficient to permit the display bezel to



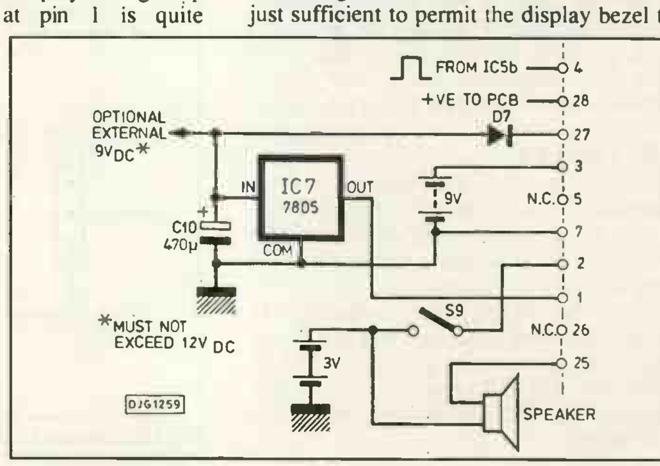


Fig.9. *(above) Timing diagram for pulse adding*
Fig.10. *(right) Connections for battery-only version*

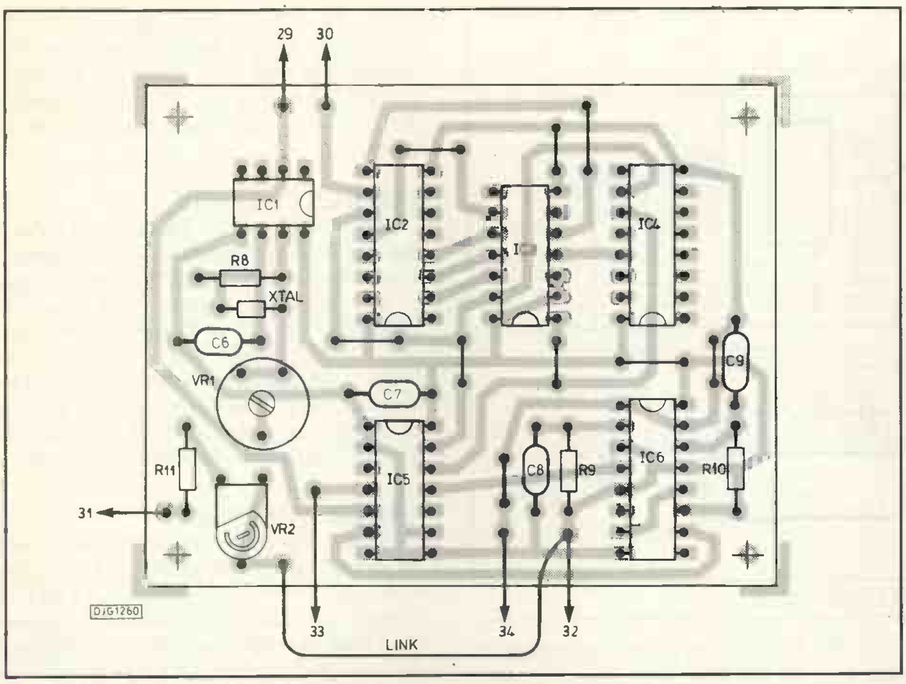


Fig.11. *PCB layout for the interface circuit*

fit across horizontally. The apertures for the keypad and the display were made by drilling a series of holes around the marked perimeters and then carefully smoothing the edges with a file.

Wires should be connected to the clock module prior to mounting it in the lid. Draw them together into a neat harness, and cut to suitable lengths. Then connect up the keypad, mount it in the lid and connect up the toggle switches, brilliance pot and the awd. The awd I used had a plastic face which I glued to the back of the lid behind a small hole to allow the sound through.

The interface pcb is mounted last. Using sticky-footed mounting pillars it straddles the back of the keypad with the pillars adhering to the back of the lid. Connections can then be made to its designated points.

The external battery input socket was mounted on the side of the box, and the holder for the 3V battery mounted on its inner base. I used two R14S 1.5V type batteries in a four-battery holder, wiring an extra lead to the spring that would normally interconnect two sets of two batteries. For the internal 9V supply a PP7 fits in easily, but there is insufficient space for a PP9. I could not locate a PP7 holder so simply wedged the battery between the 3V holder and the end of the box. The position of S8 and S10 helped to locate the battery centrally across the box with the lid closed.

SETTING-UP

The wipers of the variable trimmer capacitor C5 are visible through its body. Adjust C5 so that they are wide open. This minimises the capacitance and increases the oscillator rate to maximum.

Once the 9V battery is connected the clock will start counting and when the display is powered up it will be seen to flash on and off until S1 is pressed momentarily. The desired time display can now be set.

To establish the accuracy of the oscillator set up first in normal time mode so that any deviation is more readily checkable. Press down the time set allow switch S3 (the star on the keypad) and hold it down while pressing the fast set switch S1 (button 1 on keypad). The minutes will cycle through on the display, with the hours changing as appropriate. When the time is roughly set release S1, but keep S3 pressed, and press S2 (keypad number 2) to finely set the minutes at the slow rate, this also resets the seconds to zero. Pressing S4 causes the seconds to be displayed (for some odd reason the manufacturers intentionally blank the left hand digit of the minutes display in this mode). Once you've got the hang of it, pressing the relevant switches can be synchronised to the correct time from the telephone or radio. Incidentally, you can only cycle the count upwards.

ALARM PROCEDURE

Setting the alarm follows a similar procedure except that the alarm display (S5, pad 5) needs to be pressed instead of S3. The alarm will sound at the time set and will then remain potentially active for one hour. Briefly pressing the alarm override switch S7 (the hash symbol on the pad) will silence the alarm for eight minutes, after which it will resound. This can be done as many times during the hour allowed as your laziness prefers. At the end of the hour the alarm becomes inactive and you can go back to sleep. If you're really tired switching S8, the alarm off switch, upwards at any time totally stops it disturbing you.

The led in the bottom right of the display illuminates when the alarm is enabled.

TIMER CONTROL

The timer can be displayed by pressing S6 (pad 6). It will normally show 59 minutes. This is the maximum period that can be timed. Pressing S1 or S2 simultaneously will reduce the timer count display. When setting, if it passes zero it will recommence at 59. The timer is activated when the time display switch is pressed, and also when the alarm is triggered. Disabling the alarm resets the timer to 59 minutes. If allowed to count down, the time will otherwise turn off its output at zero. (Via a relay this output could activate the coffee making equipment, for example).

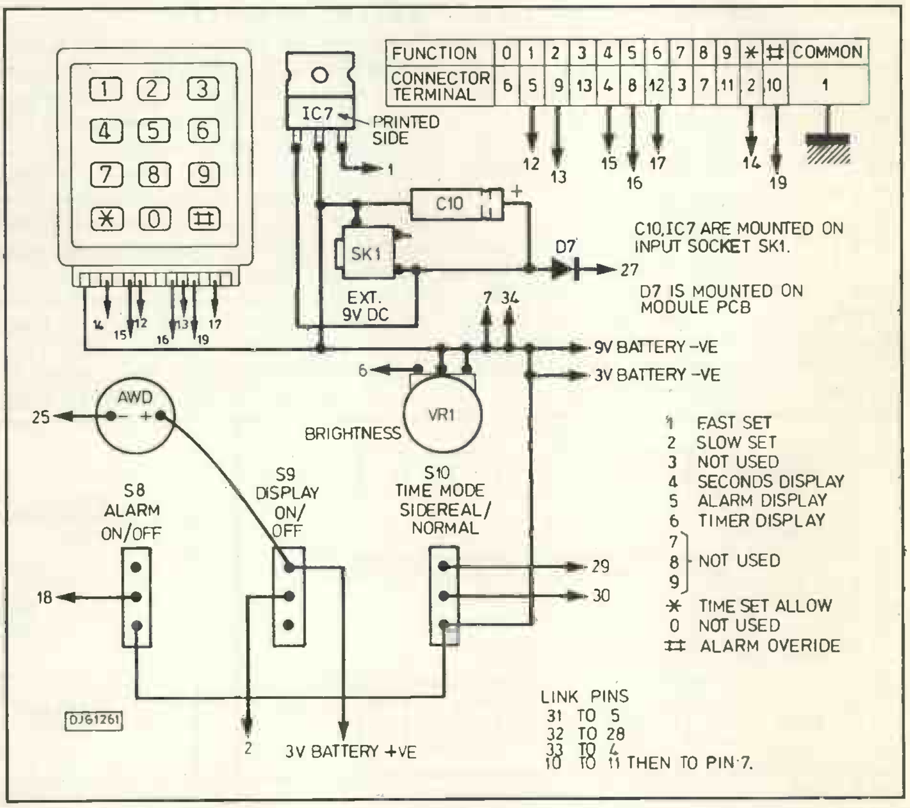


Fig.12. *Interwiring details*

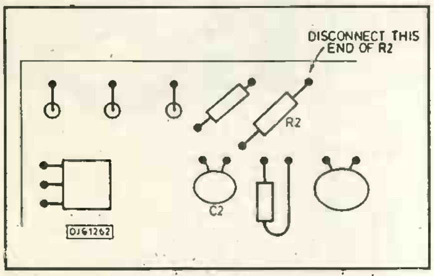


Fig.13. *Position of R2 and C2 on clock module*

FINE TUNING

Having accurately set the current time, leave the clock running for a day or two and keep track of the deviation. Then adjust C5 so that the wipers are fully closed, providing maximum capacitance and minimal output rate. Again reset the clock to accurate current time and run for a similar period. From observations of the two extreme deviations, the wiper can then be more accurately set for precise timing keeping.

Once you're satisfied with the clock's basic accuracy then switch over to sidereal mode and set the current sidereal time. This can be established either from the formula given above, or from astronomical charts.

It is just possible that the tolerance of C2 on the module may cause the short extra pulses from the interface to be inadequately registered. If sidereal time appears to be significantly slower than required, remove C2 (Fig.13) to eliminate its suppressive action.

MAINS POWERED SIDEREAL

Fig.14 shows how the clock can be connected for mains operation while still using the sidereal interface pcb. In this case the transformer supplies all the power, but the clocking waveform comes from the interface. To remove the influence of the 50Hz mains pulses, R2 must have the end connected to pin 4 extracted from the module – Fig.13 shows the location. The interface clock is then connected to the loose end of R2. Take care when desoldering R2 from the module. The awd may be connected as shown in Fig.14 or as in Fig.5. Standby oscillator components VR2 and R11 are connected as shown on the pcb layout.

STANDBY OSCILLATOR ADJUSTMENT

If the standby oscillator circuit is used it has to have its rate adjusted by VR2. With batteries in circuit, switch off the mains supply. The display colon should continue flashing as the internal oscillator takes over. Adjust VR2 until the colon flash rate appears to be once per second – counting the flashes over a minute or so should assist in this. Alternatively, use a scope to monitor module pin 5 and adjust VR2 until the observed ramp is set to 20Hz. Yes, I mean 20Hz and not 50Hz – the module's internal circuit responds slightly differently in this mode.

Note that the module's data sheet states that a 4M7 preset should be used as the variable control. Since these are hard to find, make VR2 a 1M preset, and then amend R11 from 4M7 downwards until VR2 can adjust the time within the desired range. I found that a total resistance across R11 and VR2 of 2M was adequate. These components must be hard wired to the module if the interface pcb is not used.

OUTER SPACE

Finally, Figs.15-17 show how the clock module can be interfaced to the outside world. No pcb layout or constructional details are offered for these auxiliary circuits which can be constructed on Veroboard or similar. Note that the module's output transistors have the following characteristics – Vcbo = Vceo = 45V, Ic = 100mA.

May you know your star time as accurately as Captain Kirk, Mr Spock and Dr John Mason. To the latter, of *Astronomy Now* magazine, my thanks for his advice and help on this project. **PE**

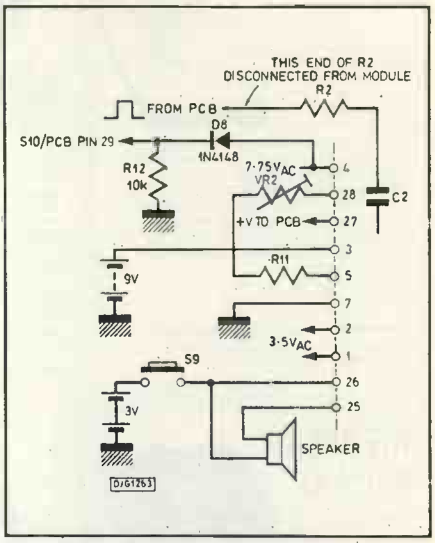


Fig.14. *Wiring for mains operation of sidereal interface and clock module.*

COMPONENTS

RESISTORS

R8	10M
R9, R10	100k (2 off)
R11	1M (see text)

All 1/4 W 5% carbon

CAPACITORS

C5	5.5p/65p trimmer
C6	33p polystyrene
C7-C9	100n polyester (3 off)

SEMICONDUCTORS

IC1	M706BI
IC2,IC4	4040 (2 off)
IC3	4082
IC5	4071
IC6	4528

POTENTIOMETER

VR1	10k log rotary
VR2	4M7 preset (see text)

SWITCHES

S1-S7	Min 3x4 keypad (1 off – see text)
S8-S10	SPDT min toggle (3 off)

MISCELLANEOUS

Clock module type RS 307-402, Phonosonics PCB 295A, 8-pin ic skt, 14-pin ic skt (2 off), 16-pin ic skt (3 off), 3.2768MHz crystal, 8ohm speaker (or awd – see text), knob, box to suit.

Fig.15. *(right) Interfacing to a timer ic.*

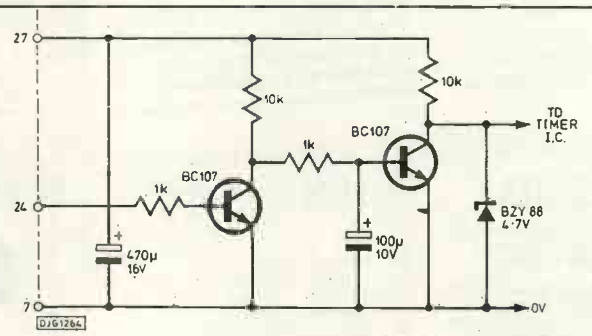


Fig.16. *(below) Output driving a relay.*

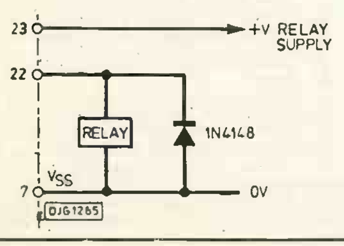
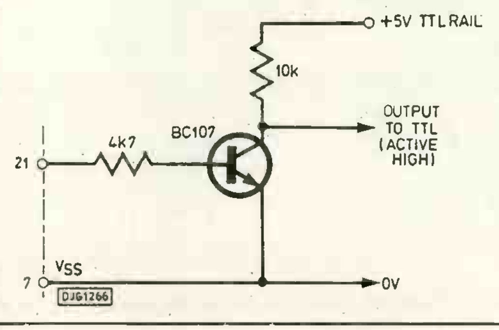


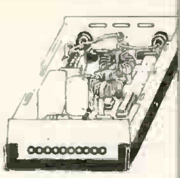
Fig.17. *(bottom right) Interfacing with ttl.*



Just for interest – one of the transparent celestial globes in the Munich Science Museum

POWER CONDITIONER

FEATURED IN ETI
JANUARY 1988



The ultimate mains purifier. Intended mainly for lowering the noise floor and improving the analytical qualities of top-flight audio equipment.

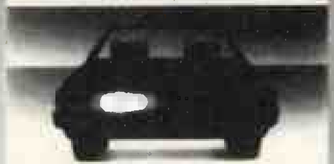
The massive filter section contains thirteen capacitors and two current balanced inductors, together with a bank of six VDRs, to remove every last trace of impulsive and RF interference. A ten LED logarithmic display gives a second by second indication of the amount of interference removed.

Our approved parts set consists of case, PCB, all components (including high permeability toroidal cores, ICs, transistors, class X and Y suppression capacitors, VDRs, etc.) and full instructions.

PARTS SET £28.50 + VAT

A low cost (but high performance) mains conditioner is also available

MAINS CONDITIONER PARTS SET £5.40 + VAT
RUGGED PLASTIC CASE £1.80 + VAT



KNIGHT RAIDER

FEATURED IN ETI JULY 1987

The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns . . . An LED display on the control box let's you see what the main lights are doing.

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The parts set consists of box, PCB and components for control, PCB and components for sequence board, and full instructions

Lamps not included

PARTS SET £19.90 + VAT

RAINY DAY PROJECTS

All can be built in an afternoon!

JUMPIN' JACK FLASH (ETI March 1988) Spectacular rock, stage and disco lighting effect!	£6.90 + VAT
CREDIT CARD CASINO (ETI March 1987) The wicked pocket gambling machine	£5.90 + VAT
MAINS CONTROLLER (ETI January 1987) Isolated logic to mains interface	£6.20 + VAT
MATCHBOX AMPLIFIERS (ETI April 1986) Listen 50W of Hi-Fi power from an amp small enough to fit in a matchbox!	
Matchbox Amplifier (20W)	£6.50 + VAT
Matchbox Bridge Amplifier (50w)	£8.90 + VAT
L165V Power Amplifier IC, with data and circuits	£3.90 + VAT
TACHO/DWELL METER (ETI January 1987) Turn your Metro into a Porsche!	£16.40 + VAT
HI-FI POWER METER (ETI May 1987) Measures Hi-Fi output power up to 100W – includes PCB, components, meters	
Mono power meter	£3.90 + VAT
Stereo power meter	£7.20 + VAT

FEATURED IN ETI AUGUST 1988

There's nothing quite so encouraging as having a quantifiable result to show for your training efforts. If you are not particularly fit, your resting heart rate will be around 80 beats per minute. As your jogging, aerobics or sport strengthens your heart, the rate will drop dramatically – possibly to 60bpm or less. With the S101, you can watch your progress day by day.

Breathing is important too. How efficiently do you take up oxygen? How quickly do you recover from 'oxygen debt' after strenuous activity? The S101 will let you know.

The approved parts set consists of, case, 3 printed circuit boards, all components (including 17 ICs, quartz crystal, 75 transistors, resistors, diodes and capacitors), LCD, switches, plugs, sockets, electrodes, and full instructions for construction and use.

PARTS SET £33.80 + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £2 for lists, circuits, construction details and training plan (free with parts set).

THE DREAM MACHINE

FEATURED IN ETI
DECEMBER 1987

Adjust the controls to suit your mood and let the gentle, relaxing sound drift over you. At first you might hear soft rain, sea surf, or the wind through distant trees. Almost hypnotic, the sound draws you irresistably into a peaceful, refreshing sleep.

For many, the thought of waking refreshed and alert from perhaps the first truly restful sleep in years is exciting enough in itself. For more adventurous souls there are strange and mysterious dream experiences waiting. Take lucid dreams, for instance. Imagine being in control of your dreams and able to change them at will to act out your wishes and fantasies. With the Dream Machine it's easy!

The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions.

PARTS SET £16.50 + VAT

Ben Sweetland's best seller GROW RICH WHILE YOU SLEEP is now in stock. £2.95 (NO VAT)

THE MISTRAL AIR IONISER

The best ioniser design yet – this one has variable ion drive, built-in ion counter and enough power to drive five multi-point emitters. For the technically minded, it has nine main drive stages, five secondary drives, and a four section booster to give an output capability of almost fifteen billion (1.47×10^{10}) ions every minute, or 2.45×10^{8} ions per second. With extra emitters this can be increased still further!

PARTS SET £24.80 + VAT

The parts set includes case, printed circuit boards, 126 top grade components, all controls, lamps, hardware, a multi-point phospher-bronze emitter and full instructions.

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit and construction details and further information (free with parts set).

READY-BUILT MISTRAL

The Mistral Ioniser (and most of our other projects) can now be supplied built, tested and ready to go. For details, please contact *Peter Leah at P.L. Electronics, 8 Woburn Road, Eastville, Bristol BS5 6TT. Tel: 0272 522703.* Evenings Only

INTERNAL EMITTER £2.69 + VAT

Can be used in place of the P-B external emitter, or both can be used together for the highest ion output. Parts set includes PCB, ion emitters, components and instructions.

IPA BOARD CLEANER £0.98 + VAT

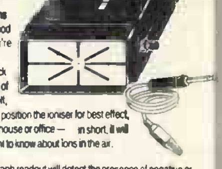
Essential for removing grease and flux residues from the Mistral PCB to achieve peak performance. Applicator brush supplied.

ION FAN £9.80 + VAT

An almost silent piezo-electric fan, mains operated, to pump ions away from the emitter and into the room. Increases the effectiveness of any ioniser by five times!

ION DISPERSION METER

FEATURED IN ETI
FEBRUARY 1989



The Q-ion is a hand-held meter which sniffs out ions in the air. It can tell the good ones from the duds if you're thinking of buying a commercial ioniser, check the efficiency and output of one you've made yourself, help you set up fans and position the ioniser for best effect, do an ion-survey of your house or office — in short, it will tell you anything you want to know about ions in the air.

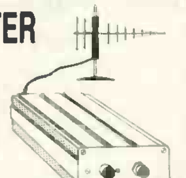
In direct mode the bar-graph readout will detect the presence of negative or positive ions and measure neg-ion strengths from 5×10^7 to 10^{10} ions per second, which covers the levels you can expect when an air ioniser is in use. For the smaller concentrations of natural air ions, integrate mode will increase the sensitivity as far as you like.

Our approved parts set comprises: case, ion collector, printed circuit board, all components (including six ICs, schottky diode, cermets, VDR, zener, 37 resistors and capacitors, LEDs, plug, socket, earth lead, etc.) and full instructions

PARTS SET £16.40 + VAT

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit, construction details and further information (free with parts set)

TV BOOSTER



Good TV pictures from poor aerials is what this project is all about. Keith Brindley's Aerial Booster gives a massive 23dB gain to ensure good viewing for campers and caravanners, from indoor aerials, or wherever a properly positioned high-gain antenna is not practical.

Based on the OM335 hybrid amplifier, the booster has specifications to rival the best: wideband operation from 10MHz to 1.4 GHz, mid-band gain of up to 26dB and a wide supply range of 9V to 26V (it will run from car batteries for caravanners, dry batteries for campers, or a mains 'battery eliminator' in the home). No special UHF construction skills are needed — the project could be made by a careful beginner.

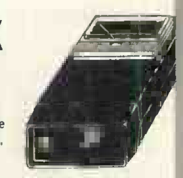
There are two parts sets for the project. AA1 contains the printed circuit board, OM335 hybrid amplifier, components and instructions. AA2 is the optional case set: rugged screened box, front and rear panels, waterproofing gaskets, feet, sockets and hardware.

AA1 PARTS SET £12.80 + VAT

AA2 PARTS SET £4.80 + VAT

BIO-FEEDBACK

FEATURED IN ETI
DECEMBER 1986



Bio-feedback comes of age with this highly responsive, self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

PARTS SET £15.80 + VAT

BIO-FEEDBACK BOOK £4.50 (no VAT)

Please note: the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book, and will only be of interest to intelligent adults.

POWERFUL AIR IONISER

FEATURED IN ETI
JULY 1986

Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build . . . and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead, and even the parts for the tester. According to one customer, the set costs about a third of the price of the individual components. What more can we say?

Instructions are included

PARTS SET WITH BLACK CASE £11.50 + VAT
PARTS SET WITH WHITE CASE £11.80 + VAT

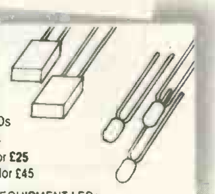
BURGLAR BUSTER

Be safe from intruders with our Burglar Buster alarm system! It has all the features you'd expect from a high-tech alarm: entry and exit delay, anti-tamper loop, delay warning and control-box protection.

The parts set includes all four PCBs and all components to go on them. Other parts (case, switches, etc.) are available separately, if you haven't got anything suitable in your spares box. Set contains 4 PCBs, ICs, transistors, relays, capacitors, resistors, diodes, regulator, piezo sounder and full instructions.

BB1 PARTS SET £12.80 + VAT

LEDs



Green rectangular LEDs for bar-graph displays.

50 for £3.50 — 500 for £25
100 for £6 — 1000 for £45

DIGITAL AND AUDIO EQUIPMENT LEDs

Assorted 3mm LEDs: red, green, yellow and orange.
25 of each (100 LEDs) for £6.80

BRAINWAVE MONITOR

FEATURED IN ETI AUGUST 1987

The most antonishing project ever to have appeared in an electronics magazine. Similar in principle to a medical EEG machine, this project allows you to hear the characteristic rhythms of your own mind! The alpha, beta and theta forms can be selected for study and the three articles give masses of information on their interpretation and powers.

In conjunction with Dr. Lewis's Alpha Plan, the monitor can be used to overcome shyness, to help you feel confident in stressful situations, and to train yourself to excel at things you're 'no good at'.

Our approved parts set contains case, two PCBs, screening can for bio-amplifier, all components (including three PMI precision amplifiers), leads, brass electrodes and full instructions.

PARTS SET £36.90 + VAT — ALPHA PLAN BOOK £2.50

SILVER SOLUTION (for plating electrodes) £3.60 + VAT

Parts set available separately. We also have a range of accessories: professional electrodes, books, etc. Please send SAE for lists, or SAE + £2 for lists, construction details and further information (free with parts set).

U.K. orders: please add 80p post and packing and 15% VAT to total.
Eire and overseas: no VAT. Carriage and insurance £4.50.
Please allow up to 14 days for delivery.

Specialist SEMICONDUCTORS LIMITED

Tel: (0600) 3715

SALES DEPT., ROOM 108, FOUNDERS HOUSE, REDBROOK, MONMOUTH, GWENT.

HDTV - THE GREAT SYSTEMS BATTLE

BY TOM IVALL

405 → 625 → 1125 → ?

High definition television demands a great leap forwards in signal processing at all stages. And the moving forwards of several billion armchairs. . . closer to the screen.

Two parts of the Western world are engaged in a battle over high-definition television (hdtv). The dispute - partly technical and partly economic - is about what television standard should be adopted internationally for hdtv studio production. Many readers will know that a television standard is the set of figures and other data which gives an exact specification of the generated picture and sound - number of scanning lines, field frequency, synchronizing, colour and sound signals, and so on. Inevitably, choosing a particular standard leads to a particular system of hardware and software.

Why do we actually want a single, world-wide production standard? In broadcasting it would simplify and encourage the exchange of hdtv programmes between different countries. It would also encourage programme sales and international programme co-productions. No complex and expensive standards converters would be needed for conversion between different hdtv systems and the possibility of picture quality degradation from this process would be avoided. In non-broadcasting hdtv productions, such as for electronic cinematography and tape programmes for home video players, there would be a similar simplification, encouragement to sales and reduction of equipment costs.

The Americas and Japan favour an hdtv production standard which is already well entrenched. After almost twenty years of engineering development it has become the basis of an excellent working system. Using 1125 lines and 60 fields per second, it was originated by Nippon Hoso Kyokai (NHK), the Japanese broadcasting corporation, and has been adopted by Sony as a standard for manufacturing video, electronic cinematography and broadcasting equipment.

But a group of West European countries finds this standard unacceptable as a candidate for world-wide use. They object to it on two counts. One is the simple fact that a field rate of 60 Hz has been chosen. This is the mains frequency, and existing tv field rate, throughout the Americas and part of Japan. Television in Europe uses a 50 Hz field rate, similarly based on the local mains frequency. A difference between the picture generation field rate and the local mains frequency can cause problems in studio production equipment.

More important, though, is the second European objection. This arises from a fundamental difference of approach. The NHK/Sony standard is 'revolutionary' because it is completely new and not compatible with existing tv sets - in any part of the world. In other words, hdtv pictures broadcast on this 1125-line standard, while providing high-definition pictures for new hdtv sets, could not also be received and displayed as ordinary pictures on existing sets. A similar problem would occur with video tape players.

What the European countries want is an 'evolutionary' approach to hdtv. For broadcasting purposes this starts from the other end - from the existing environment of millions of tv sets already installed in European homes and working on 625 lines with the PAL or SECAM colour systems. These millions of tv sets are not only a huge public investment in domestic equipment which should be utilised instead of ignored. In a compatible system they would provide an immediate audience for the first hdtv programmes - before new hdtv receivers became generally available - and thus give a commercial incentive to programme companies to produce material for this new medium.

DECISION DEFERRED

The dispute, however, is of much wider concern than the interests of the two groups mentioned above. It affects all countries in the world, because attempts to establish viable standards for broadcast engineering are normally made by international agreement through the CCIR (International Radio Consultative Committee). This permanent organisation, based in Geneva, is an organ of the ITU (International Telecommunication Union) which itself is a specialised agency of the United Nations.

In fact the CCIR is already deeply involved in the hdtv dispute. An important meeting held in Dubrovnik in 1986 tried to get an agreement on a world-wide hdtv production standard. But it failed. Only the NHK/Sony 1125-line standard was proposed, and this was supported by the USA, Japan, Canada, Brazil and Chile. The European delegates objected to it for the reasons explained above. So the meeting ended in stalemate and the CCIR decided to defer its decision on an international hdtv standard until the next equivalent meeting - a Plenary Assembly - is held in 1990.

Even before the Dubrovnik meeting there had been discussions between like-minded European broadcasters, equipment makers and government officials on the possibility of establishing an alternative hdtv production standard. The effect of the meeting was to turn these thoughts into action. Immediately afterwards, four European companies with interests in tv broadcasting equipment and receivers got together to formulate a definite proposal for an alternative standard and the development of equipment to demonstrate it. These were Bosch of West Germany, Philips of Holland, Thomson of France and Thorn-EMI of the UK.

To get backing and financial support, the proposal was put to a June 1986 conference of EEC and EFTA ministers concerned with the Eureka scheme that was founded in 1985 for international co-operation on advanced technology. It was accepted by the Eureka ministers and given the project number EU95. A first meeting of the new hdtv consortium was held in October 1986 and included government officials from the principal countries concerned, France, Germany, Netherlands and the UK. Later, Belgium, Italy, Sweden and Switzerland joined as secondary participants.

The extremely urgent research and development effort needed to catch up with the formidable NHK/Sony engineering achievement in their system is coming from eleven European teams in different countries. These are covering fundamentals and psycho-physics, production standards and conversions, studio equipment, transmission, encoding and decoding, display standards, receivers, home video recorders and players, programme material, bit-rate reduction, and overall co-ordination.

Out of all this has come an alternative proposal for a single, world hdtv production standard, with 1152 lines and 50 Hz field rate. The first practical step has been to demonstrate a Eureka working system - at Brighton in September 1988 - though this used an interim standard of 1250 lines because of the simplicity of converting to existing 625-line pictures (just dividing by two).

Apart from these two heavy-weights in the international contest there are also several other standards and systems claiming the world's attention. For example, in the USA both North American Philips and the David Sarnoff Research Center have developed systems using 1050 lines and 60Hz field rate designed to be compatible with the existing 525-line NTSC system in the USA and elsewhere. (Note that 1050 is a simple multiple of 525.) These systems are aimed at the big American broadcasters like NBC and CBS. Since there are about eight different system proposals in the USA alone it's obvious that there has to be a shake-out some time in the future.

The supporters of the NHK/Sony system and others using 60 Hz field rates point out that field repetition at 60 Hz results in less large-area flicker on the display screen than repetition at 50 Hz. This is perfectly true, because large-area flicker is dependent on screen brightness and field frequency. The supporters of 50 Hz hdtv are proposing to deal with this problem by using an extra sub-system in just the receiver which will double the display field rate to 100 Hz.

Each 50 Hz field is stored in a dram semiconductor memory and read out twice at double the original speed. As a result the line scanning frequency is doubled as well. Already Siemens, in a joint venture with Philips, has developed and put on the market a complete set of chips to provide this extra processing for new designs of conventional tv sets.

In conventional broadcast television the studio production standard has traditionally been the standard which is transmitted and displayed on the receiver screen. But standards converters - changing from 525 lines to 625 lines or vice versa - have already shown that you can produce programmes on one standard and transmit (and display) them on another. Now that digital signal processing has been made easier and cheaper by integrated circuits, it is possible for all three standards - production, transmission and display - to be different from each other.

In hdtv this facility could well come into full play. For example, if a single world-wide production standard is finally agreed on, this could be converted to different regional hdtv transmission standards, as considered desirable by the countries concerned. Then, at the receiver, the display standard could be different again - say for the purpose of reducing large-area flicker as discussed above.

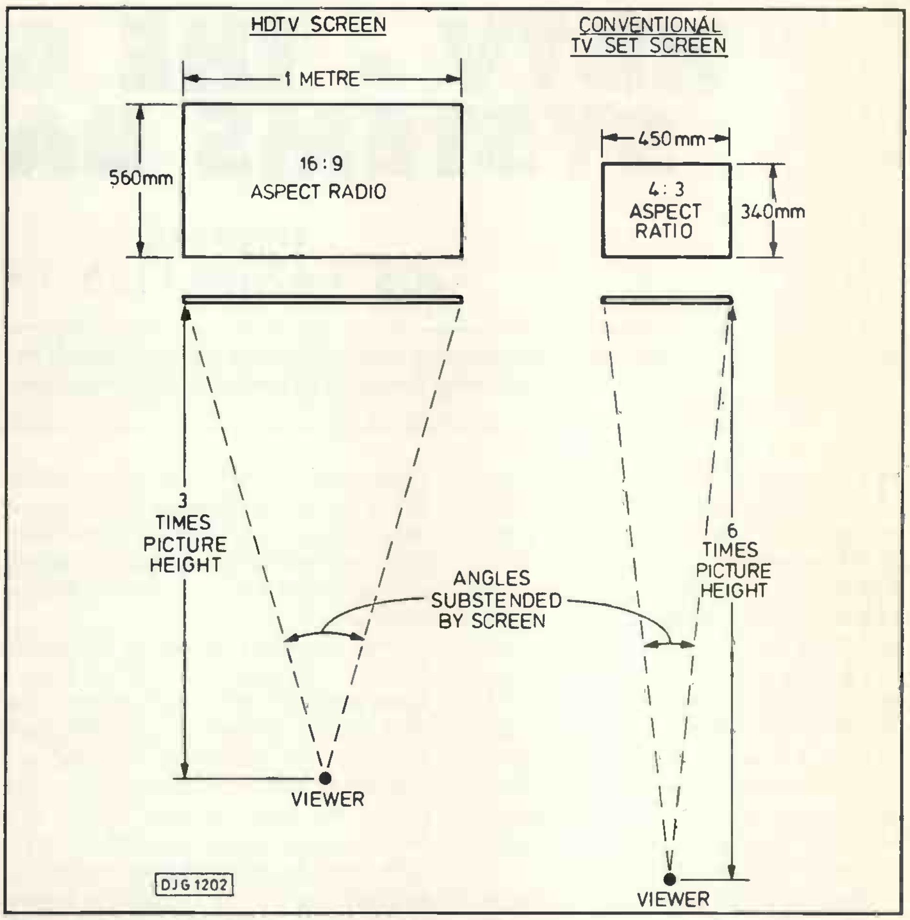


Fig.1. *Compared with the conventional tv set, hdtv has a larger and wider screen, which is viewed from a shorter distance. Dimensions shown are purely an example, not standardised.*

WHAT DOES HDTV MEAN?

In talking about hdtv we should really be calling it *higher*-definition tv in a relative sense. The fact is, improvements in definition have been going on all the time. Looking back over technical history, we see that the earliest experimental tv broadcasts in the UK used 30-(vertical)-line pictures. From there, the number of horizontal lines, and hence the vertical picture information available to the viewer, progressed through 150, 180 to 240 lines in various experimental systems. So when the BBC started up its 405-line tv service in 1936, everyone felt quite justified at that point in describing it as high-definition television.

But this, of course, was not the ultimate. The French jumped right up to 819 lines. Then, eventually, all the world settled down to either 625 or 525 lines. By this time everyone began to realise that the term 'high definition' was getting rather meaningless because it was all relative. Indeed in the UK there was considerable technical discussion on whether the new 625-line pictures really were better in quality than the 405-line ones.

In one sense the arrival of colour tv (in the USA in 1953) was a very big step forward in definition. It added visual information in a way that was immediately obvious in its sensory-aesthetic appeal and enhancement of the illusion of reality. As colour is now almost universal in tv broadcasting it is an important technical factor in deciding what can be achieved in the next step forward in higher definition.

But of course the term 'definition' is not simply the number of lines used in the scanning system. In general it means the accuracy with which the optical image entering the camera lens is defined on the viewer's screen at home. Another general way of considering it is the effectiveness with which the illusion of reality is created on that screen. Other factors could be the 'transparency' of the system or the pleasure a person gets from the viewing experience.

Such general criteria depend on a number of engineering parameters. (Fig.1.) Perhaps the most difficult one to achieve is the fineness of picture detail conveyed to the viewer, or optical resolution. A conventional colour tv set provides a resolution of about 110,000 pixels (picture elements) over its total screen area. If this number of pixels were simply spread over a larger screen, of the size envisaged for hdtv, obviously the blown-up picture would have a relatively coarse grain and the 625 lines would be very visible.

So, with a larger screen, first of all we need more pixels simply to fill the screen area at a given fineness of resolution and more lines to reduce the visibility of the line structure. And secondly, if we are aiming at a higher picture quality we will probably need even more pixels and lines to achieve the desired extra resolution.

However, what level of picture detail the tv screen displays and what level of detail the viewer can actually see are two different things. It's all a matter of human visual acuity in distinguishing closely spaced points or lines - the limit being about 1 minute of arc. If the viewer is too far away from the screen, he/she will not see the amount of detail that is actually displayed. If the viewer is too near, the screen will not provide the amount of detail which he/she is capable of seeing at that distance. So obviously any engineering decision on the number of pixels and lines must take into account the distance of the viewer from a given size of screen.

SYSTEM ENGINEERING

But all these considerations must be brought down to exact engineering specifications. The question is, what are they?

First of all, it's not technically feasible to get a noticeably higher definition on existing transmission standards and television sets. The broadcasters already transmit higher quality pictures than the average set can reproduce. If they pushed up the level of broadcast definition the existing sets wouldn't show any difference. If the sets were technically improved to match it, there would be a marginal increase in perceived picture quality - but at a very high cost. Judging from one or two manufacturers' ventures in the past, the price of the set would have to be doubled or trebled.

Substantially higher definition can only be obtained by using a different production standard, with appropriate transmission and display standards. Fortunately, all broadcasters throughout the world seem to agree that a large improvement in picture quality must be achieved to justify the effort and cost of developing hdtv. The present thinking is that, relative to conventional television, hdtv should have twice the vertical and horizontal resolution - that is, twice the ability to convey picture detail in those directions. The luminance and colour information should be transmitted separately and the colour rendition should be improved.

Also, the pictures should have a wider aspect ratio (the ratio of width to height). Here everyone seems to agree that a 16:9 aspect ratio is desirable. At a given distance from the screen, a wider picture than in conventional (4:3) television sets makes the viewer feel more involved with the programme material, possibly because there has to be more movement of the eyes to take in all the picture content. There seems to be general accord here that a viewing distance of three times the picture height is optimum, as against the typical six times of conventional tv viewing (Fig.1).

Ideally the wider display should have a larger screen area, of about 0.8 square metre. At present large screen areas are being obtained mainly by projection tv equipment. But in the future it's possible that the liquid-crystal flat-panel type of display (see Barry Fox's *Leading Edge* column in the August 1988 issue) could well provide the answer for hdtv.

Finally, most of the experts involved say that hdtv should have multi-channel, high-fidelity sound.

BROADCASTING CHANNELS

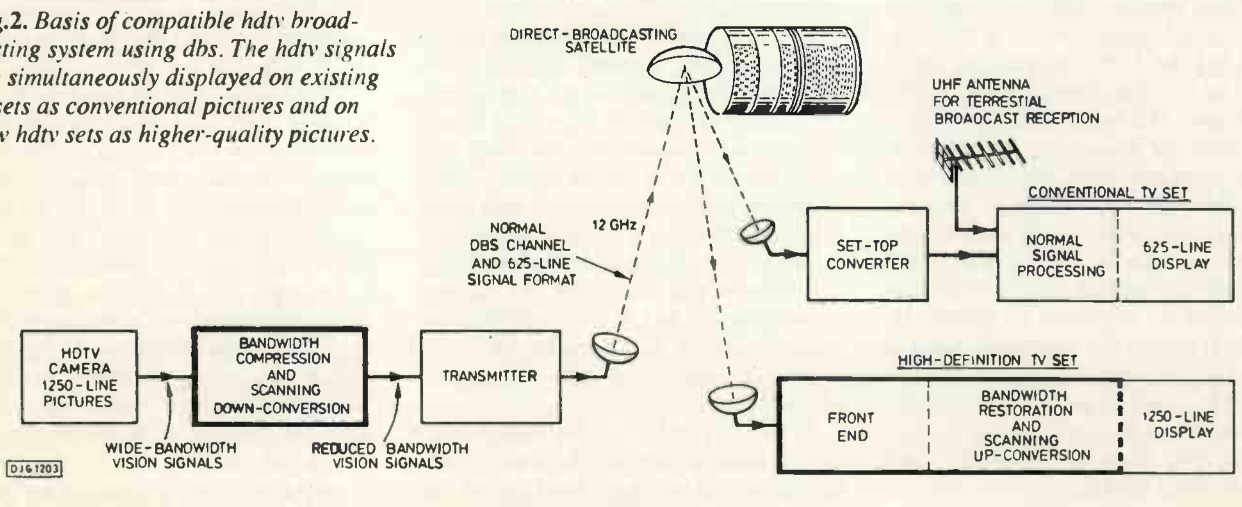
For broadcasting - as distinct from making hdtv video programmes - a rather big technical problem is where to find the necessary frequency channels to transmit the signals. At present the only promise of new frequency channels becoming available is through direct broadcasting by satellite (dbs). Here the planned channels are approximately three times as wide (in MHz) as the channels used in terrestrial broadcasting. This extra bandwidth is essential for hdtv because the higher accuracy, or resolutions of the picture requires a higher rate of information transmission.

So, as things stand at present, the coming of broadcast hdtv depends on the coming of dbs. There are satellite broadcasting allocations at 12GHz, 23GHz, 42GHz and 85GHz. The 12 GHz allocation is available for all regions of the world and is planned for transmissions in 24 MHz or 27 MHz wide channels. It will allow basebands of up to 11 MHz wide. The UK's first dbs transmissions in 1989 will be at 12 GHz. So as hdtv production standards require initial vision bandwidths in the region of 30 to 60 MHz (depending on whether the scanning is interlaced or not), a great deal of bandwidth compression will be necessary for transmission in these rf channels.

More attractive is the higher bandwidth available at 22.5 to 23 GHz. This 500 MHz wide frequency allocation, though, is only available for the Americas, Asia and Australasia, not for Europe and Africa. So there would have to be a new international agreement to allow it to be used world-wide. In the 42 and 85 GHz allocations, rain attenuation to signals is a serious problem, and much more development would be needed to make these two bands suitable for hdtv.

Most hopeful is the feasibility of turning the 22.5 - 23 GHz band into a world-wide allocation, and this has recently been considered at an ITU conference in Geneva.

Fig.2. *Basis of compatible hdtv broadcasting system using dbs. The hdtv signals are simultaneously displayed on existing tv sets as conventional pictures and on new hdtv sets as higher-quality pictures.*



HOW DOES IT WORK?

The essence of the latest experimental hdtv broadcasting systems is digital signal processing. In the complete chain from studio to home only three parts work by traditional analogue electronics: the picture source (eg tv camera); the radio frequency sections of the broadcast transmitter and domestic receiver; and the display device in the home (eg direct-view cathode-ray tube or projection system). The vision and sound signals that pass between these areas are converted into digital form and processed as data in computer-like equipment.

Why is this digital processing necessary? It's largely because of the need for compatibility as discussed above. Fig.2 shows the essentials of a proposed compatible hdtv system working through a dbs channel. The hdtv standard uses 1250 lines, while the existing conventional tv standard, for both dbs and terrestrial transmissions, is 625 lines. Because the conventional tv set must receive its normal signal, this must be transmitted in the normal 625-line signal format and within the normal dbs channel bandwidth. Consequently the vision signal generated by the hdtv camera or other source must be 'squeezed down' to fit these broadcasting requirements.

First, the hdtv camera produces a vision signal of much wider bandwidth than that from a conventional camera - about four times wider. But the existing dbs channel is really only intended for sending standard 625-line pictures (525-line in the Americas). It has an rf bandwidth of 27 MHz (24 MHz in the Americas) but, because frequency modulation is used, will carry a tv baseband signal of substantially less bandwidth - up to about 11 MHz. So the wideband hdtv vision signal has to be compressed into a relatively narrow-band transmission channel. This entails a signal processing technique called bandwidth compression at the transmitting end.

Secondly, the hdtv camera is generating a 1250-line picture while the existing tv sets need a 625-line picture. So at the transmitting end the 1250-line scanning structure has to be down-converted into a 625-line structure. This is called line shuffling.

But both the bandwidth compression and the scanning down-conversion have to be done in such a way that the hdtv set will receive all the necessary signal information to reconstruct a 1250-line, wide-bandwidth hdtv picture from the 625-line transmission in a normal rf bandwidth channel. It must also be done in such a way that the picture received on the existing tv sets is not impaired in any way: this should have the same quality as pictures received from conventional (non-hdtv) television stations.

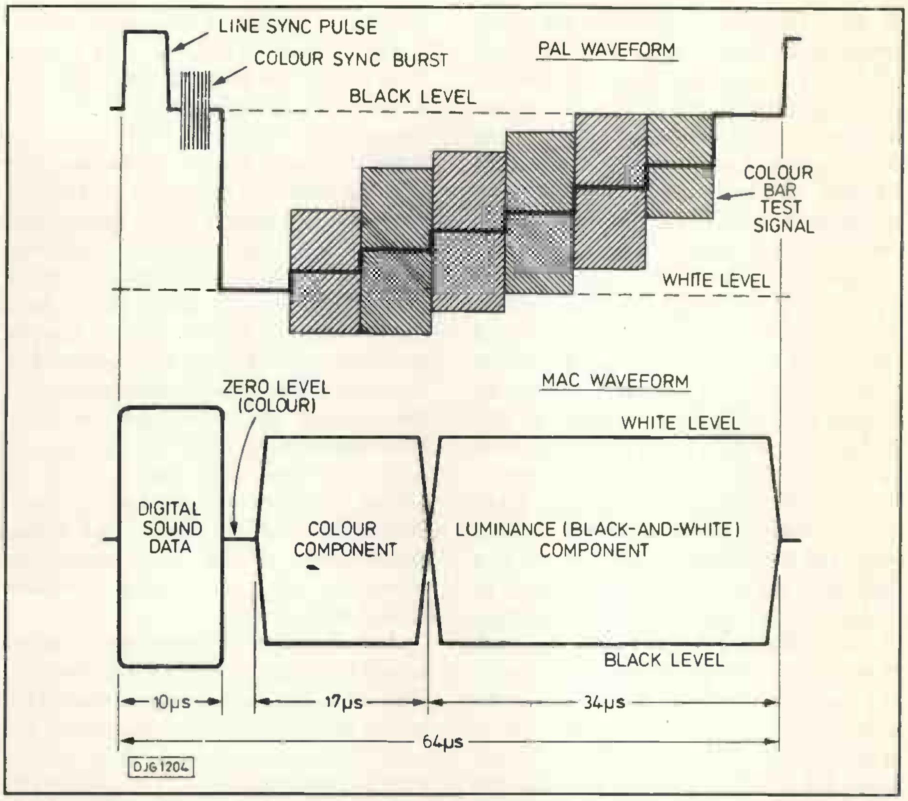


Fig.3 *MAC tv signal format, as intended for dbs delivery of hdtv signals in Europe, compared with standard PAL signal format. Each waveform shown is transmitted in a single tv line (625-line system). MAC gives better quality pictures than PAL by transmitting luminance and colour components at different times (sequentially), thus avoiding PAL patterning effects due to simultaneous transmission of colour components on a subcarrier. MAC also transmits high quality digital sound.*

In Fig.2 the signal processors needed at the transmitting and receiving ends are shown by heavy-line boxes. To meet all the compatibility requirements mentioned above, the processes required for bandwidth compression and line shuffling have to be extremely complex. Another process not shown in Fig.2 but used in some systems is time compression of vision signals at the transmitter and the reverse time expansion at the receiver. None of these techniques, which often use storage, could be achieved by analogue electronic circuitry, and digital signal processing is the only practical answer.

There is, however, a secondary reason for taking this approach. Digital video recording and digital signal transmission are already beginning to appear in broadcasting studio equipment. The basic reasons are that digital techniques offer greater accuracy and stability, with much better signal-to-noise ratios than analogue methods can provide in vision signal transmission and processing. An international standard has been established for digital encoding and decoding of vision signals in component form (luminance and colour components).

At the same time we see digital techniques coming into the domestic tv set. Several digital sets have been put on the market. So it makes good sense for hdtv to build on the advantages already proved with digital techniques in studios and receivers and to utilise the hardware already available.

As shown in Fig.2, the conventional 625-line tv set only needs a set-top converter to allow it to work from the 12 GHz satellite broadcasts. This unit converts the 12 GHz signal down to the normal uhf antenna input needed by the tv set. It also changes the dbs transmission signal format (the MAC format - explained later - has been chosen for Europe) into the conventional PAL or SECAM signals as used in terrestrial tv broadcasting. Fig.3 shows the difference between the two formats.

Thus the 625-line set displays the hdtv pictures as if they originated from the existing terrestrial or (soon to come) satellite broadcasting systems. Apart from programme content, the viewer is not aware of any difference. But the high-definition tv set is completely different. It is designed specifically to receive and display the full vision information carried in the hdtv transmissions. It includes a digital processing section (heavy-line box).which performs roughly the reverse functions to those at the transmitting end (heavy-line box). PE

TO BE CONTINUED NEXT MONTH

GREEN SCREEN HI-RES 12in MONITOR CHASSIS
Brand new and complete except for case, the super high definition (100 lines at centre) makes this monitor ideal for computer applications. Operates from 12V d.c. at 1.1A. Supplied complete with circuit diagram and 2 pots for brilliance/contrast, plus connecting instructions. Standard input from IBM machines, slight mod (details included) for other computers Only £24.95+£3 carr.

MONITOR INTERFACE KIT
Enables our hi-res monitor (above) and most others to be used with virtually any computer, PCB £3.00
Complete set of on-board components plus regulator and heatsink £9.95
Suitable transformer for interface and above monitor £5.31

Z811 Cumana touch pad for the BBC B computer. Enables you to draw on the screen using the stylus with the touch sensitive pad. Supplied with 2 stylii, power/connecting leads and demo tape with 4 progs. Originally sold at £79.95.
Our price: £19.95

'JIMMY'
the electronic football game of skill
Z817 Exciting electronic football game – Waddingtons' 'JIMMY'. Brand new models in full working order, but without plastic peripherals, stickers etc. Red plastic case 420mm long x 93mm wide contains keypad and seven segment LED's to keep score either end. The centre section 'players' are represented by red 5mm LED's, 14 altogether. The main chip is the TMS1000, programmed to make odd noises whilst playing and a tune when a goal is scored. Also inside are 13 plastic transistors. 57mm 8R speaker, power supply socket, R's, C's etc. Powered by 2xPP3 batts. Solo or dual play. Supplied with instruction sheet, playing field complete with coloured 'players'. Good fun to play as a game and good value for the electronics within. Originally retailed at £19.95 Only £5.00

Z8837 DUAL SHEET FEEDER.
Brand new breakdown unit. Contains 3 x 12V stepper motors (48 step) plus driver pannel with 4 x TIP115, 4 x TIP110, LM3302, 2 x 7407; 2 solenoids, buzzer, microswitches, control panel, 2 optocouplers plus lots of gears and mechanical bits. £24.95+£3 carr.

HEADPHONES AND SPEAKERS
Combination pack of Walkman type player units, consisting of stereo headphones and a pair of micro speakers in yellow, blue or green. Packed on a clear display card £2.50

1989 CATALOGUE
★ 100 BIG pages of components and equipment
★ Low, low prices
★ Fast "by return" service
★ 28 pages of Surplus Bargains
★ Only £1 – send for yours now!

LCD display:
Z4115 8 digit 12.7mm high LCD by Data Image. 14 segment, so letters as well as digits can be formed. List £15+
Our price £4.50

SPEECH SYNTHESIZER KIT
Z315 All parts inc. PCB to make a speech synth for the BBC micro £4.99

Z316 De-luxe version – also includes V215 case, 1m 20W cable plus connector £7.99

MICRO PANELS
Z620 68000 Panel. PCB 190 x 45 believed to be from ICL's 'One per Desk' computer containing MC68008P8 (8MHz 16/8 bit microprocessor, + 4 ROM's all in skts; TMP5220CNL, 74HCT245, 138, LS08, 38 etc. £5.00

Z625 32k Memory Boad, PCB 170 x 170 with 16 2k x 8 6116 static RAM's. Also 3.6V 100mA memopack nicad, 13 other HC/LS devices, 96w edge plug, 8 way DIL switch, R's, C's etc. £4.80

VIEWDATA LTU
Z697 Interface Panel 166 x 150 with 3 x LM324, LM339, LM393, 4066, 11 transistors, 3 reed relays etc. 3m lead with BT plug attached. Supplied with comprehensive data and ccts. £2.90

TELETEXT PANEL
Z037 265 x 145mm by GEC. Uses 8085A, 8155, 8255A, 8251, 8212 all by Intel. 2 x 2114, 2 x TC5501 + custom chips + 10 others. Nicad back up. New £9.90

Must clear excess stocks – 1/4 million low profile top quality IC sockets to dispose of!

Pins	10	100	1000
8	40p	£3.00	£20
14	68p	£5.10	£34
16	72p	£5.40	£36
18	76p	£5.70	£38
20	80p	£6.00	£40
22	84p	£6.30	£42
24	88p	£6.60	£44
28	92p	£6.90	£46
40	96p	£7.20	£48

'D' CONNECTORS

	15W	25W	37W
R/A plugs	40p	50p	60p
R/A skts	50p	60p	70p
W/W plugs	40p	50p	60p
W/W skts	50p	60p	70p
S/P plugs	40p	50p	60p
S/P skts	50p	60p	70p

All top quality gold plated

Z345 OPTICAL SHAFT ENCODER. Similar to RS631-632, but 80% cheaper! £8.50

SEMICONDUCTORS
Hundreds in Cat – look at these sample prices:
LM317K £1.00; 68008L8 £3; 27C256-25 £5; 68A00 £1.20; LM223K £3; DL1416 £7; RBG1000 £1.20; DL3416 £8; 555 20p; 741 20p; 74LS240 25p

COMPONENT PACKS

K560 Semiconductors – Over the years we have purchased many transistors, diodes, ICs etc. which for one reason or another have accumulated in one of our stock rooms. Rather than spend weeks sorting and listing them, we have decided to make them into packs. All components are full spec marked devices. Some may be coded. We believe this to be one of the best value packs ever offered, as many high value components are included. Packs are made up by weight; this means contents are very approximate – if there are several bulky power devices, there will be considerably fewer parts than those packs containing all small signal items.
Pack of approx 100 £5.50
Pack of approx 250 £12.00
Pack of approx 1000 £40.00

K539 Led Pack – not only round but many shaped leds in this pack in red, yellow, green, orange and clear. Fantastic mix.
100 £5.95 250 £13.50

K547 Zener Diodes – Glass and plastic, 250mW to 5W ranging from 3V to 180V. All readily identifiable. **100 for £4.50**

K546 Polystyrene/mica/ceramic caps. – Lots of useful small value caps up to about .01µF in voltages up to 8kV. Good variety. **100 £2.75**

K528 Electrolytic Pack – All ready cropped for PCB mounting, this pack offers excellent value for money. Good range of values and voltages from 0.47µF to 1000µF, 6V to 100V
100 £3.95 250 £8.95 1000 £32

K518 200 Disc Ceramic Caps – Big variety of values and voltages from a few pF to 2.2µF; 3V to 3kV **£1.00**

K530 100 Assorted Polyester Caps – All new modern components, radial and axial leads. All values from 0.01 to luf at voltages from 63 to 1000!!
Super value at £3.95

K520 Switch Pack – 20 different assorted switches – rocker, slide, push, rotary, toggle, micro etc.
Amazing value at only £2.00

K569 Reed Switch Pack. A selection of about 15 types of reed switch from submin 12mm long to 5A rated 50mm long, mostly form A (make), few form C (Change-over).
Pack of 30 £2.75

K540 Resistor Pack – mostly 1/8, 1/4 and 1/2W, also some 1 and 2W in carbon, film, oxide etc. All have full length leads. Tolerances from 5 to 20%. Excellent range of values. **500 £2.50 2500 £11.00**

K503 100 Wirewound Resistors – From 1W to 12W, with a good range of values. **£2.00**

K523 Resistor Pack – 1000– yes, 1000 1/4 and 1/2 watt 5% hi-stab carbon film resistors with preformed leads for PCB mounting. Enormous range of preferred values from a few ohms to several megohms.
Only £2.50 5000 £10 20,000 £36

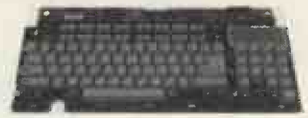
K531 Precision Resistor Pack – High quality, close tolerance R's with an extremely varied selection of values mostly 1/4 and 1/2W tolerances from 0.1% to 2% – ideal for meters, test gear etc.
250 £3 1000 £10

K525 Preset Pack – Big, big variety of types and sizes – submin, min and std, MP slider, multiturn and cermets are all included. Wide range of values from 20R to 5M
100 assorted £6.75
200 £12.95 1000 £48

K505 20 Assorted Potentiometer – All types including single, ganged, rotary and slider **£1.70**

K572 Networks 7,8,9 pin SIL; 14 & 16 pin DIL. Lots of different values. **Pack of 100 £4.50**

KEYBOARDS



Z8852 Keyboard: Superb brand new keyboard 392x181 with LCD displaying 1 line of 10 characters & a further line with various symbols. 100 keys, inc separate numeric keypad. Chips on board are 2x74HC05, 80C48.

Z8848 Alphanumeric plus separate numeric keyboard. 104 keys plus 11 chips. 442x175mm. £12.00

Z4116 24 way (8 x 3) membrane keypad. Large (200 x 90mm) area – they were used in a teaching aid. Overlay template and pinout supplied. £3.00

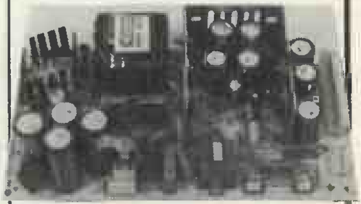
Z810 KEYBOARD Really smart alpha numeric standard qwerty keyboard with separate numeric keypad, from ICL's 'One Per Desk'. Nicely laid out keys with good tactile feel. Not encoded – matrix output from PCB taken to 20 way ribbon cable. Made by Alps. Size 333x106mm. 73 keys £8.95

Back in stock Z8833 Tatung cased keyboard VT4100. 85 keys inc sep. numeric keypad. 450 x 225 x 65/25 £14.95

POWER SUPPLIES
Z975 Cased PSU 92x57x45mm with built-in 13A mains plug. Output 14V ac @ 600mA. £3.00

Siliconix mains PSU 62x46x35mm with built-in cont. 2 pin plug. Output 4.5V DC 100mA to 3.5mm plug **ONLY £1.00**

Z4113 BBC Computer PSU (early models). Steel case 158 x 72 x 55mm, 2m long mains lead, rocker switch, fused. Outputs: +5V at 2.5A; -5V at 100mA £3.95



Z026 Astec 65 watt unit. 115/230V ac input. Outputs +5V 6A; +12V 1.5A; +12V 2.1A; -12V 0.25A,. PCB 197 x 107mm £24.95

Z4117 Special low price switch mode PSU. 50W unit on PCB 160 x 100mm. Mains input, outputs 5V at 5A; +12V at 1A; -12V at 1A.
List £40+ **Our price £9.50**

Z4112 Another switch mode PSU. Same size as Z4117. Outputs 24V at 1.7A; 12V at 0.8A £9.95

Astec type AA7271, PCB 50 x 50mm has 6 transistor cct providing current overload protection, thermal cut-out and excellent filtering. Input 8-24V DC. Output 5V 2A. Regulation 0.2% £5.00

JOYSTICKS
Z004 Skeleton Joystick, switch type. Good quality, made by AB. Brass spindle has 44mm long black plastic handle attached. Body has 4 mounting holes. These really are a fantastic bargain! **Only £1.00**

Z8831 Dragon Joystick. Made by Dragon Data. Hand-held with fire button. 2m lead with 5 pin DIN plug. Uses 2 x 100k pots. £3.00

Z615 BBC Joystick. Internal resistors give the required voltage levels. 2 fire buttons. Rubber suction feet. 120 x 110 x 155 £3.00

SOLDER SPECIAL!!
* 15W 240V ac soldering iron
* High power desolder pump
* Large tube solder
ALL FOR
£7.95

GREENWELD ELECTRONIC COMPONENTS

All prices include VAT; just add £1.00 P&P; Min. credit card £5. No CWO min. Official orders from schools welcome – min. invoice charge £10.00. Our shop has enormous stocks of components and is open 9-5 Mon-Sat. Come and see us!
HOW TO CONTACT US
By post using the address below; by **phone** (0703) 772501 or 783740 (ansaphone out of business hours); by **FAX** (0703) 787555; by EMail Telecom Gold 72:MAG36026; by Telex 265871 MONREF G quoting 72:MAG36026.

443C MILLBROOK ROAD, SOUTHAMPTON, SO1 0HX.

NOTICE TO RETAILERS
Greenweld Electronics Ltd. have been appointed Official Wholesalers of Verobloc, Veroboard, Easiwire and Accessories by Vero. We will be only too happy to supply all your Veroboard requirements at Trade Price. Ring, write or fax us for full information and prices.

THE ELECTRONIC RAILWAY

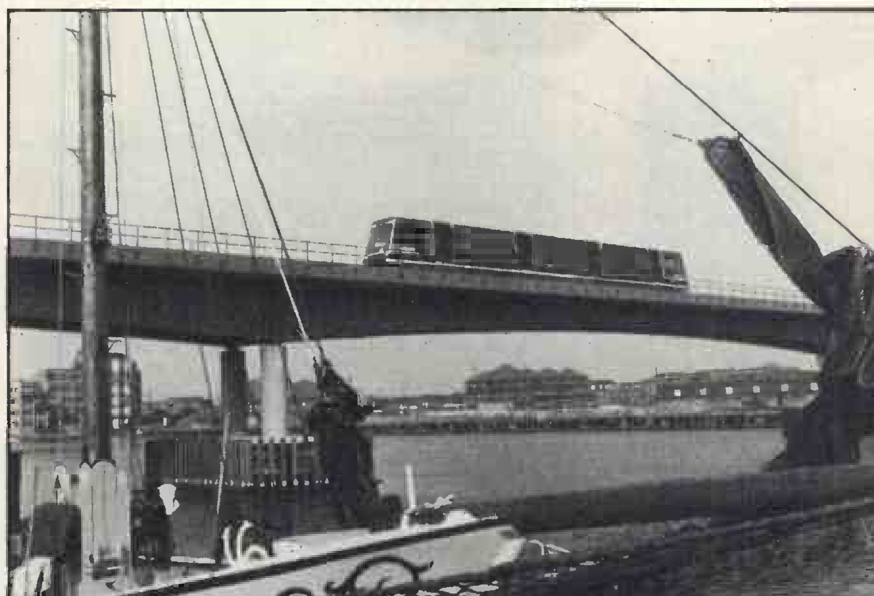
PART TWO BY NEIL HARDING

DIGITAL CUSTOMISING

Not only signalling is becoming automated, so too are the trains, the tickets and the training

Let's now consider the actual signalling control centre. A signalman operates push buttons or switches which, linked to a signalling interlocking, allow the integrity of the system to operate signal routes and hence permit the passage of trains through a signalling section. The link between the switch circuits and the main interlocking has previously been via hundreds of direct wires. However, we can dispose of the direct wires and replace them with just a couple of wires, resulting in worthwhile cost saving. This can be achieved by putting a time division multiplex (tdm) remote control system right up behind the panel and scanning the buttons and switches. The information from the computer is then transmitted to the main or remote interlockings. Additionally, an indication system is sent via the tdm from the interlocking to the control centre's computer on the panel enabling the current state of signals, points and signal routes to be displayed on the main signalling console.

An extension to the above is where the whole signalling console is replaced by visual display units. In many places this is now the means being used to indicate signalling functions. The signalman observes a vdu which is capable of displaying the signalling layout for the whole of the control area, a portion at a time. He can then operate the signalling system by using a keyboard which is linked to the computer as before. Similarly, indications of the signalling system are returned to the panel computer, which then continually updates the indications as the signalling status alters.



London Docklands Light Railway — a driveless automatic train system

TRACKSIDE SIGNALLING

For many years the main form of trackside signal used, throughout the world's railways, has been the coded light signal whereby different coloured lights, or a series of lights, are displayed to train drivers and have specific meanings. In some areas a "speed signalling" system may be employed, where the aspects displayed are interpreted as a specific maximum permitted speed for the signal section. In other areas a "route signalling" system may be employed, which advises the train driver of the signal route status in advance.

The coloured light signal is a proven system of controlling trains, but unfortunately it is not infallible. A driver may forget what aspect was displayed at the signal he has passed or he may even miss the signal completely. The result can be disastrous. Hence the implementation in some areas of an "automatic train control" system. Here, signalling information such as aspect being displayed, gradient of line, speed of line, etc, is encoded into a form which is then transmitted from a trackside transponder to a receiver on the train. The receiver passes this data, along with other information from the train itself, such as speed, braking characteristics, etc, to a processing computer. The train's desired maximum speed is then circulated and on the driver's panel. As long as the driver maintains the train's speed within this limit, then all is well. Should the speed exceed the limit then the automatic train control system will bring the train's speed down to the required limit or, in emergency, stop the train completely.

An extension to this is, of course, to have completely automatic train operation without using drivers or trackside signals. Although extremely expensive to implement on a main line railway, it is

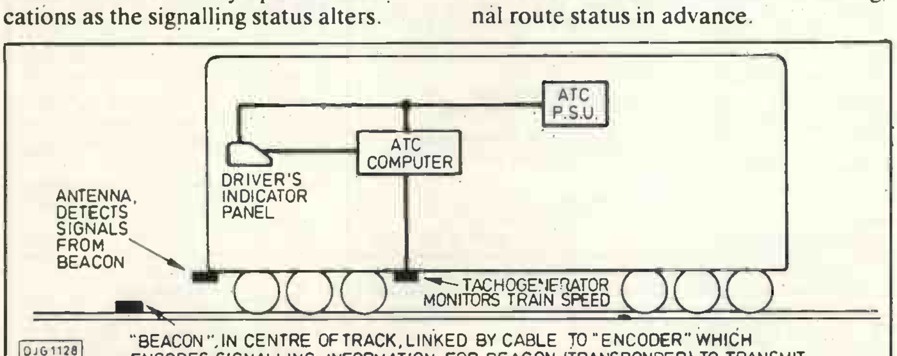


Fig.5 *Automatic train control system widely used in Sweden, Finland and parts of Australia, though not in Britain*

Automatic train control work station at London Docklands Light Railway Operating Centre

ideal to be used on light railway schemes and, indeed some new light railways are operating in this manner.

SERVICING IMPROVEMENTS

The railway passenger or freight customer may not always be aware of the efforts being made by the railway administration to improve the services offered to him. Indeed, it is generally only when there is what the customer sees as a "negative" change that he actually notices, say when the ticket price or freight tariff is increased. Ironically, there are many changes which do take place which have the effect of preventing such "negative" actions by actually increasing the efficiency behind the scenes of the services offered and thus permitting the standards, which the end-users expect, to be maintained.

There are many such changes which have taken place as a direct result of the introduction of electronic or computer technology into the railway industry and these may create greater efficiencies. On other occasions, new benefits are often given to the customer, such as improved passenger information systems, which are provided only at the expense of the railway administration. Other technologies introduced may be more indirect, such as train driver's aids, etc. Let us look at some of the systems introduced in recent years directly or indirectly benefitting the customer, whether passenger or freight client, through savings in costs for the railway.

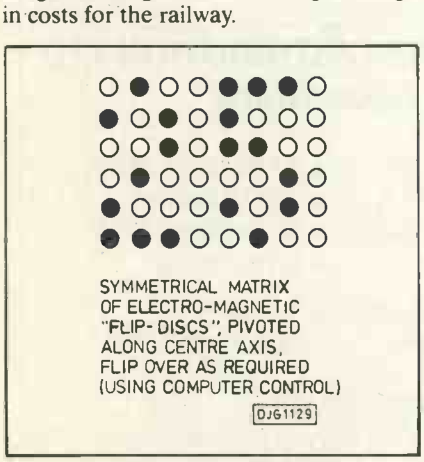


Fig.6 *Flip-disc indicator system*

NOTICEABLE IMPROVEMENTS

Passenger information systems have undergone quite considerable changes in recent years. At one time any information which the railway authority wished to impart to passengers would be simply written up on a blackboard and/or verbal announcements given by the railway staff on the platform or concourse. Now, generally, the blackboard has gone, to be replaced by computer operated indicators, like the "split-flap" or "Solari" indicator. This has up to 80-way flaps which contain pre-determined legends allowing a multitude of information to be displayed, albeit limited.

Another system in use incorporates two-colour discs, generally black on one side and fluorescent yellow on the other, organised in a matrix in such a way as to allow any required characters to be displayed, simply by "flipping" the necessary discs. This system is more versatile in that a wider range of messages can be displayed. A further development of this idea is the use of leds instead of the flip-discs. Liquid crystal displays are also being introduced.

Both of these systems are operated by computers, with information being entered by the station staff via a keyboard. The lcd systems can usually have certain parts of the displayed messages either highlighted or flashed as required. The systems can also be linked to timetable data and, in conjunction with the train describer system, give passengers a true report of the current train information.

DIGITAL PA SYSTEMS

Public address systems have similarly undergone changes in recent years. Originally all announcements were spontaneous, being made as and when required by the announcer. Following on from this, pre-recorded tape messages were often used. These days the messages are digitally recorded using sophisticated electronic techniques and these are also linked to the timetable and train describer computers, in order to give accurate, automatic announcements at exactly the right time. Moreover, these digitally recorded systems are virtually maintenance free and therefore produce considerable savings for the railway concerned.

CASHLESS TICKETS

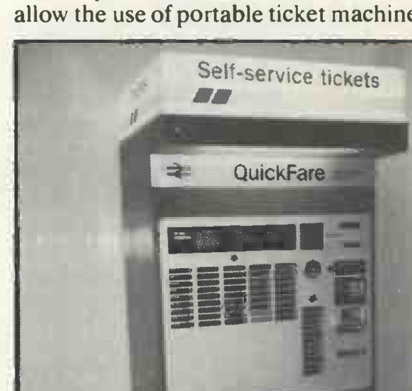
Currently, the passenger is able to pay for a ticket by one of several methods. Cash is still accepted, but its future in the "cashless society" is looking very dubious! Credit cards can now be inserted by the passenger into machines similar to "automatic teller machines". Once a personal identification number has been entered, as well as other information such as destination, class, etc, this computerised machine then issues the ticket to the passenger, automatically deducting its cost from the passenger's bank or credit card account. Of course, the computer also carries out one or two other checks at the same time, the most obvious one being the interrogation of the card's details, comparing them against a list of stolen or otherwise invalid cards. Thus some degree of integrity is introduced into the computerised system to help prevent fraud.

Split flaps and tv display units at London Victoria Station

Automatic ticket issuing machine at London Victoria

Similarly, the booking office in a modern railway system has the use of a computerised machine which, upon entering the details of a passenger's requirements, automatically prints and issues the ticket and advises the cost. All these machines are linked to a central computer and thus updating of information, such as fare tariffs, can be carried out easily and simultaneously for all the stations on the system.

The system has also been extended to allow the use of portable ticket machines



London underground automatic ticket issuing machine on board trains by conductor/guards. These portable machines store a smaller number of ticket details such as only those required for the particular area in which the train runs, together with details of tickets and fares to major destinations within the overall railway network. At the end of the day's work, these machines are plugged in to the mainframe computer so that the day's revenue, ticket sale details, etc, can be recorded. In addition, the portable devices store details of stolen season tickets so that instant checks can be made to see if fraudulent use of a ticket is being attempted.

RESERVATIONS

Many modern railways now use computerised seat reservation systems. Here the customer obtains a guaranteed seat reservation, subject to availability, to meet his exact requirements for a journey. Items to be selected include type of class, destination, smoking or non-smoking, etc. In addition it is usually possible to book sleeping car reservations on the same system. Previously, only a small number of trains would have been permitted to carry reserved seats, as it was not practical for more than one station to carry the details of a particular train's seating arrangements as double-booking of seats could result. The alternative, of course, would be to allow several stations to have an allocation of seats each for any particular train. This, though, often would result in one station using up its complete allocation while another used up none, with the resultant imbalance being very inefficient, losing much revenue for the railway. However, using the computerised system, each station linked to the computer has the ability to book seats on any train with the knowledge that no double-booking can take place. A greatly extended set of services can thus be offered to the customer.

FREIGHT TRANSPORT

In the freight transportation section of the railways, computers are in use which contain the details of all the freight vehicles used by the railway administration (including those vehicles which may be temporarily out of service due to repair, maintenance, etc) as well as all the details of freight installations which can possibly by served by them. At each installation, the details of all the vehicles which are at present at that location will be recorded within the computer. When the freight controller is preparing to despatch a train, all the details of the train's consist, load destination, etc. are entered into the system and, when the train actually departs, that information is also entered. The result is that, at any time, an enquiry can be made to the system from any freight depot to determine the exact location of any particular vehicle, whether at a freight installation or on route to one, together with its various details. Similarly a freight yard controller may want to determine the details of all vehicles and loads currently within his jurisdiction or, alternatively, on their way to the yard. Thus, overall, a very accurate picture of the freight scene can be portrayed, with maximum use being made of all the vehicles and freight depots used by the railway administration.

LASER TRACKING

In the civil engineering field, lasers are now being extensively used in a variety of different functions. As well as being used in survey work as the modern day version of the surveyor's theodolite, lasers are now used when constructing bridges or other large structures in order to accurately align connecting sections. Similarly, when carrying out track-laying, the use of lasers permits new track to be laid accurately to exact pre-determined requirements.

TRAINING

As with all training schemes, the training of personnel to drive trains is a very expensive exercise, which returns no income at all to the railway authority. The cost of the in-class teaching portion is perhaps insignificant compared to the much greater costs of actually taking a locomotive on to the running line purely for teaching purposes. Because of this some railways have now purchased "driver's simulators" and which are similar in principle to the flight simulators used by airlines to train pilots. These railway simulators permit the trainee drivers to be put through a very extensive training programme in such a way that driving techniques can be adapted to allow the optimum performance from the driver. When the driver does eventually take a train onto the running line, it can then be driven in the most efficient manner possible, thus giving maximum savings to the railway authority.

This concludes our brief insight into the fascinating world of the modern-day railway industry. I hope that you are now a little more aware of the technologies which are in use to keep the world's trains running efficiently and safely.

PE

The London Docklands Light Railway photos were kindly supplied by GEC-General Signalling Ltd.

Track Trends

In its 1988 Annual Review, British Rail's Research Division highlights the range of research carried out in the engineering and scientific fields during the last 12 months.

Research projects approaching fruition include installation of integrated electronic control centres (IECCs) at London's Liverpool Street, Newcastle on Tyne and Glasgow, combining solid state interlocking with automated regulation and route setting, together with high resolution visual display units.

An automatic vehicle identification system for 'merry-go-round' coal traffic is planned to be operational by 1991, following the success of a pilot scheme.

Quality of service to customers is set to improve with a computer-based timetable enquiry system now being installed at 24 telephone enquiry bureaux in Network SouthEast, including BR's largest at Waterloo with 53 answering positions.

Many other research projects are highlighted in the Research Review 1988 copies of which may be obtained from the Public Affairs Manager, Research Division, Railway Technical Centre, Derby. Tel: 0332 386695.

ANGLIAN ROLL-OUT

The first of Network SouthEast's brand new Class 321 'Anglia Electric' trains has been rolled out at British Rail Engineering's York manufacturing works in a special ceremony.

A fleet of 46 four-car Anglia Electric trains is on order from BREL under a contract worth more than £62 million. From early 1989 they enter service on Network's busy Liverpool Street to Cambridge and Southend Victoria lines. Delivery is expected to be completed in Summer 1989.

The main features of the new 100mph trains, which will provide more than 14,000 extra seats, are First and Standard Class seating in Network's bright and attractive colours, two toilets, facilities for disabled people, public address equipment and wall murals depicting local scenes and landmarks.

Network SouthEast's Director Chris Green congratulated BREL's York team for achieving the "seemingly impossible task" of completing the first Class 321 some 6 weeks ahead of target.

SOFTMACHINE DISTRIBUTION LTD
FOR OEMs/TRADE

★ EPROM WRITER ★ EPROM ERASER
★ PC HAND TOOLS ★ CPU STANDS
★ COMPUTER CASES ★ POWER SUPPLY
★ MAIN BOARDS ★ MONITORS

TRADE HOURS: 10 - 6pm
TEL: 01-8077644 FAX: 01-807 2748

SOFTMACHINE DISTRIBUTION LTD
UNITS F18/F25, HARBET ROAD,
LEA VALLEY, EDMONTON,
LONDON, N18 3LR ENGLAND.

ELMASET INSTRUMENT CASE
300 x 133 x 217mm deep ..... **£10 ea (£2.20)**

REGULATORS
LM317T PLASTIC T0220 variable **£1**
LM317 METAL **£2.20**
7812 METAL 12V 1A **£1**
7805/12/15/24V plastic ..... **45p** 100+**20p** 1000+ **15p**
7905/12/15/24 plastic ..... **45p** 100+**20p** 1000+ **15p**
CA3085 T099 variable reg ..... 2/£1
LM338 5A VARIABLE **£5**

COMPUTER ICS
4164-15 ex equipment **£1**
USED 41256-15 ..... **£4.20**
9 x 41256-15 SIMM MODULE NEW **£36**
41256-10 SURFACE MOUNT EX NEW BOARDS **£4**
HD146818 CLOCK IC **£2**
2864 EEPROM **£6**
27128A 250nS EPROM NEW **£3.20**
1770 FLOPPY DISC CONTROLLER CHIP **£10**
68008 PROCESSOR EX-EQPT **£5**
ALL USED EPROMS ERASED AND BLANK CHECKED CAN BE PROGRAMMED IF DESIRED.
2764-30 USED **£2**
2716-45 USED ..... **£2** 100/£1
2732-45 USED ..... **£2** 100/£1
2764-30 USED ..... **£2** 100/**£1.60**
27128-25/30 USED **£2.50**
27C256-30 USED **£3**
1702 EPROM EX EQPT **£5**
2114 EX EQPT 60p 4116 EX EQPT **70p**
6264-15 8k static ram **£6**
4416 RAM **£3.50**
ZN427E-8 ..... **£3.50**
ZN428E-8 ..... **£3.50**

CRYSTAL OSCILLATOR
1.8342 MHz ..... 2/£1

CRYSTALS
2.77 MHz/4.9152 MHz/49.504MHz ..... **£1 each**

TRANSISTORS
BC107, BCY70 PREFORMED LEADS
full spec **£1**/20 **£4**/100 **£30**/1000

SIL RESISTOR NETWORKS
8 PIN 10k 22k ..... 5/£1
9 PIN 22k ..... 5/£1
10 PIN 68R 180R 22k ..... 5/£1

POWER TRANSISTORS
OC35 (Marked CV7084) **£1**
POWER FET IRF9531 8A 60V ..... 2/£1
2SC1520 sim BF259 ..... 3/£1 100/£22
TIP141/2 £1 ea TIP112/125/42B ..... 2/£1
TIP35B TIP35C **£1.50**
SE9301 100V 10A DARL. SIM TIP121 ..... 2/£1
2N3055 EX EQPT TESTED ..... 4/£1
PLASTIC 3055 OR 2955 equiv 50p ..... 100/£35
2N3773 NPN 25A 160V £1.80 ..... 10/£16
BD132 ..... 5/£1

QUARTZ HALOGEN LAMPS
A1/216 24V 150 WATTS **£2.25**
H1 12V 50W (CAR SPOT) **£1.50**

NICKEL CADMIUM BATTERIES
7.2 volts 1.8 A/hr.C CELLS IN PACKS OF 6 ..... **£5 p&p £1**
ZIF SOCKETS ..... **2/£1.50**
TEXTOOL single in line 32 way. Can be ganged (coupling supplied) for use with any dual in line devices.

MISCELLANEOUS
NEW ULTRASONIC TRANSDUCERS 40kHz ..... **£1.50** pair
12 CORE CABLE OVERALL SCREEN ..... **£1**/3 metres
POWERFUL SMALL CYLINDRICAL MAGNETS ..... 3/£1
OP AMP LM10CLN **£2.90**
BNC 50 OHM SCREENED CHASSIS SOCKET ..... 3/£1
BNC TO CROC CLIPS LEAD 1 metre **£1**
MOULDED INDUCTOR 470μH
size of a 1 watt film resistor ..... 5/£1
TO-220 HEAT SINK sim RS 403-162 ..... 10/£2.50
SMALL MICROWAVE DIODES AEI DC1028A ..... 2/£1
D.I.L. SWITCHES 10 WAY **£1** 8 WAY **80p** 4/5/6 WAY **50p**
180 volt 1 watt ZENERS also 12v & 75v ..... 20/£1
OLIVETTI LOGOS CALCULATOR KEYBOARD (27 KEY) PLUS 12 DIGIT FLUORESCENT DISPLAY ON DRIVER BOARD (i.e. CALCULATOR LESS CASE, TRANSFORMER AND PRINTER) **£1.30**
PLASTIC EQUIPMENT CASE 9 x 6 x 1.25 in. WITH FRONT AND REAR PANELS CONTAINING PCB WITH EPROM 2764-30 AND ICS 7417 LS30 LS32 LS74 LS367 LM311 7805 REG, 9 WAY D PLUG, PUSH BUTTON SWITCH, DIN SOCKET **£1.90**
VN10LM 60v ½A 5ohm TO-92 mosfet ..... 4/£1 100/£20
MIN GLASS NEONS ..... 10/£1

RELAY 5v 2 pole changeover looks like RS 355-741 marked STC 47WB05T ..... 2/£1
MINIATURE CO-AX FREE PLUG RS 456-071 ..... 2/£1
MINIATURE CO-AX FREE SKT. RS 456-273 ..... 2/£1.50
DIL REED RELAY 2 POLE n/o CONTACTS **£1**
PCB WITH 2N2646 UNIJUNCTION with 12v 4 POLE RELAY **£1**
400m 0.5w thick film resistors (yes four hundred megohms) 4/£1
MINIATURE CO-AX FREE PLUG RS 456-071 ..... 2/£1
MINIATURE CO-AX FREE SKT. RS 456-273 ..... 2/£1.50
STRAIN GAUGES 40 ohm Foil type polyester backed balco grid alloy ..... **£1.50 ea 10+ £1**
ELECTRET MICROPHONE INSERT **£0.90**
Linear Hall effect IC Micro Switch no 613 SS4 sim RS 304-267 ..... **£2.50** 100+ **£1.50**
HALL EFFECT IC UGS3040 + MAGNET **£1**
OSCILLOSCOPE PROBE SWITCHED X1 X10 ..... **£10**
CHEAP PHONO PLUGS ..... 100/£2 1000/£18
1 pole 12 way rotary switch ..... 4/£1
AUDIO ICS LM380 LM386 ..... **£1 ea**
555 TIMER 5/£1 741 OP AMP ..... 5/£1
ZN414 AM RADIO CHIP **80p**
COAX PLUGS nice ones ..... 4/£1
COAX BACK TO BACK JOINERS ..... 3/£1
4 x 4 MEMBRANE KEYBOARD **£1.50**
15,000uF 40V ..... **£2.50 (£1.25)**
INDUCTOR 20uH 1.5A ..... 5/£1
NEW BT PLUG + LEAD **£1.50**
1.25" PANEL FUSEHOLDERS ..... 5/£1
CHROMED STEEL HINGES 14.5 x 1" OPEN ..... **£1 each**
12v 1.2w small wire ended lamps fit AUDI VW TR7 SAAB VOLVO ..... 10/£1
12V MES LAMPS ..... 10/£1
STEREO CASSETTE HEAD **£2**
MONO CASS.HEAD £1 ERASE HEAD **50p**
THERMAL CUT OUTS 50 77 85 120°C ..... **£1 ea**
THERMAL FUSE 121°C 240V 15A ..... 5/£1
TRANSISTOR MOUNTING PADS TO-5/TO-18 ..... **£3**/1000
TO-3 TRANSISTOR COVERS ..... 10/£1
STICK ON CABINET FEET ..... 30/£1
PCB PINS FIT 0.1" VERO ..... 200/£1
TO-220 micas + bushes ..... 10/**50p** 100/£2
TO-3 mica + bushes ..... 20/£1
PTFE min screened cable ..... 10m/£1
Large heat shrink sleeving pack **£2**
CERAMIC FILTERS 6M/9M/10.7M ..... **50p** 100/£20
TOKIN MAINS RFI FILTER 250v 15A **£3**
IEC chassis plug rfi filter 10A **£3**
Potentiometers short spindles values 2k5 10k 25k 1m
2M5 lin ..... 5/£1
500k lin 500k log ..... 4/£1
40Khz ULTRASONIC TRANSDUCERS EX-EQPT NO DATA **£1**/pr
PLESSEY INVERTER TRANSFORMER ..... **50 CYCLES**
11.5-0-11.5V to 240v 200VA ..... **£6 (£3)**

ZENERS
5.6V 1W3 SEMIKRON 50K AVAILABLE @£25/1000
SUPRESSOR OF606 120V BI DIRECTIONAL ZENER IN 3 AMP W/E PACKAGE ..... 5/£1

DIODES AND RECTIFIERS
1N4148 ..... 100/£1.50
1N4004/SD4 1A 300V ..... 100/£3
1N5401 3A 100V ..... 10/£1
BA158 1A 400V fast recovery ..... 100/£3
BA159 1A 1000V fast recovery ..... 100/£4
120V 35A STUD **65p**
BY127 1200V 1.2A ..... 10/£1
BY254 800V 3A ..... 8/£1
BY255 1300V 3A ..... 6/£1
6A 100V SIMILAR MR751 ..... 4/£1
VM88 800mA 100V DIL B/REC ..... 5/£1
BY164 BRIDGE RECTIFIER ..... 2/£1
1A 800V BRIDGE RECTIFIER ..... 4/£1
4A 100V BRIDGE ..... 3/£1
6A 100V BRIDGE ..... 2/£1
8A 200V BRIDGE ..... 2/£1.35
10A 200V BRIDGE **£1.50**
25A 200V BRIDGE **£2** ..... 10/£18
25A 400V BRIDGE **£2.50** ..... 10/£22

SCRS
2P4M EQUIV CI06D ..... 3/£1 100/£20
MCR72-6 10A 600V SCR **£1**
35A 600V STUD SCR **£2**
TICV106D 800mA 400V SCR ..... 3/£1 100/£15
MEU21 PROG. UNIJUNCTION ..... 3/£1

TRIACS ..... DIACS 4/£1
BT137-600 8A TO-220 ..... 2/£1
BT138-600 12A TO-220 ..... **70p**
NEC TRIAC AC08F 8A 600V TO220 ..... 5/£2 100/£30
TXAL225 8A 400V 5mA GATE ..... 2/£1 100/£35
TRAL2230D 30A 400V ISOLATED STUD ..... **£4 each**

CONNECTORS
34 way card edge IDC CONNECTOR (disk drive type) **£1.25**
CENTRONICS 36 WAY IDC PLUG **£2.50**
CENTRONICS 36 WAY IDC SKT **£4.00**
BBC TO CENTRONICS PRINTER LEAD 1.5M **£3.50**
CENTRONICS 36 WAY PLUG SOLDER TYPE **£4**
USED CENTRONICS 36W PLUG+SKT **£3**

USED D CONNECTORS price per pair
D9 **60p**, D15 **£1.50**, D25 **£2**, D37 **£2**, D50 **£3.50** covers **50p ea.**

WIRE WOUND RESISTORS
W21 or sim 2.5W 10 of one value **£1**
R10 OR15 OR22 2R0 2R7 4R7 5R0 5R6 8R2 10R 12R 15R 18R 20R 22R 27R 33R 36R 47R 56R 62R 91R 120R 180R 390R 430R 470R 680R 820R 910R 1K15 1K2 1K5 1K8 2K4 2K7 3K3 3K0 5K0
10K R05 (50 milli-ohm) 1% 3w ..... 4 FOR £1
W22 or sim 6W 7 OF ONE VALUE **£1**
R47 R62 1R0 1R5 1R8 3R3 6R8 9R1 12R 20R 24R 27R 33R 51R 56R 62R 68R 100R 120R 180R 220R 390R 560R 620R 910R 1K0 1K2 1K5 1K8 2K2 2K7 3K3 3K9 4K7 8K2 10k 15K 16K 20K
W23 or sim 9W 6 of one value **£1**
R22 R47 1R0 1R1 15R 56R 62R 100R 120R 180R 220R 300R 390R 680R 1KO 1K5 5K1 10K
W24 or sim 12W 4 OF ONE VALUE **£1**
R50 2R0 9R1 18R 22R 27R 56R 68R 75R 82R 100R 150R 180R 200R 220R 270R 400R 620R 1K0 6K8 8K2 10K 15K

PHOTO DEVICES
SLOTTED OPTO-SWITCH OPCOA OPB815 ..... **£1.30**
2N5777 ..... **50p**
TIL81 PHOTO TRANSISTOR **£1**
TIL38 INFRA RED LED ..... 5/£1
OP12252 OPTO ISOLATOR **50p**
PHOTO DIODE **50p** ..... 6/£2
MEL12 (PHOTO DARLINGTON BASE n/c) **50p**
RPY58A LDR **50p** ORP12 LDR **70p**
LEDs RED 3 or 5mm 12/**£1** ..... 100/£6
LEDs GREEN OR YELLOW 10/**£1** ..... 100/£6.50
LEDS ASSORTED RD/GN/YW + INFRA/RED ..... 200/£5
FLASHING RED OR GREEN LED 5mm **50p** ..... 100/£35

SUB MIN PRESETS HORIZONTAL 15/£1 100/£5
1K 4K7 10K 22K 47K 1M 10M

STC NTC BEAD THERMISTORS
G22 220R, G13 1K, G23 2K, G24 20K, G54 50K, G25 200K, G16 1M, RES @ 20°C DIRECTLY HEATED TYPE ..... **£1 ea**
FS22BW NTC BEAD INSIDE END OF 1" GLASS PROBE RES @ 20°C 200R ..... **£1 ea**

CERMET MULTI TURN PRESETS ¾"
10R 20R 100R 200R 250R 500R 2K 2K2 2K5 5K 10K 22K 47K 50K 100K 200K 500K 2M2 ..... **50p each**

IC SOCKETS
6 pin 15/**£1** 8 pin 12/**£1** 14/16 pin 10/**£1** 18/20 pin 7/**£1**, 22/24/28 pin 4/**£1** 40 pin **30p**

SOLID STATE RELAYS
40A 250V AC SOLID STATE RELAYS **£18**

POLYESTER/POLYCARB CAPS
1n/3n3/5n6/8n2/10n 1% 63v 10mm ..... 100/£6
10n/15n/22n/33n/47n/68n 10mm rad ..... 100/£3.50
100n 250v radial 10mm ..... 100/£3
100n 600v sprague axial 10/**£1** ..... 100/£6 (£1)
2u2 160v rad 22mm ..... 100/£10
10n/33n/47n 250v ac x rated 15mm ..... 10/£1
470n 250v ac x rated rad ..... 4/£1
1U 600V MIXED DIELECTRIC ..... **50p ea.**

RF BITS
12 volt CO-AXIAL relays sim. RS 349-686 ..... **£6**
Ex-equipment, with BNC tails
TRIMMER CAPS ALL **4/50p**
SMALL 5pf 2 pin mounting 5mm centres
SMALL MULLARD 2 to 22pF **4/50p**
SMALL MULLARD 5 to 50pF **4/50p**
grey larger type 2 to 25pF
TRANSISTORS 2N4427 ..... **60p**
FEED THRU CERAMIC CAPS 1000pF ..... 10/£1

MINIATURE RELAYS Suitable for RF
5 volt coil 1 pole changeover **£1**
5 volt coil 2 pole changeover **£1**
12 volt coil 1 pole changeover **£1**

MONOLITHIC CERAMIC CAPICITORS
10n 50v 2.5mm ..... 100/£4.50
100n 50v 2.5mm or 5mm ..... 100/£6
100n ax short leads ..... 100/£3
100n ax long leads ..... 100/£6
10n 50v dil package 0.3" rad **£4**/100 **£35**1000
100n 50v dil package 0.3" rad **£10**/100

STEPPER MOTORS
4 PHASE 2 9V WINDINGS **£3.50**

KEYTRONICS
TEL. 0279-505543
FAX. 0279-757656
P O BOX 634
BISHOPS STORTFORD
HERTFORDSHIRE CM23 2RX

MAIL ORDER ONLY
MIN CASH ORDER £3.00 OFFICIAL ORDERS WELCOME
UNIVERSITIES COLLEGES SCHOOLS GOVT DEPARTMENTS
MIN. ACCOUNT ORDER £10.00
P&P AS SHOWN IN BRACKETS (HEAVY ITEMS)
65p OTHERWISE (LIGHT ITEMS)
ADD 15% VAT TO TOTAL
ELECTRONIC COMPONENTS BOUGHT FOR CASH

Access

ELECTRONICA 88 - MUNICH

BY JOHN BECKER

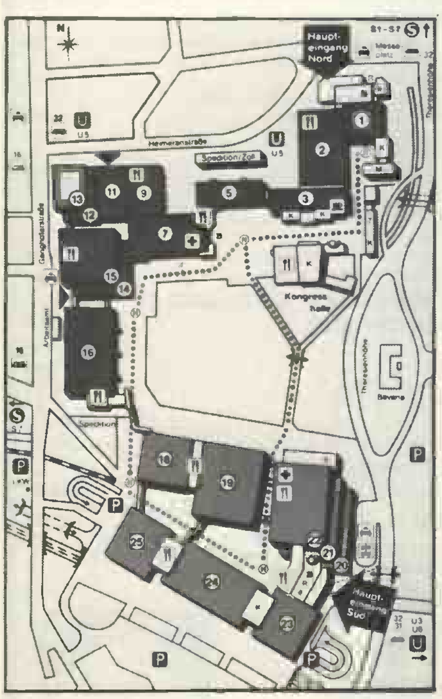
The World's largest trade fair for electronic components and assemblies took place at Munich between the 8th and 12th of November 1988. What an amazing exhibition it was. . .

Manufacturers from both major and minor industrial nations from around the globe were at Electronica 88 in force displaying the latest in electronic high technology.

Irrespective of nationality, all exhibitors had one objective - to make their products better known to potential buyers. An exhibition of this calibre is where major decisions are made that determine the nature of tomorrow's equipment - from industrial control automation and military defense systems to consumer goods. It was a show no-one with a significant interest in electronics could afford to miss, but even for those with no direct use for hi-tech components, the technology on display will ultimately have an impact.

DEPARTURE

Friday the 11th thus saw me at crack of dawn taking the first flight from Gatwick down to Munich. First, though, there was an ironic and unscheduled display of some of the problems yet to be solved by electronic systems - the main computer at Heathrow took a break from duty and was out of action for an hour. This affected flights not only at Heathrow, but also at Gatwick, resulting in our flight waiting at the take-off point with engines shut down for over half an hour.



Munich Messegelande Exhibition complex

Even so, I was still at the exhibition in reasonable time and made myself known at its Press Office. Though I've previously been to Munich, I've not had the opportunity to visit the Messegelande Exhibition Centre before, but the full extent of it soon became apparent.

FACTS AND FIGURES

The Centre consists of 25 halls set on three sides of a square enclosing an area of semi-parkland. The perimeter around the complex is probably in the region of three to four kilometres.

All the halls were in use for the exhibition and associated conferences and the space available had been fully booked several months before the official deadline. There were approximately 2500 exhibitors from 37 countries.

This level of participation shows that the semiconductor industry in particular is recovering well from the recent slump. Indeed various forecasts predict that, assuming developments on the world economic scene remain stable, there is every reason for optimism. Some forecasters believe that by the turn of the century the international semiconductor market will increase in volume to 160 billion dollars - an increase of five times from that of 1987. European chip manufacturers, although regarded as somewhat conservative in their investments, are likely to see a growth of about 23 per cent annually, achieving a market volume of 11 billion dollars by the much-talked-about date of 1992. Regrettably, though, European manufacturers are unlikely to be in a position to cover European demand for chips. though they are making efforts to reverse the current situation in which around 60 per cent of demand is satisfied by US and Japanese suppliers.

The exhibition confirmed (as if confirmation were necessary!) that no industry, however remote from electronics, can afford to ignore microelectronics. Increasingly, this applies to the motor industry, mechanical and electrical engineering, precision mechanics and optics, as well as to office automation, data processing and consumer products.

MICROPROCESSORS AND MEMORIES

Those of you who consider controlling a DIY mechanical or electronic device will probably think of using a microprocessor, associated interfaces and data storage chips. The exhibition showed that techniques of this type are likely to be in demand for the foreseeable future and many manufacturers had products related to this multi-chip approach, though as we shall see in a moment, more sophisticated techniques have taken a firm hold.

On the memory scene faster, smaller, greater capacity chips were in abundance. One megabit rams are commonplace (or would be if supply could keep up with demand!) and already 4-megabit rams and eproms are in the advanced development stages. Some Japanese manufacturers are also working on 16-megabit rams but an enormous investment is required in the development of memory devices that need innumerable uniform structures measuring less than one-thousandth of a millimetre. Remember that increased memory capacity within a single device is usually only beneficial if it can be accessed quickly, and that can only be achieved when the distance the signal has to travel is small. However, European manufacturers, in joint effort under JESSI (Joint European Submicron Silicon) expect to surpass 16-megabit

Interior of one of the halls


International components for all disciplines

capacity by introducing a 64-Mbit dram by the mid 1990s. These will be capable of storing over 4000 typewritten pages (around 8.4 million characters), and will be barely any larger than an average finger nail. Inevitably I wonder how soon these will replace hard disks in many computers.

RISC

RISC processors are rapidly becoming a dominant force. These benefit from a much smaller set of instruction commands, so reducing the overall circuit size, permitting more functions to be included, and increasing the access speed. In simple terms, their instruction sets include only the most commonly used commands - in the region of 20 per cent of those available in more conventional processors. Typically, risc processors can consist of single chips capable of performing over 100,000 functions enabling computers to process up to 17 million instructions per second. In addition to increasing computer speeds, risc chips have many applications ranging from graphics generation and robotic control to language recognition.

ASICS increasingly important

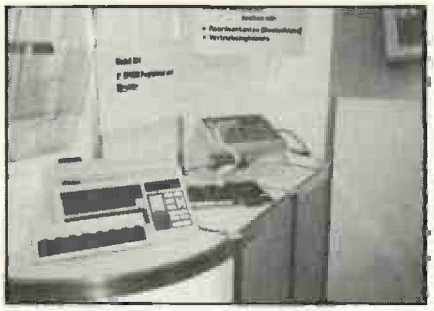
ASICS

Many manufacturers were obviously well aware of the importance of user-programmable logic elements including gate arrays and plds (programmable logic devices) and other devices in the asic family (application specific ics).

Although asics have been in existence since the mid-sixties they have become increasingly important over the last few years. In a nut-shell, they basically allow chips to be tailored to the desired task. Whereas previously a logic system might be made up of numerous individual off-the-shelf devices, asics can be programmed to perform the same task within a single chip. This technique provides for lower manufacturing costs, reduced power consumption, more compact system size and increased functionality. The applications for asics are countless though most are currently used in telecommunications, the automobile industry, and, inevitably, in military applications. It is hardly surprising that a very wide range of asic-type devices were in strong evidence.

A few examples of computer aided electronic automation design systems were also on display.


Typical CAD system


Eprom simulators

OTHER PROGRAMMABLES

Improvements to conventional programmable devices continue to be made. New eproms with faster programming speeds and lower programming voltages; eeproms with increased life-cycle expectancy; and new breeds of non-volatile memory devices that retain data without applied power or burn-in programming pulses.

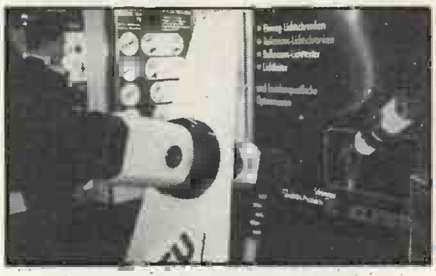
TRANSPUTERS

Surprisingly, though there was some evidence of transputer-orientated systems, I saw less than I had expected. Parallel processing devices of this nature must surely become more commonplace soon - much greater processing speed can be achieved if several computations can be carried out simultaneously rather than consecutively.


INMOS transputer stand

CONVERTERS

With the increased speed of microprocessors and the like, real-world interfaces need to keep pace by also being upgraded. Analogue to digital converters for example were in abundance, some of them having 18-bit resolution, others having scanning rates as high as two gigahertz.


Strong emphasis on optoelectronics

ECL & GAAS

MOS and modern ttl chips are likely to remain with us for the foreseeable future, but chip manufacturers were obviously aware of the importance of the more recently introduced bipolar ecl and gallium arsenide ics. Though both products are capable of extremely high processing speeds, it appears that ecl is more in favour at present. Gallium arsenide devices are currently hampered by high production costs and low output yield.

OPTOELECTRONICS

Optoelectronic devices were well represented. This technology is vital to office automation, telecommunications and so forth, and no doubt will be even more heavily emphasised at the "Lasers, Optoelectronics, Microwaves" exhibition to be held in Munich during June 5th to 9th 1989. Many aspects of this technology were on display, including simple leds, cathode ray tubes, fibreoptic networks and lcds. I was especially impressed by the use to which lcds were put - from computer screens and message displays, to solid state oscilloscope readouts. There were also several examples of colour lcd displays.


LCD scopes on display


CCD products

New versions of ccd light detectors were on show, and various forms of infra-red detector. I was highly amused by the exhibitor of an infrared camera used for detecting body heat from persons trapped in collapsed buildings. Seeing me photograph the camera in its display case, he enthusiastically removed the camera and had a young fraulein member of staff demonstrate it so that I could take a more interesting photograph. Such kind helpfulness!

Heat detecting camera proudly displayed

POWER SEMICONDUCTORS

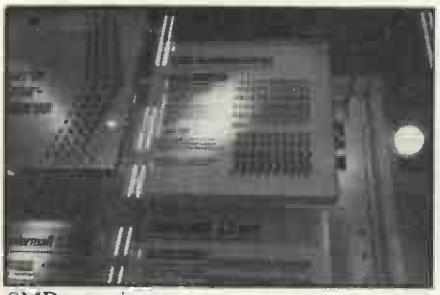
It was obvious that power semiconductors are gaining in significance and capabilities. Automation of mechanical control systems is one area where power semiconductors, including diodes, thyristors, triacs, bipolar transistors and power mosfets, will greatly enhance performance and reliability, and reduce production costs.


PCBs well represented

PCBS

Printed circuit technology was naturally well represented and some of the pcbs on display were mind-boggling examples of manufacturing and design sophistication. There was one board that I thought so impressive that I asked the exhibitor if I might photograph it - the full meaning of his reply was beyond my knowledge of German, but I gathered that on no account would he run the risk of my copying his board from a photograph! What a contrast to the ir-camera man.

Some of the multi-layer pcbs on display could never have their sophistication shown in a single photo - even a double-sided board is difficult, let alone one having 16 layers of tracking. Typically, multilayer pcbs can have conductor widths of less than 150 microns, and through-plated holes of only 0.3mm diameter. Flexible pcbs are now well established and there were numerous examples of those that could be bent to fit a particular enclosure shape, or which


SMD capacitors

could be subjected to constant flexing in moving systems without damage to the tracks.

SMT

Surface mounting technology in principle should allow pcbs to become smaller since smds themselves are smaller and do not require holes to be drilled in pcbs. Two things were obvious on this score, first that the pcbs on display simply had far more components on them when smds were used. Secondly, despite the earlier expectations that smds would in many instances replace normal through-hole mounting components, industry appears reluctant to make the change in manufacturing techniques.

There were smds on display, but by no means in the quantities I would have expected. I gather that only about five per cent of pcb assemblies use nothing-but smds, most other boards still use conventional wire-ended components, either intermixed with smds, or on their own. Nonetheless it is inconceivable that smt will remain underused and there seems no doubt that more manufacturers will soon recognise its advantages, even though it is currently more expensive and requires highly sophisticated design and assembly equipment.


Robotic PCB assembly

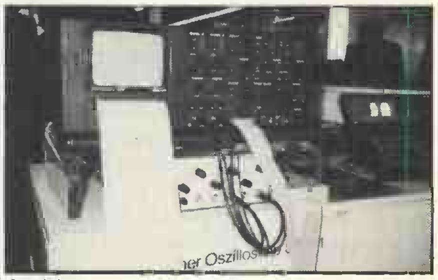
ASSEMBLY

I had hoped that there would be examples of pcb manufacturing and assembly equipment on display, but as I progressed from hall to hall it became increasingly obvious that equipment of that size would have been out of place in a components exhibition. Apart from one robot impressing an audience by inserting ics into a pcb I saw little else that was directly related to automatic assembly. There were, though, examples of computer-aided pcb design, and also many varieties of eprom programmers.


Automatic IC tester

TESTING

With increased circuit speeds and precision comes the need for ever faster and more sophisticated test equipment. Different types of test equipment were on show that enable automatic post-assembly checking to be carried out to pcb mounted circuitry. Equipment ranged in capabilities from checking analogue and digital circuits as separate entities, to full testing of combined analogue and digital circuits. Some sophisticated equipment was also capable of learning from a correctly working circuit what responses it should look for in other similar assemblies.


Oscilloscope with printout. An LCD scope is seen to the right

Many oscilloscopes were on display, from the conventional analogue, to multiple-storage digital types, with maximum display rates ranging from 1MHz to 100MHz and beyond. Liquid crystal display scopes were also in evidence, though as yet the screens remain on the small size. There were signal generators galore, spectrum analysers with ranges up to 5GHz, and scores of power supplies with practically every output option conceivable. There were more varieties of digital multimeter than I would have cared to count, many of them appealing to aesthetics as much as functionality by being made in different colours. Much of the test equipment was capable of being plugged into a computer for storage and analysis procedures. Many items also had in-built printers for paper printouts of the data.

Multimeters galore


Customised test bench

QUALITY CONTROL

A fair proportion of the show was to do with automatic quality control. Quality control these days is rarely a visual task, especially when it comes to electronics manufacturing. With components containing thousands or even millions of interconnected elements computer aided quality assurance (caq) is essential if a company is to remain competitive.

CAQ is implemented at strategic stages of component manufacture so keeping final rejects to minimum. I have previously commented in PE that component failure is now extremely rare. This is due to manufacturers ensuring that their inspection techniques minimise the risk of in-service failure. It was obvious at the show that manufacturers place great emphasis on quality planning and control and that end-users should have confidence in manufacturing inspection processes. Naturally, product price will depend on the degree of acceptable failure rate and this may be specified by the customer. But even zero-defect consignments may be ordered by equipment manufacturers who are totally dependent upon fully automated assembly lines in which any component failure could be financially problematic.

CONCLUSION

This show at Munich probably ranks as the most incredible exhibition on a single main technology that I have had to pleasure and interest to visit. It was extremely well organised, spaciously and comfortably laid out, and was highly informative. I am conscious that there were other aspects that I have not mentioned here, but a single day was insufficient to examine everything from 2500 exhibitors. Nor was there time, for example, to sit in on any of the conferences that were running concurrently with the exhibition. I could quite happily have spent the whole week there and still found more to study.

Shows like Electronica give reality to the world of developing electronic sophistication in a way that cannot be achieved by browsing through floods of press releases and trade magazines. The exhibition will take place again at Munich in two years time - I can hardly wait.

PE

EXHIBITORS

Argentina	1	Ireland	25
Australia	2	Israel	18
Austria	23	Italy	82
Belgium	17	Japan	83
Brazil	1	Korea	11
Canada	19	Liechtenstein	1
China	1	Mexico	1
Czechoslovakia	1	Monaco	1
Denmark	15	Netherlands	26
Finland	12	Norway	4
France	112	Singapore	12
East Germany	2	South Africa	1
West Germany	1243	Spain	24
Greece	2	Sweden	14
Great Britain	174	Switzerland	91
Hong Kong	11	Taiwan	56
Hungary	5	USA	394
India	1	USSR	1
		Yugoslavia	1

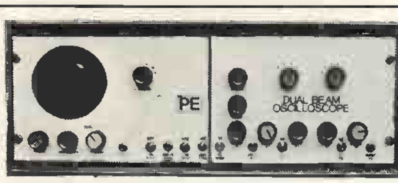

An amazing exhibition with so much of interest

PUBLISHED DESIGN FEATURES

★ LEARN BY BUILDING ★ ENJOY BY USING ★

PROJECT KITS

★ BE CREATIVE ★ RAISE YOUR SKILLS ★ GET KITTED! ★


DUAL BEAM OSCILLOSCOPE
2Y-amps, 6 ranges, variable level, DC to over 1MHz. 4 modes – Y1, Y2, Y1 & Y2, Y1 & Y2 to X. Time base variable from 0.05Hz to 20KHz. Variable sync level, polarity and source. Separate bright-line, brilliance and focus controls. Independent trace deflection controls. Details in catalogue.

BURGLAR ALARM CONTROLLERS
MULTIZONE CONTROL SET280 £22.77
Two entry-zones, anti-tamper loop, personal attack, entry-exit timing, timed duration, automatic resetting, latching LED monitors.
SINGLE ZONE CONTROL SET279 £9.32
With timed duration control and latching LED monitor.
Both units can be used with any standard detection devices, such as contact or magnetic switches, pressure pads, tremblers, ultrasonics, infrared etc., and will activate standard bells, strobes or sirens.

COMPUTER KITS
The software listings published with the computer kit projects are for use with C64, PET and BBC computers.
CHIP TESTER SET258F £39.30
Computer controlled logic and chip analyser.
EPROM PROGRAMMER SET277 £25.25
Computer controlled unit for 4K Eproms.
MICRO-CHAT SET276 £64.50
Computer controlled speech synthesiser.
MICRO-SCOPE SET247 £44.50
Turns a computer into an oscilloscope.
MICRO-TUNER SET257 £55.32
Computer controlled, tuning aid and freq counter.
MORSE DECODER SET269 £22.16
Computer controlled morse code-decoder.

SEND 9"x4" S.A.E. FOR CATALOGUE AND WITH ALL ENQUIRIES (OVERSEAS SEND £1.00)

VARIOUS
VOICE SCRAMBLER SET287 £42.22
32 switchable channels to keep your communications confidential.
STORMS! £29.50 each unit
Raw nature under panel control! Wind & Rain SET250W. Thunder & Lightning SET250T.
DISCO-LIGHTS SET245F £62.50
3 chan sound to light, chasers, auto level.
EVENT COUNTER SET278 £31.50
4-digit display counting for any logic source.

ASTRONOMY

SIDEREAL CLOCK SET295 £49.50
Dual purpose star-time and solar-time digital clock with alarm.

ENVIRONMENT
WEATHER CENTRE
Keep the Met Office in check and monitor the wind speed and direction, rain, temperature, soil moisture and sunny days.
Six detector circuits – KIT 275.1 £18.07
Automatic metered control monitor circuit – KIT 275.2 £40.95
Optional computer control circuit – KIT 275.3 £14.20
ELECTRONIC BAROMETER SET285 £35.55
Computer controlled unit for monitoring atmospheric pressure.
GEIGER COUNTER SET264 £59.50
A nuclear radiation detector for environmental and geological monitoring. With built in speaker, meter and digital output. This project was demonstrated on BBC TV.

ORDERING
Send 9"x4" SAE for detailed catalogue, and with all enquiries (overseas send £1.00 or 5 I.R.C.'s). Add 15% VAT. Add P&P – Sets over £5 add £2.50. Others add £1.50. Overseas P&P in catalogue. Text photocopies – Geiger 264 and Weather 275 £1.50, others 50p, plus 50p post or large SAE. Insurance 50p per £50. MAIL ORDER, CWO, CHQ, PO, ACCESS VISA. Telephone orders: Mon-Fri, 9am – 6pm. 0689 37821. (Usually answering machine).

PHONOSONICS, DEPT PE92, 8 FINUCANE DRIVE, ORPINGTON, KENT, BR5 4ED. MAIL ORDER

MAGENTA ELECTRONICS Ltd

PROJECT KITS

Magenta supply Full Kits: Including PCB's (or Stripboard), Hardware, Components, and Cases (unless stated). Please state Kit Reference Number, Kit Title, and Price, when ordering.
REPRINTS: If you do not have the issue of E.E. which includes the project, you will need to order the instruction reprint as an extra: 80p each. Reprints are also available separately–Send £1 in stamps.

REF NO.	KIT-TITLE	PRICE
789	AMSTRAD P10 Sept 88	(phone)
788	TIME SWITCH Aug 88	£17.61
787	SPIKEATER July 88	£3.99
786	UNIVERSAL NICAD CHARGER July 88	£6.99
785	ISOLINK July 88	£24.51
784	VIDEO WIPER July 88	£33.59
783	HEADLIGHT REMINDER June 88	£7.99
782	DOOR SENTINEL May 88	£12.81
781	SUPER SOUND EFFECTS	
	GENERATOR May 88	£12.99
780	CABLE & PIPE LOCATOR April 88	£15.35
779	STEREO NOISE GATE April 88	£26.98
778	INDUCTIVE PROXIMITY DET. April 88	£8.63
777	LOW FUEL ALERT April 88	£6.43
772	SEMICONDUCTOR TESTER Mar 88	£23.51
776	LIE DETECTOR Mar 88	£11.80
775	ENVELOPE SHAPER Mar 88	£14.99
774	SOS ALERT Mar 88	£9.36
769	VARIABLE 25V-2A BENCH	
	POWER SUPPLY Feb 88	£49.73
	CAR LAMP CHECKING SYST. Feb 88	£7.10
770	GAME TIMER Feb 88	£14.32
765	QUIZMASTER Jan 88	£18.96
767	TRANSISTOR CURVE TRACER (BBC)	£14.98
763	AUDIO SIGNAL GENERATOR Dec 87	£13.64
764	DUAL MAINS LIGHTS FLASHER Dec 87	£20.98
739	ACCENTED BEAT METRONOME Nov 87	£20.96
740	ACOUSTIC PROBE Nov 87	
	(less bolt & probe)	£16.26
741	BBC SIDEWAYS RAM/ROM Nov 87	£27.53
744	VIDEO CONTROLLER Oct 87	£29.14
745	TRANSTEST Oct 87	£9.70
734	AUTOMATIC PORCH LIGHT Oct 87	£17.17
735	CARAVAN FRIDGE ALERT Oct 87	£5.44
736	STATIC MONITOR Oct 87	£8.66
723	ELECTRONIC MULTIMETER Sept 87	£46.96
729	NOISE GATE Sept 87	£23.25
728	PERSONAL STEREO AMP Sept 87	£14.31
730	BURST-FIRE MAINS CONTROLLER Sept 87	£13.57
724	SUPER SOUND ADAPTOR Aug 87	£38.39
718	3 BAND 1.6-30MHz RADIO Aug 87	£26.53
719	BUCCANEER I.B. METAL DETECTOR inc. coils	
	and case, less handle and hardware July 87	£26.45
720	DIGITAL COUNTER/FREQ METER (10MHz)	
	inc.case July 87	£67.07
721	MONOMIX July 87	£21.00
722	FERMOSTAT July87	£12.14
711	VISUAL GUITAR TUNER Jun 87	£22.99
715	MINI DISCO LIGHT Jun 87	£12.59
709	WINDSCREEN WASHER WARNING May 87	£5.12
708	FRIDGE ALARM May 87	£9.88
707	EQUALIZER (IONISER) May 87	£15.53
705	BULB LIFE EXTENDER April 87 (less case)	£5.24
703	EXP. SPEECH RECOGNITION April 87	£20.98
700	ACTIVE I/R BURGLAR ALARM Mar 87	£35.65
581	VIDEO GUARD Feb 87	£8g39
583	CAR VOLTAGE MONITOR Feb 87	£12.58
584	SPECTRUM SPEECH SYNTH. (no ca)Feb 87	£20.92
578	SPECTRUM I/O PORT less case. Feb 87	£9.44
579	STEPPING MOTOR BOOSTER (for above)Feb 87	£5.46
	STEPPING MOTOR MD200 Feb 87	£16.80
575	HANDS-OFF INTERCOM (per station)	
	inc. caseJan 87	£10.49
568	CAR ALARM Dec 86	£12.47
571	RANDOM NUMBER GENERATOR Dec 86	£15.72
569	BBC 16K SIDEWAYS RAM Dec 86	£12.97
564	CAR FLASHER WARNING Nov 86	£9.37
563	200MHz DIG. FREQUENCY METER Nov 86	£62.98
562	10 WATT AUDIO AMPLIFIER Oct 86	£36.70
561	LIGHT RIDER LAPEL BADGE Oct 86	£10.20
560	LIGHT RIDER DISCO VERSION	£19.62
559	LIGHT RIDER 16 LED VERSION	£13.64
558	SCRATCH BLANKER Sept 86	£56.83
556	INFRA-RED BEAM ALARM Sept 86	£28.35
555	FREEZER FAILURE ALARM Sept 86	£15.50
554	CAR TIMER Sept 86	£8.72
553	BATTERY TESTER Aug 86	£7.19
544	TILT ALARM July 86	£7.82
546	CARAVAN BATTERY MONITOR July 86	£17.17
547	SQUEEKIE CONTINUITY TESTER July 86	£3.52
548	ELECTRONIC SCARECROW July 86	£8.87
540	PERCUSSION SYNTH June 86	£30.43

REF NO.	KIT-TITLE	PRICE
542	PERSONAL RADIO June 86	£11.53
543	WATCHDOG June 86	£8.24
529	MINI STROBE May 86	£13.86
528	PA AMPLIFIER May 86	£26.95
523	STEREO REVERB Apr 86	£26.44
524	VERSATILE PSU Apr 86	£24.69
526	FREELOADER Apr 86	£8.48
513	BBC MIDI INTERFACE Mar 86	£27.94
514	INTERVAL TIMER Mar 86	£18.87
515	STEREO HI-FI PRE-AMP	£49.19
512	MAINS TESTER & FUSE FINDER Mar 86	£8.82
503	FUNCTION GENERATOR Feb 86	£24.84
504	POWER SUPPLY FOR ABOVE	£7.62
497	MUSICAL DOOR BELL Jan 86	£18.72
493	DIGITAL CAPACITANCE METER Dec 85	£41.55
481	SOLDERING IRON CONTROLLER Oct 85	£5.47
473	R.I.A.A. PRE-AMP Sept 85	£16.74
464	STEPPER MOTOR INTERFACE FOR THE BBC	
	COMPUTER less case Aug 85	£11.68
	1D35 STEPPER MOTOR EXTRA	£14.50
	OPTIONAL POWER SUPPLY PARTS	£5.14
461	CONTINUITY TESTER July 85	£6.20
459	AMSTRAD USER PORT July 85	£17.67
455	ELECTRONIC DOORBELL June 85	£7.56
453	GRAPHIC EQUALISER June 85	£26.94
444	INSULATION TESTER Apr 85	£19.50
432	GAMES TIMER Jan 85	£9.11
430	SPECTRUM AMPLIFIER Jan 85	£6.91
417	DOOR CHIME Dec 84	£18.78
392	BBC MICRO AUDIO STORAGE SCOPE	
	INTERFACE Nov 84	£36.25
394	PROXIMITY ALARM Nov 84	£22.66
387	MAINS CABLE DETECTOR Oct 84	£5.53
386	DRILL SPEED CONTROLLER Oct 84	£8.68
381	GUITAR HEAD PHONE AMPLIFIER Sept 84	£7.99
362	VARICAP AM RADIO May 84	£13.15
363	EXPERIMENTAL POWER SUPPLY May 84	£23.50
364	SIMPLE LOOP BURGLAR ALARM May 84	£17.16
358	FUSE/DIODE CHECKER Apr 84	£4.35
356	QUASI STEREO ADAPTOR Apr 84	£13.73
344	SIGNAL TRACER Feb 84	£18.77
337	BIOLOGICAL AMPLIFIER Jan 84	£24.14
334	CONTINUITY TESTER Dec 83	£12.59
332	CHILDREN'S DISCO LIGHTS Dec 83	£10.48
333	NOVEL EGG TIMER Dec 83 inc. case	£12.90
301	STORAGE 'SCOPE INTERFACE FOR	
	BBC MICROAug 83 less software	£19.34
299	HIGH POWER INTERFACE BOARD	
	Aug 83 no case	£12.99
292	USER PORT I/O BOARD	
	less cable +plug	£13.22
293	USER PORT CONTROL BOARD July 83	
	less cable+plug+case	£31.67
277	MW PERSONAL RADIO less case,May 83	£9.60
278	MOISTURE DETECTOR May 83	£6.88
270	NOVELTY EGG TIMER April 83less case	£6.91
263	BUZZ OFF March 83	£5.68
262	PUSH BIKE ALARM Feb 83	£14.77
255	ZX TAPE CONTROL Nov 82	£8.98
242	2- WAY INTERCOM July 82 no case	£5.69
243	REFLEX TESTER July 82	£9.79
240	EGG TIMER June 82	£6.86
237	CAR LED VOLTMETER less case. May 82	£4.00
225	CAMERA OR FLASH GUN TRIGGER	
	Mar 82 less tripod bushes	£17.20
205	SUSTAIN UNIT Oct 81	£17.63
206	TAPE NOISE LIMITER Oct 81	£5.976.27
207	HEADS AND TAILS GAME Oct 81	£3.47
209	PHOTO FLASH SLAVE Oct 81	£4.79
211	FUZZ BOX Oct 81	£10.05
197	0-12V POWER SUPPLY Sept 81	£24.55
181	SOIL MOISTURE INDICATOR E.E. May 81	£5.66
149	GUITAR PRACTICE AMPLIFIER Nov 80	£22.95
	SOUND TO LIGHT Nov 80 3 channel	£29.38
124	SPRING LINE REVERB UNIT Jan 80	£34.27
122	UNIBOARD BURGLAR ALARM Dec 79	£8.38
118	DARKROOM TIMER July 79	£4.03
113	MICROCHIME DOORBELL Feb 79	£21.99
111	SOUND TO LIGHT Sept 78	£18.98
108	IN SITU TRANSISTOR TESTOR Jun 78	£9.42
106	WEIRD SOUND EFFECTS GEN Mar 78	£7.82
101	ELECTRONIC DICE Mar 77	£6.26

TOP KITS

MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY

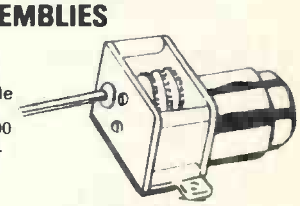
A superb design giving 0-25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V.
Current-Limit control allows Constant Current charging of NICAD batteries, and protects circuits from overload. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

OUR KIT REF. 769 £49.73

COMPONENTS, KITS, BOOKS, TOOLS, MOTORS, GEARS, PULLEYS, OPTICAL FIBRES, ROBOTICS, AND MUCH MUCH MORE–IN OUR NEW CATALOGUE £1.00

MOTOR–GEARBOX ASSEMBLIES

Miniature gearboxes complete with quality electric motor. Variable ratios by fitting 1 to 6 gears. 1.5–4.5v, 3–2200 rpm. Long 3mm shaft. Ideal for robots and buggies.



SMALL (MGS) £3.49 LARGE (MGL) £3.98

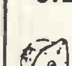
ADVENTURES WITH ELECTRONICS

An easy to follow book suitable for all ages. No soldering, uses an S DEC breadboard. Lots of clear diagrams and instructions to build 16 projects. Component pack includes S DEC and all components for the projects.

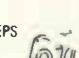
LEGO Technic Sets

TEACHERS WE ARE STOCKISTS OF THE WHOLE RANGE. CONTACT US FOR BROCHURES. VERY COMPETITIVE PRICES AND QUICK DELIVERIES

STEPPING MOTORS 12 VOLT



48 STEPS	200 STEPS
ID35	MD200
£14.50	£16.80



OPTICAL FIBRES TRIAL PACK OF 10 METRES. Nine assorted types & data. **£1.99**

MAGENTA ELECTRONICS LTD.
SHOP NOW OPEN – CALLERS WELCOME

PE11, 135 HUNTER STREET,
BURTON-ON-TRENT,
STAFFS. DE14 2ST.
0283 65435, Mon-Fri 9-5
Access/Barclaycard (Visa) by phone or post.
24 hr Answerphone for credit card orders.
Our prices include VAT

ADD £1 P&P TO ALL ORDERS.
PRICES INCLUDE VAT.
SAE ALL ENQUIRIES.
OFFICIAL ORDERS WELCOME
OVERSEAS: Payment must be sterling.
IRISH REPUBLIC and BFPO. UK PRICES.
EUROPE: UK PRICES plus 10%.
ELSEWHERE: write for quote
SHOP HOURS: 9-5 MON-FRI.

0283 65435

FROM MAGENTA

A SELECTION OF OUR BEST PROJECT KITS

As usual these kits come complete with printed circuit boards, cases, all components, nuts, screws, wire etc. All have been tested by our engineers (many of them are our own designs) to ensure that you get excellent results.

INSULATION TESTER

An electronic High Voltage tester for mains appliances and wiring. An inverter circuit produces 500 volts from a PP3 battery and applies it to the circuit under test. Reads insulation up to 100 Megohms. Completely safe in use.

OUR KIT REF 444 £19.58

DIGITAL CAPACITANCE METER

Simple and accurate (1%) measurements of capacitors from a few pF up to 1,000 uF. Clear 5 digit LED display indicates exact value. Three ranges -- pF, nF, and uF. Just connect the capacitor, press the button and read the value.

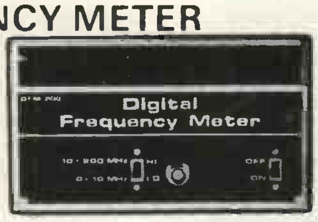
£41.55 OUR KIT REF 493

3 BAND SHORTWAVE RADIO

Covers 1 6 30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

OUR KIT REF 718 £25.27

DIGITAL FREQUENCY METER 200 MHz



An 8 digit meter reading from A.F. up to 200 MHz in two ranges. Large 0.5" Red LED display. Ideal for AF and RF measurements, Amateur and C.B. frequencies.

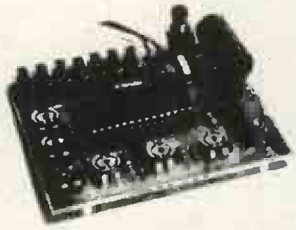
KIT REF 563 £62.98

'EQUALISER' IONISER

A mains powered Ioniser that produces a breeze of negative ions in the air. A compact, safe, simple unit that uses a negligible amount of electricity.

KIT REF 707 £15.53

SUPER SOUND--EFFECTS GENERATOR



A wide range SN76477 sound effects board giving: Bird Chirps, Sirens, Helicopters, Explosions, Phaser Guns, Steam Train sounds, and more. Supplied without a case.

KIT REF 781 £12.99

THE Cirkit WINTER '88-89 CATALOGUE IS OUT NOW!

and features many new products:

- *Books - 12 Latest Titles*
- *Navico 2m Transceiver*
- *Miniature Mains Rocker Switches*
- *8 Channel Logic Analyser*
- *Collet Knobs and Caps*
- *2.4GHz Frequency Meter*
- *10.7MHz Ceramic Filters*
- *Broadcast Band FM Tunersets*
- *RF Dip Meter*
- *IEC Mains Connectors*
- *Scanning Receivers - New Models*
- *100MHz 3 Ch Oscilloscope*
- *RF and AF Signal Generators*
- *Pyropen - Cordless Gas Iron*
- *High Temp Elec Capacitors*
- *Miniature Analogue Multimeter*

Plus discount vouchers, easy to enter competition and feature project. Available from your newsagent or directly from Cirkit.

PRICE £1.30

Cirkit

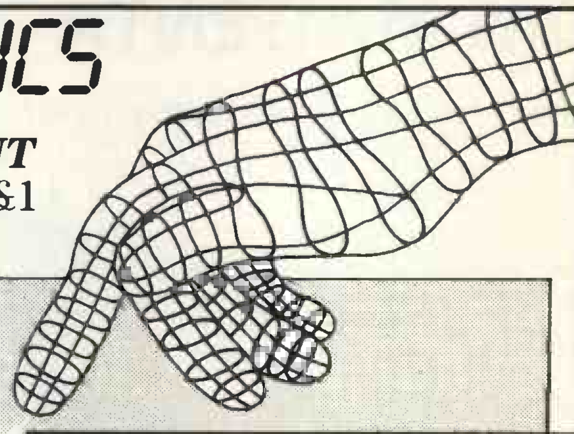
Access VISA

Cirkit Distribution Ltd.
Park Lane, Broxbourne, Herts EN10 7NQ
Telephone (0992) 444111 Telex: 22478

CRICKLEWOOD ELECTRONICS

OUT NOW!

1989 100 PAGE COMPONENT CATALOGUE PRICE £1



SEND OFF FOR YOUR COPY TODAY...

- WE STOCK AN UNRIVALLED RANGE
- ALL OUR COMPONENTS ARE FIRST CLASS BRANDED ITEMS
- WE OFFER A SAME DAY SERVICE ON ALL STOCK ITEMS
- NO MINIMUM ORDER—IF YOU NEED ONE COMPONENT WE CAN SUPPLY ONE COMPONENT
- WE HAVE ADOPTED A NEW LOWER PRICING POLICY + QUANTITY DISCOUNTS
- FREE VOUCHERS WITH YOUR CATALOGUE—ORDER ONE NOW!..

JUST FILL IN THE COUPON OPPOSITE AND POST IT WITH YOUR £1 PAYMENT TO THE ADDRESS BELOW. YOU WILL RECEIVE NOT ONLY OUR SUPERB 100 PAGE CATALOGUE, BUT ALSO FREE VOUCHERS WHICH YOU CAN USE ON YOUR NEXT COMPONENTS ORDER.

CRICKLEWOOD ELECTRONICS LTD 40 CRICKLEWOOD BROADWAY LONDON NW2 3ET TEL: 01-450 0995/452 0161 FAX: 01-208 1441 TELEX: 914977

FREE VOUCHERS!

SEND OFF FOR YOUR CATALOGUE AND VOUCHERS TODAY.

I WOULD LIKE TO RECEIVE...... COPY(COPIES) OF THE 1989 CRICKLEWOOD ELECTRONICS COMPONENT CATALOGUE. I ENCLOSE £...... PLEASE ENCLOSE MY FREE VOUCHERS.

Tape your £1 coin here, or send a cheque or postal order for £1.00 for every catalogue you require.

NAME.......................................

ADDRESS.......................................

....

....

DATA CHIP TECHNOLOGY LTD. (0782) 202617

CPU

Z80A	1.50
Z80B	3.00
8085	1.60
80C85	4.20
8086	9.00
6502	4.40
8031	2.80
80C31	3.50
63A03	7.50
8748	6.50
8749	6.50
64180-8	14.00
68000-8	8.10

CO-PROCESSORS

8087-8	110.00
80287-10	215.00
80387-20	370.00

PERIPHERALS

Z80ACTC	1.30
Z80BCTC	3.00
Z80APIC	1.30
Z80A510-1	1.30
Z80B510-1	3.00
8155	2.00
81C55	3.00
8212	1.45
82C12	3.05
8251	1.90
8251-5	2.70
82C51	3.00
8253	1.60
8253-5	1.95
8255	1.80
8255-5	2.10
82C55	3.00
6522	3.00
6520	2.70
2661CN2B	2.60
6551	4.00
6551A	4.50
6845	5.50

MEMORIES

EPROMS

2716	4.00
2732A	3.80
2764-20	2.85
27C64-20	3.25
27128-25	4.30
27C128-25	3.60
27256-25	5.00
27C256-25	4.35
27C512-25	8.90

SRAMS

6116LP-15	5.80
6264LP-12	7.25
62256LP-12	10.50

DRAMS

4164-15	2.00
41256-15	5.00
4256-10	9.50
51C256-12	8.25

LOGIC

74L500	0.18
74L502	0.18
74L504	0.18
74L508	0.18
74L510	0.18
74L511	0.20
74L514	0.25
74L520	0.20
74L530	0.20
74L532	0.20
74L574	0.20
74L575	0.20
74L586	0.20
74L593	0.25
74L5138	0.30
74L5139	0.30
74L5151	0.30
74L5153	0.25
74L5157	0.30
74L5158	0.35
74L5161	0.40
74L5164	0.45
74L5165	0.60
74L5169	0.60
74L5175	0.45
74L5191	0.45
74L5193	0.45
74L5221	0.50
74L5240	0.50

LOGIC

74L5244	0.50
74L5245	0.50
74L5373	0.50
74L5374	0.50

74XX SERIES

7400	0.28
7404	0.33
7406	0.37
7408	0.28
7410	0.28
7414	0.40
7420	0.28
7432	0.33
7473	0.40
7474	0.42
7486	0.38
7493	0.50
7413B	0.45

LOGIC 4000 CMOS

4000	0.17
4001	0.20
4002	0.20
4008	0.35
4011	0.20
4012	0.20
4013	0.26
4017	0.32
4023	0.24
4028	0.36
4040	0.36
4042	0.38
4051	0.38
4053	0.38
4066	0.34
4069	0.20
4070	0.20
4071	0.20
4081	0.20
4085	0.40
4093	0.30

LINEAR

555	0.20
556	0.44
TL082	0.50
TL084	0.50
LM393	0.32
741	0.20
747	0.55

INTERFACE

1488	0.40
1489	0.40
ULN2001	0.55
ULN2002	0.55
ULN2003	0.55
ULN2004	0.55

OPTO

LEDS

3mm	0.10
5mm	0.15
ILQ74	1.80

DATA CHIP TECHNOLOGY LTD.
P.O. BOX 55,
DERBY,
DE1 1WZ.
0332-704629

PLEASE ADD 40p P&P THEN 15% VAT TO TOTAL.

DIGITAL ELECTRONICS

BY OWEN BISHOP

PART 6 – CONVERTERS

Ha! Digital-to-analogue converters and analogue-to-digital converters are another class of devices without which electronics would be ineffectual. By converting smooth signals to pulses or steps, the machine can "see" the outside world.

This month we continue the theme of *interfacing*. Let's think up some improvements on last month's temperature-sensitive interface, the one which uses a thermistor as sensor. When the temperature is high, the interface gives a low level output. When the temperature is low, it gives a high level output. This is a typical *binary* interface. It understands only *two* input conditions – high temperature or low temperature. It has only *two* output states – logic high and logic low. We decide where the threshold between high and low temperature is set, by adjusting a variable resistor in the interface.

Now we take it a stage further. Suppose we want the interface to respond to four different levels of temperature. It would have four different output states, one to correspond to each level. The easiest way of getting four different possible output states is to have two binary outputs. To put it another way, we have an output of two binary digits – two *bits*.

Let's see how we are getting on with our design (Fig. 1). The system shows a sensor (a thermistor, R1) and resistor, R2, arranged just as in last month's interface. As temperature increases, the resistance of R1 decreases and the voltage V_{in} rises. V_{in} is fed to three *comparators*, represented in the figure by three triangles. Each could be built from an opamp. They normally have a high output, but are triggered to give a low output when the voltage at their '-' input is greater than the voltage at their '+' input. Their '+' inputs are connected to a chain of resistors which give a range of threshold voltages from V_1 up to V_3. These are the three voltage levels at which the circuit is to change state. They correspond to the three temperature levels we want the circuit to respond to.

When temperature is very low, V_{in} is lower than all the voltages V_1 to V_3. The outputs from the comparators are all high (111). As temperature rises and V_{in} rises past the first threshold V_1, the lower comparator is triggered. The outputs are now 011 (reading from the bottom of the diagram upward). As temperature continues to rise and V_{in} rises past the second threshold, the outputs become 001. If

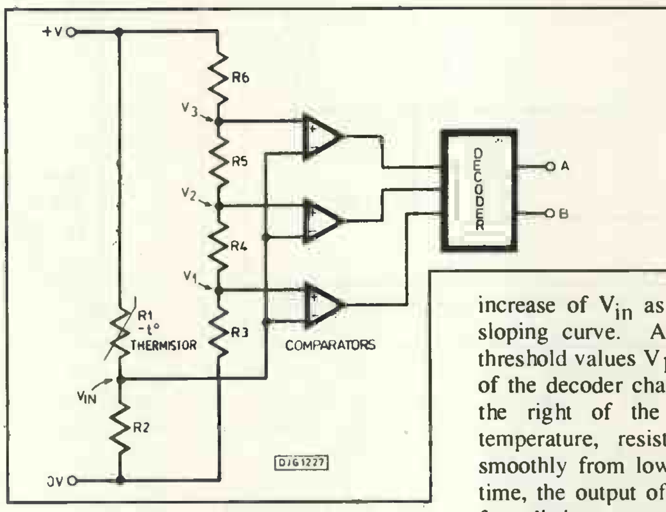


Fig.1. *Analogue to digital converter using "Flash" encoding*

temperature continues rising the outputs finally become 000.

The sequence of outputs could be used as it stands, but it is usually more convenient to change it into a proper binary sequence. Instead of 111, 011, 001, 000, we would prefer 00, 01, 10, 11. The output from the comparators goes to a decoder circuit that gives the required binary outputs. Try your design skills on working out how to build this decoder from NAND and/or NOR gates (one solution is given at the end).

Fig. 2 summarises the changes that occur with changing temperature. As temperature increases, the resistance of the thermistor decreases, as shown by the downward-sloping curve. The result of this is a steady

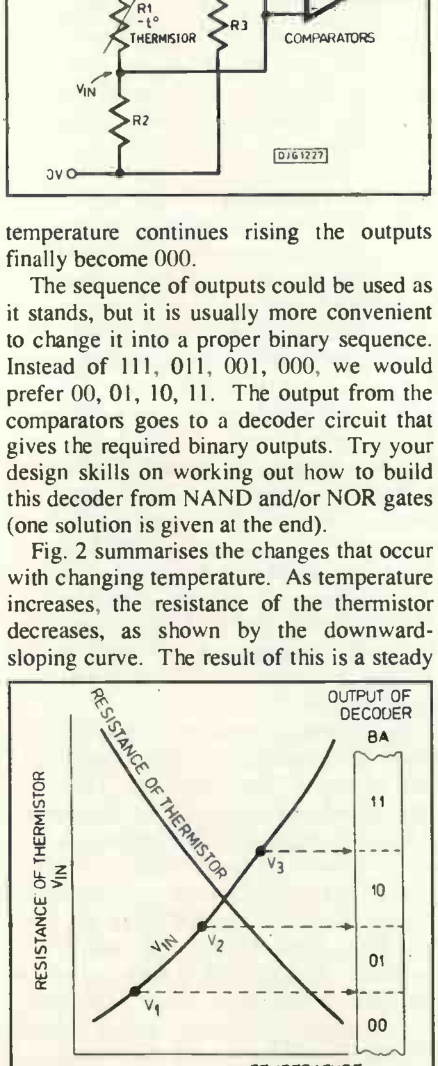
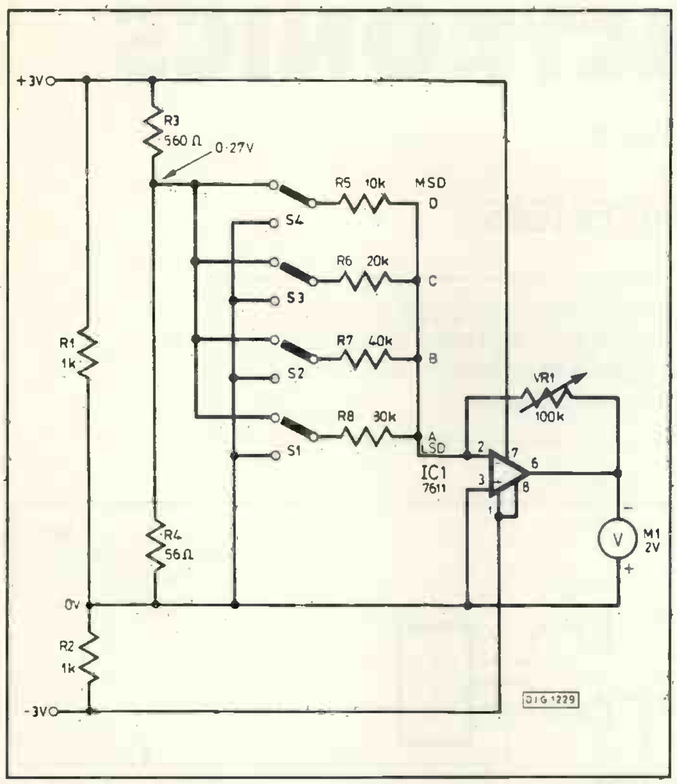


Fig.2. *Analogue and digital quantities*

increase of V_{in} as shown by the upward-sloping curve. As V_{in} passes the three threshold values V_1, V_2 and V_3, the output of the decoder changes state, as shown on the right of the diagram. Note that temperature, resistance and V_{in} change smoothly from low to high. At the same time, the output of the decoder changes in four distinct steps, from 00 to 01 to 10 to 11.

There is an essential point about this circuit that we have not thought about so far. Electronic circuits do not respond to temperature as such. The thing that makes it work is the change in resistance of R1. In general, circuits respond only to things that mean something to them, such as voltage, resistance, or current. What we have done is to use a component (the thermistor) in which the change in outside temperature brings about a change in resistance. We design the circuit so that the change in resistance results in a corresponding change in V_{in}.

To describe the connection between temperature and resistance, we use a word that means 'similar or corresponding'. This word is analogous. We say that the resistance of the thermistor is analogous to the temperature. Or, to put it in slightly different words, we say that the resistance is an analogue of temperature. The circuit responds not to temperature itself but to an analogue of temperature. But, since the analogue behaves in a way that is similar to the way temperature behaves, it is the same as if the circuit was really responding to temperature. It's true that the analogy is not perfect – resistance goes down as temperature goes up – but that is something we can take care of in the circuit design. We have done so here. The voltage V_{in} is



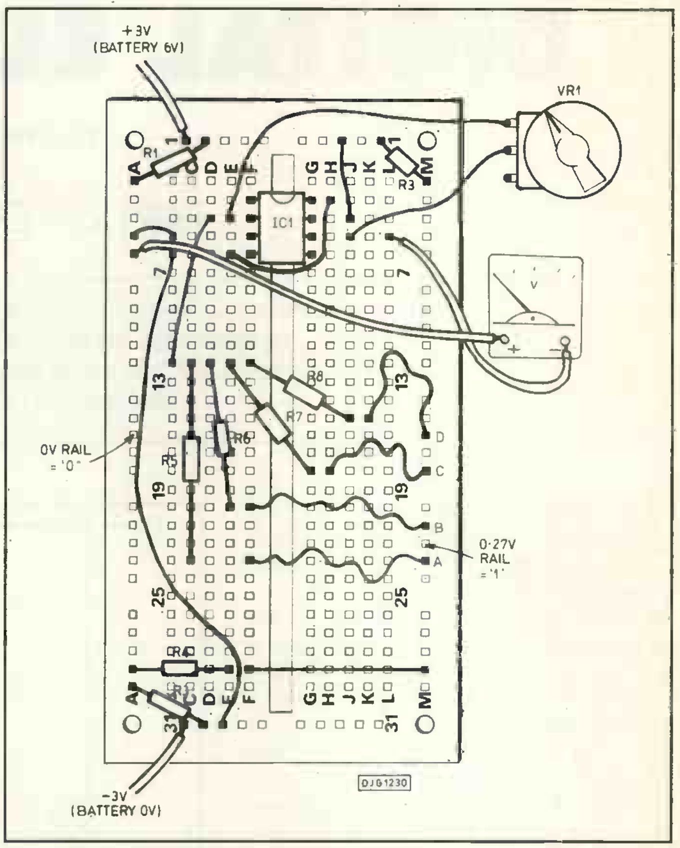


Fig.3. *(above) Digital to analogue converter using opamp summer.*
Fig.4. *(right) Breadboard versionof Fig.3.*

also an analogue of temperature, and moreover increases with increasing temperature.

When we get to the decoder and output stages of the circuit we are no longer dealing with an analogue of temperature. The outputs of the comparators do not smoothly change as temperature changes. They flip abruptly from one state to another as thresholds are crossed. The binary output is incremented in distinct steps. This is a digital output. So the circuit is an analogue-to-digital converter.

A/D CONVERTERS

The conversion of analogue quantities to digital quantities is something we often need in practical applications of electronics. A digital thermometer (one that has a digital read-out) responds to temperature. It can only do that by generating an analogue to the temperature, ie V_{in}. The display is driven by logic, which is digital so, somewhere along the line, there must be an a/d converter.

The circuit of Fig. 1, suitably extended by having more comparators and a decoder to give, say, an 8-bit output, could be used as the basis of a digital thermometer. This type of a/d converter has the advantage that it works fast. The delays in the comparators and decoders are only a few nanoseconds. For this reason, this type of a/d converter is known as a flash converter. You can buy the complete circuit in a single ic but it is expensive. We would not normally want to use a flash converter in a digital thermometer as we can afford to wait a few microseconds for the conversion. But, in a circuit that is converting analogue tv signals into digital signals very high speed is essential. Flash converters are ideal for video and audio digitising applications.

D/A CONVERTERS

Before we go on to try out some practical examples of a/d converters, let us look at the reverse conversion, digital to analogue. For example, we may want to control the speed of a motor in the arm of a robot. The robot is controlled by a micro-computer or a keyboard so the input to the robot is digital. Electronic circuits are not directly able to control speed (they can't put a foot on the brakes!). Instead the circuit produces something that circuits know all about – a voltage. This voltage, which we refer to as V_{out} is an analogue of the speed. The speed of the motor is proportional to V_{out}. Voltage can also be an analogue of other quantities such as the brightness of a lamp, the loudness of a sound or the strength of a magnetic field, depending on the application.

Fig. 3 shows a circuit for a d/a converter based on an opamp ic. This is an easily-built converter that could be ideal for robotics and other applications. The opamp is wired as a summer. The operation of the circuit depends on the fact that, if we feed several currents toward the (-) input of an opamp, the output current (from pin 6 in Fig. 3) is proportional to the sum of the currents. Actually the output current is inversely proportional, since what really happens is that the currents flowing through R5, R6, R7 and R8, toward the (-) input do not actually flow into the input. Indeed, since the input presents a resistance of 10^{12} ohms, it is hard for any appreciable current to enter. Instead, the currents flow on though VR1 and into the output terminal of the opamp. The output voltage therefore must be negative. Note that the voltmeter is connected to measure negative voltages.

The next thing to notice is that the currents are weighted. If S1 is closed, current flows through an 80k resistor. The potential at the (-) input is 0V, while the potential at the junction of R3 and R4 is 0.27V. Thus the voltage across R8 is 0.27V, and the current through it is 3.4µA. R7 has a resistance of 40k, half that of R8. So, if S2 is closed, the current through R7 is double that through R8, 6.8µA. Let us see what happens if S1 and S2 are closed in all possible combinations:

The circuit is converting a digital quantity (opening or closing of switches) to an analogue quantity (current entering output). This analogue also appears as the negative output voltage required to draw the current into the output. It is an analogue of the speed of the motor to be controlled by the circuit.

The table shows only two bits of the conversion, but the same principle applies to the other switches (S3, S4). The switches correspond to four digits of a binary number. S4 is the most significant digit (msd). It lets current flow through R5, which is the smallest resistor, so passes the largest (most significant) current. S1 is the least significant digit (lsd) since it controls the least current. By switching all combinations of the four switches, we can produce an analogue voltage corresponding to the sixteen binary numbers 0000 to 1111. In the circuit the digital input is produced by mechanical switches but we could use high and low outputs from logic gates, fed through the weighting resistors. So the circuit can convert either manual (eg keyboard, or a binary switch) or logical (eg from a microcomputer) inputs to an analogue voltage. You can have more bits by putting more switches and resistors into the circuit (160k, 320k, and so on).

Trial 1

D/A converter using op amp summer

Get the feeling of how this converter works by trying it out on a breadboard (Fig. 4). The circuit works with a 6V battery. R1 and R2 split the voltage to give the 0V line. From now on we refer to the battery 6V as +3V, taking all our measurements with reference to the new 0V line. We use this particular cmos opamp, the 7611, because it works on low voltages and because its output is able to swing fully between +3V and -3V. We also use a pair of resistors (R3 and R4) to produce as reference voltage of 0.27V. The circuit does not actually include switches; just push the flying leads into the right-hand socket strip (0.27V rail) for 'on' or '1' and push it into the left-hand strip (0V rail) for off or '0'.

The precision of this circuit depends on the resistors having exactly their stated values. Even if you use 1% tolerance resistors, there is still an appreciable error. For the purpose of this demonstration (and indeed for many applications) there is no need to worry about high precision. Ordinary 5% resistors will do. If you do not have the required values, make them up by using two resistors in series. For 40k, you can use 39k and 1k in series. An 82k resistor is near enough for R8.

Start with all leads plugged into '1'. This corresponds with an input of 1111, or 15 decimal. The meter reading may have any value to start with. Adjust VR1 until the reading is exactly 1.5V. This sets the scaling of the converter so that a binary input 1111 (decimal 15) produces an analogue output of 1.5V. We expect that a binary input of, say, 1001 (decimal 9) will produce an output of 0.9V. Try it! Experiment with various combinations of inputs and confirm that the analogue output varies accordingly.

VOLTS AND LADDERS

Another type of d/a converter is based on the 'ladder' circuit of Fig. 5. Since the resistors are of only two values, one set having twice the resistance of the other set, this is known as a R-2R ladder. It does not matter what the value exact of R is provided that the '2R' resistors have precisely twice the resistance of the 'R' set. In most converters the ladder is eight stages long, which gives a complicated resistor network. Rather than try to sort out how it works, wire it up on the breadboard and discover what it does.

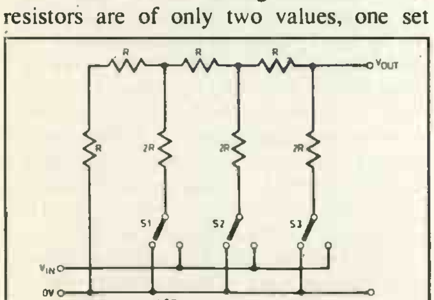


Fig.5. *R-2R ladder*

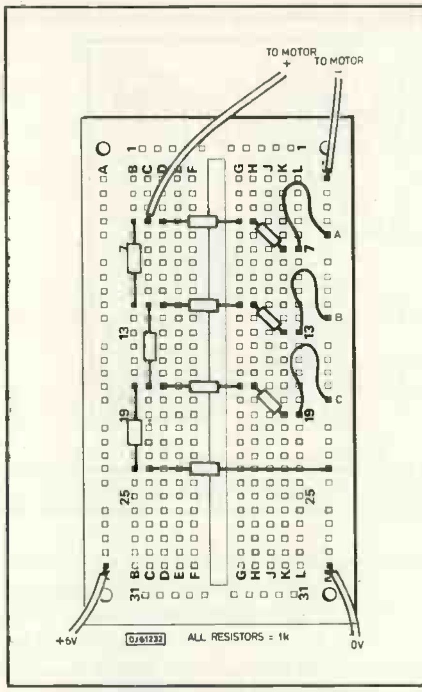


Fig.6. *A breadboard R-2R ladder*

Trial 2

The R-2R ladder

In the bread-board version (Fig. 6), you can use any value resistors you like, provided that they all have the same resistance. We have used two resistors in series to obtain the 2R set. In the diagram, leads A, B and C are plugged into the 0V line. This corresponds to input 000. Obviously, since there is no connection to the +6V line, the meter reads '0V'. Now plug one or more of the leads into the +6V line and read the meter. Try various combinations of input – in fact try all eight possible combinations from 000 to 111. In what way does the analogue output correspond with the digital input? (Answer at the end).

D/A CONVERTER IC

The ZN428E is one of many D/A converters based on the R-2R ladder (Fig. 7). It has an 8-bit input. When the ENABLE input is made low, data on the input terminals is transferred to the latches. The output from each latch is used to control eight solid-state switches. These connect the 'rungs' of the R-2R ladder either to 0V or to a fixed voltage, just as in our breadboarded version of Fig. 6. The main difference is that the voltage is an accurately stabilised reference voltage V_{ref} of 2.5V. The chip has its own in-built circuit for producing the reference voltage, needing only the external capacitor C1 to hold it steady. This is available from pin 7 (V_{OUT}, see Fig. 8). Although it is possible to use an external reference voltage, and feed this to V_{IN} at pin 7, we are using the internal reference by connecting pins 7 and 8 together.

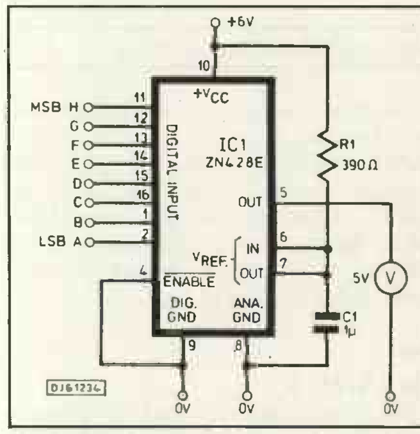


Fig.8. *Digital to analogue converter ic.*

The ic has an 8-bit digital input which can be controlled by switching or by using the outputs of logic gates. As the input is incremented from 00000000 to 11111111, the output voltage increases from 0V to V_{ref}, in 256 steps of just under 10mV each. The output voltage is accurate if only a small current is drawn, The R-2R ladder acts as a 4k resistance so that if, for example, you need to draw a current of 100μA from the output, the maximum voltage is less than V_{ref} by 0.0001 x 4000 = 0.4V. This is a relatively small drop but, if larger currents are drawn the drop is greater. In such cases it is necessary to feed the output to an amplifier, to act as a buffer.

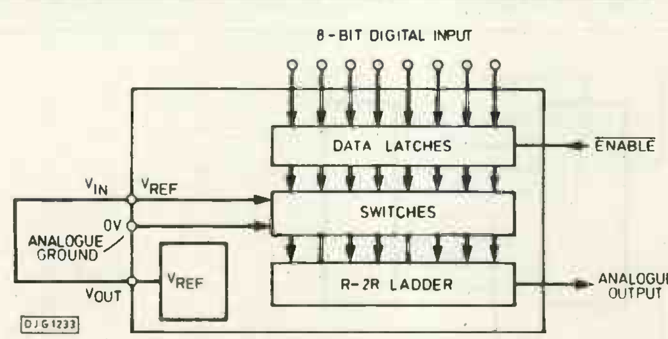


Fig.7. *System diagram of the ZN428E*

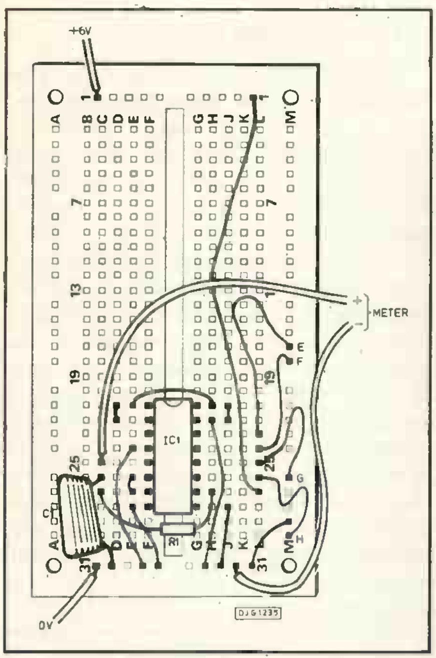


Fig.9. *Breadboard version of Fig.8.*

There are two ground connections, one for connection to the 0V rail of the digital circuits, the other for the 0V rail of the analogue circuits. There can be up to 200mV difference between these rails. Often the 0V rail is common to both sections of the circuit, so both pins are connected to the same 0V rail.

Trial 3

The ZN428E ic

Fig. 8 shows the circuit and Fig. 9 shows how to breadboard it. To simplify the trial, the four least significant input bits, A to D, are wired to 0V. We use only the four most significant bits, E to H. Fig. 9 shows all inputs connected to the 0V rail, to give an input of 00000000. Try moving one or more of the flying leads to the +6V rail at the top of the board. This gives you digital inputs from 00010000 (decimal 32) to 11110000 (decimal 240) in steps of 32. Read the corresponding analogue output on the meter.

When you have seen the converter in action, try the effect of presenting it with the output from a 4-bit counter, as in Fig. 10. The counter is driven by an astable based on a Schmitt trigger gate. This is a useful astable circuit that has many applications in other circuits. To vary its

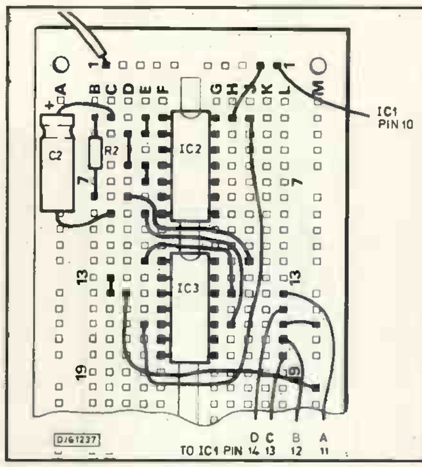


Fig.11. *Completing the circuit of Fig.10.*

rate of oscillation, you can alter C1, but not R2. Here we have it running fairly slowly so that we can observe the action of the converter as the count increases. The counter (IC3) produces an output running from 0000 to 1111, then resets to 0000 and repeats, indefinitely. Outputs A to D of the counter are fed to the most significant inputs (E to H) of the converter. This is equivalent to providing an input of 0 to 240 in steps of 32, the same as you have just done manually. Fig. 11 shows what to add to the breadboard circuit of Fig. 9 to complete the circuit of Fig. 10.

Switch on the power and watch the needle of the voltmeter. Look closely. At first glance it seems to move slowly and smoothly from 0V up to about 2.5V, then return rapidly to 0V and repeat. In fact, it is moving up in 16 distinct and slightly jerky steps.

Although the output from a d/a converter is supposed to be an analogue and therefore is supposed to vary smoothly over its range, it does in fact vary in steps. In this circuit we have made the steps big enough to be noticeable on the meter. If this output is connected to a motor, the motor runs at one of 16 different speeds (including 'stop'). Probably this is good enough for the purpose. If not, we can obtain a much smoother action by using the less significant bits. You could wire up an 8-bit counter (take the D output from IC3 and feed it to A_{IN} input of a second counter ic). Use it to provide an 8-bit to IC1. Then V_{out} varies from 0 to 2.5V in 256 steps instead of only 16 steps. The difference between one step and the next is less than 10mV, which is imperceptible on the meter. This is how a stepping output voltage may be made close enough in practice to a true, smoothly-ranging analogue voltage.

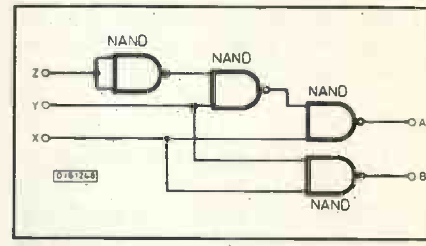


Fig.12. *Decoder circuit for the converter of Fig.1.*

Answers to questions

Decoder: The input from the comparators is ZYX, reading from the bottom comparator up. The truth table for input ZYX and output BA is:

Input ZYX	Output BA
111	00
011	01
001	10
000	11

These are the only four input combinations that we need consider, as the other four combinations of X, Y and Z can not occur in this circuit. Our first 'solution' required seven gates, but we gradually reduced it to four (Fig. 12). Since all of these are NAND gates, the decoder can be constructed from a single 7400, or 4011 ic. Can any reader solve it in three gates? (Note: EXOR gates not allowed!)

R-2R ladder: V_{out} increases in proportion to the binary input (with a certain amount of error due to variation between nominally equal resistors).

Space in this month's issue prevented completion of this part of Digital Electronics – the remainder will be published next month. PE

HIGH POWERED

Blackheath Common in London is a traditional kite flying locality. Driving across it a few weeks ago I noticed that, as usual, children were enjoying the thrills of getting kites even higher. I also noticed the darkening storm clouds looming from the West. Did the kids not realise the dangers of being struck by lightening?

I was reminded of Benjamin Franklin, probably the best known of all kite flyers, and whose experiments have become legend. It was in June 1752 that he confirmed that electricity could be conducted from a thunder cloud down the line of a high flying kite. As the storm approached his kite, he first noticed loose threads on the hemp string beginning to stand erect and avoid one another. On closing a switch between the string and his apparatus he then observed "a very evident spark". He was fortunate and lived to tell the tale.

Other experimenters followed Franklin's investigations, some of them drawing sparks as much as ten feet long. Not surprisingly, some experimenters also died from being struck by lightning. **Ed.**

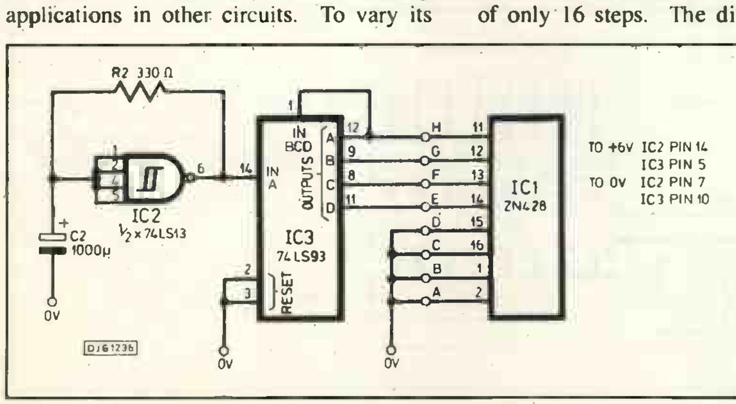


Fig.10. *Converting a 4-bit count to its analogue equivalent*

QUALITY...

SECURITY SUPPLIES

FOR DIY & TRADE

...AT LOWEST PRICES

CONTROL UNITS
■ Automatic ■ Modular
■ Lighting ■ Timer

SENSORS
■ Passive Infra-Red
■ Ultrasonic
■ Infra-Red Beam

ACCESSORIES
■ Contacts ■ Pressure Pads
■ Security Lighting
■ Cable Etc. Etc.

CARS & VANS

HOMES & FACTORIES

PRODUCT OF THE MONTH

CPU 9000 SELF-CONTAINED ALARM SYSTEM Immediate Security Without Installation
For homes storerooms, clubhouses, caravans etc...
■ Detects intruders up to 30ft ■ Penetrating 103db Siren with auto reset. ■ Compact size only 203x180x78mm. ■ Easily extended for coverage of additional rooms or large areas. ■ Operates from 240V ac and 12V dc. Priced £67.72 +VAT

TELEPHONE OR SEND FOR FREE LITERATURE TODAY

The Security Specialist

RISCOMP LIMITED

Dept. PE1, 51 Poppy Road, Princes Risborough, Bucks. HP17 9DB

Callers by Appointment
Office hours Mon–Fri 9am–5pm

(084 44) 6326

BARCLAYCARD VISA

PROFESSIONAL

SURVEILLANCE

EQUIPMENT KITS

- **MTX** Micro-miniature VHF transmitter. The smallest kit on the market measuring market measuring an incredible 17mm × 17mm including on-board mic. Super sensitive. Fully tuneable over FM band, 9V operation with range up to 1000m. £10.95
- **VT500** High power version of the MTX with on-board PA stage providing 250mW of RF. Measures just 20mm × 40mm, power requirements 9-15V. Excellent sensitivity and stability. Fully tuneable over FM band. Ranges over 3000m can be expected. £12.95
- **VOX75** Voice-activated transmitter. Variable sensitivity trigger level switches transmitter on when sounds are detected. Stays on for time delay variable between 1-20 sec. Fully tuneable output covers all FM band. Very sensitive and low standby current through CMOS circuity. 9V operation, range up to 1000m. Measures 30mm × 40mm. £15.95
- **CTX900** Sub-carrier scrambled transmitter. Audio is double modulated providing very secure transmissions. Any unauthorised listener will not be able to demodulate signal without DSX900 Decoder unit. Variable modulation on-board. Fully tuneable output covering FM band. 9V operation, range up to 1000m. Measures 30mm × 40mm. £18.95
- **DSX900** Decoder unit for CTX900. Connects to earphone output of receiver to descramble signal from CTX900. Monitor using small speaker or headphones. Variable decode frequency on-board for best resolution. 9-12V operation. Measures 35mm × 50mm. ... £17.95
- **TLX700** Micro size telephone transmitter. Connects onto line at any point and requires no batteries. Clearly transmits both sides of conversations on both incoming and outgoing calls. Undetectable by phone users. Fully tuneable output covering FM band. Range up to 1000m. Measures just 20mm × 20mm. £9.95
- **ATR2** Micro size telephone recording unit. Connects onto line at any point and connects into ANY normal cassette recorder, standard or micro having MIC and REM sockets. Requires no batteries. Switches recorder on silently when phone is used for incoming or outgoing calls, switches off when phone replaced. Clearly records both sides of conversations. Undetectable by phone users. Measures 10mm × 35mm. £10.95
- **XML900** RF Bug Detector/Locator. Wide band input circuitry detects presence of RF field and triggers flashing LED and piezo bleeper. Variable sensitivity enables source of transmission to be pinpointed to within 6 inches. Max sensitivity will detect MTX or similar transmitter at around 15-20 feet. 9V operation. Measures 55mm × 55mm. £21.95

All kits come fully documented with concise assembly and setting-up instructions high quality fibreglass PCB and all components necessary to complete the module. All prices are inclusive but please add £1.50 to cover P&P. Orders over £50.00 post free. Please state requirements clearly and enclose cheque or PO to cover.
Phone orders on ACCESS or AMEX accepted. Tel: 0827 714476.

NOTE: It is illegal to operate a transmitter in the UK without a licence
Send 9×4 S.A.E. for full catalogue of these and other surveillance kits.

SUMA DESIGNS, DEPT.PE, THE WORKSHOPS, 95 MAIN ROAD, BAXTERLEY, Nr. ATHERSTONE, WARKS CV9 2LE. TEL: 0827 714476

AMERICAN EXPRESS

NEW

THREE SIMPLE CONSTRUCTION KITS

Especially aimed for the beginner. Have fun with your project even after you have built it and also learn a little from building it. These kits include high quality solder resist printed circuit boards, all electronic components (including speaker where used) and full construction instructions with circuit descripton.

SK1 DOOR CHIME – plays a tune when activated by a pushbutton £3.90
SK2 WHISTLE SWITCH – switches a relay on and off in response to whistle command £3.90
SK3 SOUND GENERATOR – produces FOUR different sounds, including police/ambulance/fire-engine siren and machine gun £3.90
SPECIAL OFFERS FOR SCHOOL AND TRAINING CENTRES – Contact Sales Office for discounts and samples.

SOLID STATE RELAY BARGAIN

- ZERO VOLTAGE SWITCHING:- No radio interference problems
- 2.5 KV INPUT to OUTPUT ISO- LATION:- No risk of damage to your computer or driver circuits.
- 4 KV TERMINALS TO HEAT-SINK ISOLATION:- Simply bolt onto a heatsink
- 3V to 32V INPUT VOLTAGE:- easily interfaced to TTL or CMOS LOGIC.

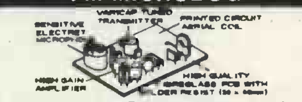
- 24V to 240V rms LOAD VOL-TAGE:- allowing mains loads to be switched
- BUILT IN SNUBBER NETWORK:- Enabling switching of inductive loads.
- 10A MAXIMUM CURRENT:- 4A with no heatsink fitted at 40°C.

CD240/10 £2.25

ELECTRONIC GUARD DOG KIT

One of the best deterrents to a burglar is a guard dog and this new kit provides the barking without the bite! The kit when assembled can be connected to a doorbell, pressure mat or any other intruder detector and will produce a random series of threatening barks making the would-be intruder think you have a guard dog and try his luck elsewhere. The kit is supplied complete with high quality PCB, mains transformer, all components and instructions. The kit even includes a horn speaker which is essential to produce the loud sound required. The "dog" can be adjusted to produce barks ranging from a Terrier to an Alsatian and contains circuitry to produce a random series of barks giving a more realistic effect. Don't delay, fit one before you go on holiday and let our dog help you guard your home.
XK125 Complete kit of parts £24.00

SUPER-SENSITIVE FM MICROBUG

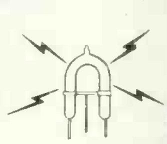


Highly sensitive FM transmitter measuring only 45 x 25 x 15mm, including the built-in microphone. Frequency 88-100MHz enabling reception on a standard domestic FM radio. Range approximately 300m depending on terrain. Powered by 9V PP3 (7mA). Its small size and highly sensitive electret microphone makes it ideal for surveillance, baby alarm, etc.
INTRODUCTORY PRICE £5.50

MICROPROCESSOR TIMER KIT

Designed to control 4 outputs independently switching on and off at present times over a 7-day cycle. LED display of time and day, easily parogrammed via 20 way keyboard. Ideal for cnetral heating control including different switching time for weekends. Battery back-up circuit. Includes box 18 time settings.
CT6000K £47.20
XK114 Relay kit for CT6000 includes PCB connectors and one relay. Will accept up to 4 relays 3A/240V c/o contacts £4.30
701 115 Additional relays £1.80

POWER STROBE KIT



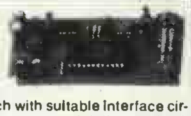
Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz, this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator.
Instructions are also supplied on modifying the unit for manual triggering, as a slave flash in photographic applications or as a warning beacon in security applications. The kit includes a high quality pcb, components, connectors, 5Ws strobe tube and full assembly instructions. Supply: 240V ac. Size: 75x50x45.
XK124 Stroboscope Kit £13.75

DISCO LIGHTING KITS

DL1000K This value-for-money 4-way chaser features by-directional sequence and dimming. 1kW per channel £19.25
DLZ1000K — A lower cost uni-directional version of the above. Zero switching to reduce interference £10.80
DLA/1 Optional opto input allowing audio 'beat'/light response 77p
DL3000K — 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel. £15.60

The DL8000K is an 8-way sequencer kit with built in opto-isolated sound to light input which comes complete with a pre-programmed EPROM containing EIGHTY — YES 80 different sequences including standard flashing and chase routines. The KIT includes full instructions and all components (even the PCB connectors) and requires only a box and a control knob to complete. Other features include manual sequence speed adjustment, zero voltage switching, LED mimic lamps and sound to light LED and a 300W output per channel. And the best thing about it is the price: ONLY £31.50.

VERSATILE REMOTE CONTROL KIT



This kit includes all components (+ transformer) to make a sensitive IR receiver with 16 logic outputs (0-15V) which with suitable interface circuitry (relays, triacs, etc – details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits.
Supply: 240V AC or 15–24V DC at 10mA.
Size (excluding transformer) 9 x 4 x 2 cms.
The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.
MK12 IR Receiver (incl. transformer) £16.30
MK18 Transmitter £7.50
MK9 4-Way Keyboard £2.20
MK10 16-Way Keyboard £6.55
601 133 Box for Transmitter £2.60

GIANT SOLAR CELLS

NOW IN STOCK these giant size solar panels 12x12in will deliver 12 volts 200mA in bright sunlight and 11.5 volts 60mA on a typical British summer day (dull and overcast). HUNDREDS OF USES in the car or caravan, e.g. Charging NiCads, powering low voltage circuits where mains or battery supplies are inconvenient or coupled to a lead acid battery and a simple inverter you could build yourself a self contained mains supply for low power appliances. Stock No. 303 145. £14.50 (plus £1.75 for p&p on total order).

TK ELECTRONICS
13 BOSTON RD.
LONDON W7 3SJ
Tel: 01 567 8910

SEND 9" × 6" SAE & 50p FOR CATALOGUE OR CALL AT SHOP Mon-Fri 9-5 pm Saturday 10-4 pm

VISA

ORDERING INFORMATION:
ALL PRICES EXCLUDE VAT
FREE P&P on orders over £50 (UK only), otherwise add £1 + VAT. Overseas P&P: Europe £3.50. Elsewhere £10. Send cheque/PO/Barclaycard/Access No. with order. Giro No. 529314002.
LOCAL AUTHORITY AND EXPORT ORDERS WELCOME
GOODS BY RETURN SUBJECT TO AVAILABILITY

No. 1 LIST BAKERS DOZEN PACKS

All packs are £1 each, if you order 12 then you are entitled to another free. Please state which one you want. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

BD2	5	13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
BD7	4	In flex switches with neon on/off lights, saves leaving things switched on.
BD9	2	6V 1A mains transformers upright mounting with fixed clamps.
BD11	1	6½in speaker cabinet ideal for extensions, takes our speaker. Ref BD137.
BD13	12	30 watt reed switches, it's surprising what you can make with these – burglar alarms, secret switches, relay, etc., etc.
BD22	2	25 watt loud speaker two unit cross-overs.
BD29	1	B.O.A.C. stereo unit is wonderful value.
BD30	2	Nicad constant current chargers adapt to charge almost any nicad battery.
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
BD34	48	2 meter length of connecting wire all colour coded.
BD42	5	13A rocker switch three tags so on/off, or change over with centre off.
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day original cost £40 each.
BD49	10	Neon valves, with series resistor, these make good night lights.
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
BD59	2	Flat solenoids – you could make your multi-tester read AC amps with this.
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
BD91	1	Mains operated motors with gearbox. Final speed 16 rpm, 2 watt rated.
BD103A	1	6V 750mA power supply, nicely cased with mains input and 6V output leads.
BD120	2	Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
BD122	10m	Twins screened flex with white pvc cover.
BD126	10	Very fine drills for pcb boards etc. Normal cost about 80p each.
BD132	2	Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
BD134	10	Motors for model aeroplanes, spin-to start so needs no switch.
BD139	6	Microphone inserts – magnetic 400 ohm also act as speakers.
BD148	4	Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
BD149	6	Safety cover for 13A sockets – prevent those inquisitive little fingers getting nasty shocks.
BD180	6	Neon indicators in panel mounting holders with lens.
BD193	6	5 amp 3 pin flush mounting sockets make a low cost disco panel.
BD196	1	in flex simmerstat – keeps your soldering iron etc. always at the ready.
BD199	1	Mains solenoid, very powerful, has 1in pull or could push if modified.
BD201	8	Keyboard switches – made for computers but have many other applications.
BD210	4	Transistors type 2N3055, probably the most useful power transistor.
BD211	1	Electric clock, mains operated, put this in a box and you need never be late.
BD221	5	12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
BD242	2	6in ×4in speakers, 4 ohm made from Radiomobile so very good quality.
BD252	1	Panostat, controls output of boiling ring from simmer up boil.
BD259	50	Leads with push-onb ¼in tags – a must for hook-ups – mains connections etc.
BD263	2	Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor.
BD275	1	Guitar mic – clip-on type suits most amps.
BD283	3	Mild steel boxes approx 3in × 3in × 1in deep – standard electrical.
BD293	50	Mixed silicon diodes.
BD296	2	Car plugs fit into lighter socket.
BD305	1	Tubular dynamic mic with optional table rest.
BD400	4	Books, useful for beginners, describes amplifiers, equipment and kit sets.
BD653	2	Miniature driver transformers. Ref. LT44. 20k to 1k centre tapped.
BD553a	2	3.5V relays each with 2 pairs changeover contacts.

Most other packs still available and you can choose any as your free one.

VERY POWERFUL 12 VOLT MOTORS – ⅓ HORSEPOWER Made to drive the Sinclair C5 electric car but equally adaptable to power a go-cart, a mower, a rail car, model railway, etc. B rand new. Price £15.00 plus £2.00 postage. Our ref 15P8.

OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen packs.

A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letter.

ATARI 65XE COMPUTER

At 64k this is most powerful and suitable for home and business. Brand new, complete with PSU, TV lead, owner's manual and six games. Can be yours for only £45 plus £3 insured delivery.

CAMERAS. We have made a big purchase and can offer you three cameras all by famous makers; Kodak etc. one disk and two different instant cameras. All in first class condition, believed in perfect working order; sold as untested. 3 for £10 inc. V.A.T. which must be a bargain if only for the lenses, flash guns etc. Our ref 10P58.

BD400 for books, useful for beginners, describes amplifiers, test equipment and kit sets.

BD653. Two miniature driver transformers. Ref. LT44. 20k to 1k centre tapped.

BD553a. 2 3.5V relays each with two pairs changeover contacts.

DATA RECORDERS ACORN for Acom Electron, etc., reference number ALF03, with TV lead, manual and PSU. Brand new. Price £10 plus £1.50 post. Order ref 10P44. ATARI XC12 for all their home computers. With leads and handbook. Brand new. Price £10 plus £2 post. Order ref 10P53.

JOYSTICK FOR ATARI OR COMMODORE for all Atari and Commodore 64 and Vic20. New. Price £5. Order ref 5P126.

EXTRA SPECIAL OFFER We will supply the Atari 65XE, data recorder XC12, joystick and six games for £57.50 plus £4 insured delivery.

SUB-MIN TOGGLE SWITCH Body size 8mm x 4mm x 7mm SBDT with chrome dolly fixing nuts. 4 for £1. Order Ref. BD649.

Re-CHARGEABLE NICADS 'D' SIZE
These are tagged for easy joining together but tags, being spot welded, are easy to remove. Virtually unused, tested and guaranteed. £2.00 ref 2P141 or 6 wired together for £10.00 ref 10P47.

RECORD PLAYER DECK BSR, 12 volt operated, belt driven with an 11in turntable, stereo cartridge. It will play 7in-10in or 12in individually at either 45rpm or 33rpm. Fitted speed selector and pick-up cueing lever. Price £12 plus £3 postage. Order ref 12P4.

2.5kw TANGENTIAL BLOW HEATER has an approximate width of 8in (plus motor), elements made up of two 1.2kw sections so with switch available you can have 2.5kw, 1.2kw or cold blow. Over-heat cutout eliminates fire risk should fan stop or air flow be impeded. Fan blades are metal. Price £5 plus £2.50 post. Our ref 5P62. Switch 50p.

ALBA TWIN CASSETTE RECORDER AND PLAYER WITH STEREO RADIO This is a mains/battery portable made to sell, we understand, at about £50 but the ones we have are fine rejects. They are brand new still in the manufacturers' boxes but have a slight defect associated with the cassette section. The radio and amplifier section, both mono and stereo, is perfectly OK. If you are handy at mending things then this should be for you. Price £20 or two for £38 plus £3 insured post, either package. Our ref 20P7 or 2 x 20 P7.

LASER TUBE

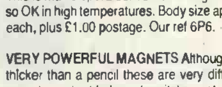
Made by Phillips Electrical. New and unused. This is helium-neon and has a typical power rating of 1.6mW. It emits random polarised light and is completely safe provided you do not look directly into the beam when eye damage could result. Do not use in the presence of children unless a diverging lens if fitted. DON'T MISS THIS SPECIAL BARGAIN! Price £29.95 plus £3 insured delivery.

POWER SUPPLY FOR PHILIPS LASER Is now available in kit form. Price £13 plus £2 postage or made-up ready-to-use at £18 plus £2.50 postage. Our ref 13P1 for the kit and 18P1 for the made-up version.

PAPST AXIAL FAN-MANUFACTURERS REF NO. TYP4560N.
This is mains operated. 15 watt rating and in a metal frame with metal blades so OK in high temperatures. Body size approx. 4¾" square x 1⅝" thick. £6.00 each, plus £1.00 postage. Our ref 6P6.

VERY POWERFUL MAGNETS Although only less than 1" long and not much thicker than a pencil these are very difficult to pull apart. Could be used to operate embedded reed switches, etc. Price 50p each, 2 for £1.00. Ref BD642.

ORGAN MASTER



Is a three octave musical keyboard. It is beautifully made, has gold plated contacts and is complete with ribbon cable and edge connector. Brand new, only £12 plus £3 postage.

MUSIC FROM YOUR SPECTRUM 128 We offer the Organ Master three octave keyboard, complete with leads and the interface which plugs into your 128. You can then compose, play, record, store, etc., your own music. Price £19 plus £3 special packing and postage. Order ref 28P2.

20A DOUBLE POLE RELAY WITH 12V COIL complete with mounting brackets made by the Japanese Omron Company. Price £2 each. Our Ref. 2P173A

TORROIDAL MAINS TRANSFORMER with twin outputs. 6.3V 2A and 12V 600mA, so ideal for FDD power supply. Price £5. Our Ref. 5P122.

DOUBLE MICRO CASSETTE DECK made by the Japanese ABS company. This takes two micro cassettes and is complete with motors, solenoids to select the deck to use and record and playback heads. Price £10. Our Ref. 10P49.

QUICK FIX MAINS CONNECTOR A must for your workshop. Saves putting on plugs as you just push the wires under the spring clips. Automatically off when lid is up. Price £7.50. Our Ref. 7P5/1.

BT HANDSET with curly lead terminating with flat BT plug. Colour cream. Price £5. Our Ref. 5P123.

J & N BULL ELECTRICAL
Dept PE, 250 PORTLAND ROAD, HOVE BRIGHTON, SUSSEX BN3 5QT

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1.50 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted. Brighton (0273) 734648 or 203500.

POPULAR ITEMS

Some of the many items described in our current list which will you receive if you request it

VENNER TIME SWITCH. Mains operated with 20 Amp switch. One one/off per 24 hours. Repeats daily automatically correcting for lengthening and shortening day. An expensive time switch, but you can have it for only £2.95 without case. Metal case £2.95. Adaptor kit to convert this in to a normal 24 hour time switch, but with the added advantage of up to 12 on-offs per 24 hours thus making an ideal controller for immersion heater etc. Price of the advertising kit £2.30.

3½in FDD CHINON 80 track 500k. Shugart compatible interface. Standard connections. Interchangeable with most other 3½in and 5¼in drives. Brand new £28.50 plus £3 insured post

CASE NOW AVAILABLE FOR THE CHINON F353 This is the 80 track, single sided one which we have been selling at £28.50. The case is sheet metal, finish in hammer-beige with ample ventilation and rubber feet. Overall size 4¼in x 7in x 1½in approx. Designed to take the ribbon cable and 3 core power lead. Price £8. Our ref 8P21.

3in FDD HITACHI HFO3X3XA Shugart compatible interface 500k on 3in disc. Recommended for many Amstrads but interchangeable with most drives. £29.50 plus £3 insured post.

FDD CASE AND POWER SUPPLY KIT for the 3in or 3½in. £11.00. Ref 11P2 for the Chinon, 11P3 for the Hitachi.

9in MONITOR made for ICL, uses Phillips black and white tube. Brand new and complete but uncased. £16.00 plus £5.00 post.

ACORN COMPUTER DATA RECORDER REF ALF03 Made for the Electron or BBC computers but suitable for most others. Complete with mains adaptor, leads and handbook. £10.00. Ref 10P44

POWERFUL IONISER Uses mains transformer. Generates approx. 10 times more ions than the normal diode/cap ladder circuits. Complete kit £11.50 plus £3.00 post.

FREE POWER! Can be yours if you use our solar cells – sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine – they work just as well in bright light. Voltage input is .45–you join in series to get desired voltage – and in parallel for more amps. Module C gives 400mA. Price £2. Our ref. 2P199 Module D gives 700mA, Price £3, Our ref. 3P42.

SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £8. Our ref. 8P3.

90V 20A TRANSFORMER 'C' Core construction so quite easy to adapt for other outputs–tapped mains input. Only £25 but very heavy so please add £5 if not collecting. Order Ref. 25P4.

SWITCH AC LOADS WITH YOUR COMPUTER This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.

METAL PROJECT BOX Ideal size for battery charger, power supply etc.; sprayed grey, size 8in x 4¼in x 4in high, ends are louvred for ventilation other sides are flat and undrilled. Order Ref. 2P191. Price £1.

BIG SMOOTHING CAPACITOR. Sprague powerlytic 39,000uF at 50V. £3. Our ref. 3P41.

4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core size 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres £2. Our ref. 2P196 or 100 metres coil £8. Order ref. 8P19.

6-CORE FLEX CABLE. Description same as the 4-core above. Price 15 metres for £2. Our ref. 2P197 or 100 metres £9. Order ref. 9P1.

TWIN GANG TUNING CAPACITOR. Each section is .0005uF with trimmers and good length ¼in spindle. Old but unused and in very good condition. £1 each. Our ref. BD630.

13A PLUGS Good British make complete with fuse, parcel of 5 for £2. Order ref. 2P185.

13A ADAPTERS Takes 2 13A plus, packet of 3 for £2. Order ref. 2P187.

28V -0- 20V Mains transformers 2½ amp (100 watt) loading, tapped primary. 200-245 upright mountings £4. Order ref. 4P24.

BURGLAR ALARM BELL – 8" gong OK for outside use if protected from rain. 12V battery operated. Price £8. Ref. 8P2.

24 HOUR TIME SWITCH – 16A changeover contacts, up to 6 on/offs per day. Nicely cased, Intended for wall mounting. Price £8. Ref. 8P6.

CAPACITOR BARGAIN – axial ended, 4700µF at 25V. Jap made, normally 50p each, you get 4 for £1. Our ref. 613.

SPRING LOADED TEST PRODS – Heavy duty, made by the famous Bulgin company, very good quality. Price 4 for £1. Ref. BD597.

ASTEC P.S.U. – Switch mode type. Input set for +230V. Output 3.5 amps at +5V, 1.5 amps at +12V, and 3 amps at +5V. Should be Ok for floppy disc drives. Regular price £30. Our price only £10. Ref. 10T34. Brand new and unused.

APPLIANCE THERMOSTATS – Spindle adjust type suitable for convector heaters or similar. Price 2 for £1. Ref. BD582.

3-CORE FLEX BARGAIN No. 1 – Core size 1.25mm so suitable for long extension leads carrying up to 13 amps, or short leads up to 10 amps. 15mm for £2. Ref. 2P190.

3-CORE FLEX BARGAIN No. 2 – Core size 1.25mm so suitable for long extension leads carrying up to 13 amps, or short leads up to 25A. 10m for £2. Ref. 2P190.

ALPHA-NUMERIC KEYBOARD – This keyboard has 73 keys giving trouble free life and no contact bounce. The keys are arranged in two number pad, board size is approx. 13" x 4" – brand new but offered at only a fraction of its cost, namely £3 plus £1 post. Ref. 3P27.

WIRE BARGAIN – 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 plus £1 post. Ref. 3P31 – that's well under 1p per metre, and this wire is ideal for push on connections.

INTERRUPTED BEAM KIT – This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components – relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price £2. Ref. 2P15.

⅛TH HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which revs at 3,000 rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. Price £6. Our ref 6P1, discount for quantities of 10 or more.

READERS' LETTERS

TRACING THE YEARS

Dear Ed,

After defecting from regular subscription to PE for many years, the appearance of your interesting series 'Dual Beam Oscilloscope' has brought me back to the fold, so to speak.

Like you, E.N.Bradley's 'The Oscilloscope Book' (five shillings well spent!) did a lot for my interest in electronics and as a result of my experimenting with oscilloscope circuitry and other pieces of equipment, I was able to progress from my original career in domestic radio and tv servicing to a more progressive one in industrial electronics, always with a bias towards test equipment and testing methods. Now that I have retired, electronics is my main hobby and my soldering iron is rarely cold!

Many thanks for the present nature of PE, with just the right mixture of articles and projects for my taste and interests.

Geoffrey T. Edwards, Weymouth, Dorset.

May neither of our irons ever remain cold or our screens long stay dark - there're just too many exciting circuits to explore.

Ed

NO SCOPE

Dear Sir

I wasted my money buying your December 88 issue as the oscilloscope project does not go up to 10MHz.

L.H.Singleton, Llanelli.

The intention of this project is to provide early electronic starters with a simple and cheap visual display of what is occurring on the types of circuit they are most likely to encounter in the days before their knowledge and interest progresses to more sophisticated requirements.

Most beginners will probably only be concerned with audio frequencies up to about 20kHz and logic signals up to about 1MHz. This project satisfies that requirement, being capable of displaying frequencies beyond 1MHz as discussed within the article. It also satisfies the low price aspect in that it should cost in the region of only £100 to build. If greater sophistication had been designed in the price would have risen significantly, in which event there would have been little cost benefit from building one's own instrument when ready-made equipment would fall into a similar price bracket.

To those who are advanced constructors I unhesitatingly recommend that a ready-made scope should be bought, but to be prepared to spend at least £350 on a dual beam instrument that will satisfy their needs for many years to come.

For beginners, the published project will give a good insight into what occurs in circuits, thereby hopefully encouraging them to become far more interested, at which time it then becomes worthwhile spending a lot more money on more advanced equipment. It is pointless for a beginner to spend a lot of money on equipment until such time as he or she is convinced that electronics is the interest which they wish to pursue.

From the letters we have received from many readers we know that we have made the correct decision in publishing a low cost elementary scope. The feedback from the companies supplying the various parts for the project also confirms that many readers are building the project, and that they are pleased to be given the opportunity to do so.

As a final point, I must comment that before spending money on anything, whether it is a piece of equipment, or a magazine, it is prudent to establish whether it is what you want before you buy it.

Ed

LOLLYSCOPE

Dear Ed

A long time ago I was given a tube that seems to have nearly the same specs as the one you use in your dual beam scope. I've always wanted a scope, but didn't know how to set about using the tube I've got. And the cheapest built scope I could find was nearly two hundred pounds, which I haven't got to spend, and anyway it only had one beam. Thank you for showing me how to build one cheaply.

Justin Carrerras, Canterbury, Kent

PRIME VIEWING

Dear Ed

Thanks to PE for being the magazine to publish an interesting article on building an oscilloscope. I have long been puzzled about what signals really look like as they pass through circuits. Now I shall be able to have a look without spending a fortune on commercial equipment.

Michael Davis, Wragby, Lincs

EFFECTIVE SCREENING

Dear John,

My interest is in building musical effects units for use with my guitar. Until now I've just had to 'play things by ear (ha ha)' when coming up with different circuit variations. With your simple scope I shall be able to look at different waveforms, see their phase relationships, and measure things like echo and reverb delays.

Bernard Bartolph, Hitchin, Herts.

TRACK TRACING

Dear John

I like buying old amplifiers and repairing them but I have had to do this using signal tracers to follow the signal. After a long while of having noises filling my ears as I probe in different places I get a real headache! I'm glad you've done a visual signal tracing piece of test gear so that I can listen to my Walkman while mending amps.

Rob Anderson, Belfast.

DIGISCOPE

Dear Ed

I am following Owen Bishop's digital electronics series and use a meter to look at logic levels. Now I am building your scope so that I can look at logic levels in more than one place. This will be cheaper and more interesting than having several meters.

Peter Henshaw, Solihull.

MICROSCOPE

Dear Ed,

I've got a Commodore 64 computer and enjoy using it to control some of the circuits published in PE. But in the early stages of testing some of these projects I've been hampered by not being able to use a meter to monitor some of the faster signals from the computer. Using your dual beam scope with its sync input as well I shall be able to tap into three input-output lines at the same time.

Brian T. Williams, Salisbury, Wilts

TELLY-SCOPE

Dear Ed,

Your dual beam scope design is very welcome, but I think that many would be builders may be deterred by the cost of the 'inexpensive' 7cm tube. Could you not have used a low cost monochrome tv receiver tube?

J.E.Houghton, Goole, North Humberside.

Before commencing the design of the scope I hunted round for a source of low cost tubes but found that the lowest cost current production tube was about £75. Subsequently, I was put in touch with Langrex Supplies who had good stocks of a tube which is no longer being manufactured and which they were prepared to make available to PE readers at around half the price of the other tube. Had it not been for Langrex's comparatively low-priced stock it is unlikely that I would have pursued the project.

Certainly I considered using tv and computer monitor tubes, including the idea that existing drive circuitry could be modified to suit scope requirements. I rejected the idea since the project was aimed at early beginners who, I felt, might be unprepared to tackle projects involving the very high voltages required. Additionally, I considered using lcd screens, but as yet the cost of these screens and the associated circuitry is still too high, though undoubtedly that situation should change in the near future.

Ed

PERRYSCOPE

Dear John

If only you had published this scope some years ago I could have tuned all the oscillators and filters in my home-made organ much more easily. I've never really been happy with the trial and error adjustments I made -with your scope I shall be able to tune in properly. PE is music to my eyes and ears in more ways than one.

Chris Perry, Renfrew, Scotland.

These are just a selection of the letters and phone calls received about the scope articles. It's also obvious from phone calls that, contrary to my above opinion about using tv tubes, there are probably many readers who are using them in conjunction with modifications they are making to the published circuits. Another caller told me he is updating his very old valve driven scope by installing the PE circuits. It seems like we've hit the jackpot with this project!

Ed

SEMICONDUCTORS

BY ANDREW ARMSTRONG

PART 13 – OPERATIONAL AMPLIFIERS

Designing an opamp circuit appears simple. But how do the offset current and voltage, slew rate, and noise level affect the performance?

The term opamp is widely used to describe anything from a substandard 741 to a high precision instumentation amplifier costing tens of hundreds of pounds. In the days before cheap ic opamps were available, the term opamp referred to an instrumentation quality amplifier made using valves or later discrete transistors, and used in applications such as analogue computers or measuring instruments. With the advent of cheap and cheerful ic differential amplifiers, the term opamp has been downgraded to refer to any differential input ic amplifier, while the precision types are often referred to as "instrumentation amplifiers".

The majority of opamps sold are used in general signal processing and amplifying applications. In these applications the qualities needed from an instrumentation amplifier are largely irrelevant, but some other aspects of performance become important. In order to understand what matters in a given application, a good understanding of what an opamp does and approximately how it does it is helpful.

PERFECTION

Even before considering the snags, however, we shall approach an understanding of opamps by considering how a perfect one would perform. The real limitations of performance imposed by the laws of physics (Ye canna break...) will then be thrown into stark relief, and ways to minimise the effect of the limitations will follow on logically.

Fig. 121 shows a perfect opamp with its inputs connected to 0V. In this condition the output is also at 0V. If a variable voltage is connected to one input, as shown in Fig. 122, then the output takes up a voltage equal to the difference in voltage between the two inputs multiplied by the voltage gain of the opamp. Mathematically this is expressed as $V_{out} = A_v \times (V^+ - V^-)$. Our perfect amplifier does not have infinite gain as some people might imagine, because this is difficult to deal with in equations. This opamp is so perfect that even the maths is easy, so it has a gain which is arbitrarily high, always sufficient for the application.

For the purposes of this thought experiment a gain of 1,000,000 is suitable. If an input of 1µV is applied, then an output of 1V will result. A sinewave input of amplitude 1µV would produce an output sinewave of amplitude 1V.

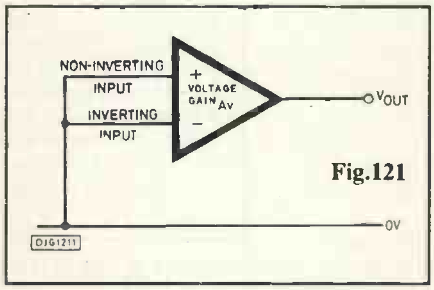


Fig.121

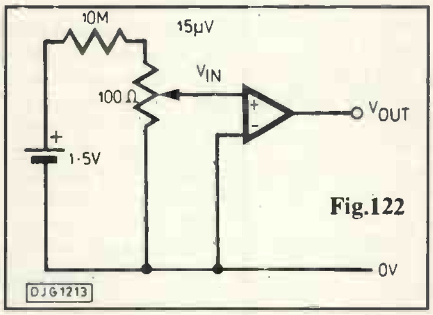


Fig.122

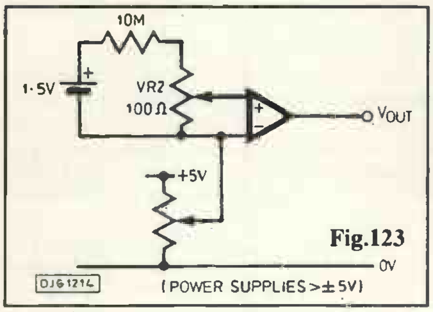


Fig.123

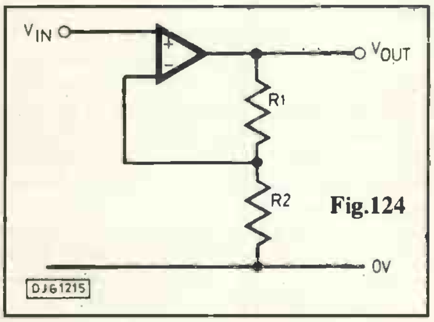


Fig.124

Fig. 123 shows yet another test circuit. In this circuit, varying VR1 produces no change in the output voltage, while VR2 varies the output voltage in the ratio given above, 1,000,000:1. VR1 has no effect because, as stated above, the output voltage depends only on the voltage difference between the inputs.

An arbitrarily high gain may be a good characteristic for an opamp ic, but it is not always what is needed for an application circuit. Fig. 124 shows the circuit of a dc amplifier which has a well-defined and finite gain. The gain is set by the ratio of resistors R1 and R2, and by the inherent gain of the device. It may not be intuitively obvious why this circuit works, though it is a widely used building block for larger application circuits. It works in the form shown because a very small difference in voltage between the two input terminals produces a large change in the output in such a direction as to bring the voltage on the inverting input closer to that on the non-inverting input.

To take an example, assume that the gain of the device is 1,000,000 and that R1 has a value of 9k and R2 has a value of 1k. If an input voltage of 1V is applied, then the amplifier's output will rise until the voltage on the inverting input is almost equal to the input voltage (the difference in voltages being due to the finite gain of the opamp). If we imagine for a moment that this difference is zero, then we have 1V across R2. By using simple potential divider theory, we can see that there must be 9V across R1 and thus that the output is at 10V.

In practice, of course, the opamp needs a difference in voltage between the input terminals to maintain its output, and with a gain of 1,000,000 the required difference is 10µV. Applying potential divider law again shows that the output must be 100µV low. A 100µV error on a 10V signal would normally be considered too small to matter, so that one normally assumes that the gain of the circuit is actually set by R1 and R2 and nothing else. Our perfect opamp always has enough gain to make this true, regardless of the application, but when using real opamps the finite gain available does constrain the possible applications.

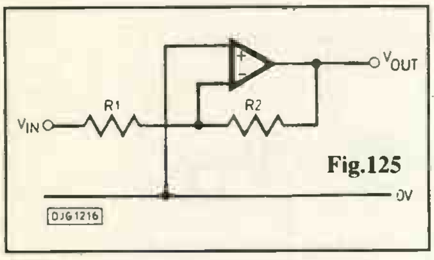


Fig.125

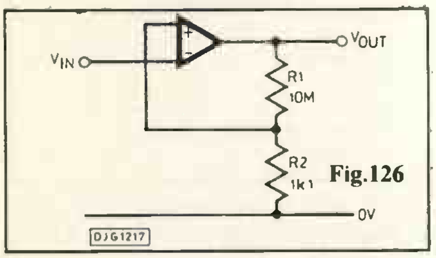


Fig.126

NEGATIVE GAIN

In the circuit of Fig. 124, the output is of the same polarity as the input, and the gain is (R1 + R2)/R2. In the circuit of Fig. 125 the output is of the opposite polarity to the input, and the gain is simply R2/R1. As with the circuit of Fig. 124, the feedback connection of the opamp is such as to allow it to attempt to keep the voltages on its input terminals the same. This means that, because the non-inverting input is connected to 0V, the opamp will attempt to maintain the inverting input as 0V. If an input voltage is applied, and the inverting input remains at 0V, then a current of Vin/R1 will flow in R1; because it has nowhere else to go, this current must also flow in R2. Therefore, the output voltage must be such as to cause this particular current to flow in R2. Given that the left hand end of R2 is at 0V, and given the direction of the current, the output voltage has got to be negative and has got to have the same ratio of voltage to resistance as Vin/R1. The same argument about the finite gain of the opamp applies to this circuit, of course.

The preceding two circuits have both used the opamp as a signal amplifier. There is another function which it can perform for which it is equally apt, that of a comparator. If the opamp is used with no feedback resistors at all, it almost works as a comparator anyway, because only a very modest input signal is required to drive the output to the power supply voltage, positive or negative. There is a small linear region which is undesirable in a comparator, and the circuit of Fig. 126 is designed to eliminate the linear region and replace it with a region of hysteresis. The transfer

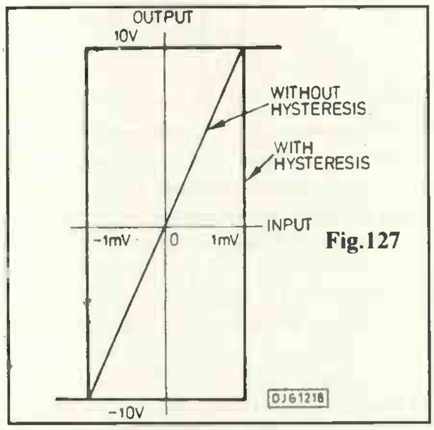


Fig.127

characteristic of this is shown in Fig. 127. This is how it works: let us assume that the output is capable of reaching a maximum of ±10V, and that initially the input is at 0V and the output is at +10V. With the resistor values given, the non-inverting input will be at 1mV, and will remain in this condition unless the input voltage is raised above 1mV. As soon as the input voltage exceeds 1mV, the output voltage will fall. As it falls, it increases the difference between the two input voltages, thus reinforcing the fall in output voltage. The output falls to -10V, where it remains, until and unless the input voltage goes below -1mV. In this example, it is assumed that the gain of the opamp is so high that an infinitessimal difference in input voltages is sufficient to hold the output at one extreme or the other. A real opamp with limited gain would begin to switch a little before the input voltage reached +1mV or -1mV.

Comparator circuits often use much more than 1mV hysteresis. Such a low level would be used only in a precision circuit, where the hysteresis adds to any error in the switching point. In this sort of application, the hysteresis would be chosen to be just sufficient to ensure clean switching.

PRACTICAL OPAMPS

Real opamps deviate from the ideal in many ways. There is normally a choice as to which types of imperfection are minimised, and which suffer as a consequence. For example, it is unusual to find a very fast opamp with low dc offset and low bias current. On the other hand, some ultra low offset devices are available, but they tend to be slow. To start with we shall look at the limitations on performance which matter in most applications.

So far we have assumed that, when an input voltage current is applied to an opamp, no current flows into the input. In practice, some input current must flow. Table 9 shows a comparison of the main characteristics of some common opamps. From this you can see that the bias current of simple bipolar opamps fall in the range of 40nA to 1µA. J-fet opamps have much lower bias currents, and cmos devices have even lower bias current requirements. If too high a resistance dc path to a bias voltage is present, the bias current in an opamp may give rise to significant voltage error on the inputs.

This is particularly so if a different value of dc resistance is used on each input. For example, if a difference in dc resistance of 560k is used with a 5532 bipolar opamp, then the difference in voltage between the two inputs due to this resistance could be of the order of half a volt. This input offset would be multiplied by the dc gain of the stage, and could result in output saturation.

Where significant dc resistance to bias point is required in a bipolar opamp application, it is normal to attempt to equalise the resistance to each input. This is not always easy, as will be clear in some of the later application circuits, but it is a

TABLE 9

Device	Input Offset Voltage mV	Input Bias Current nA	Input Offset Current nA	Voltage Gain Min. Volts/V	Bandwidth @Voltage Gain = 1 MHz	Operating Power Supply* Voltage Min	Operating Power Supply* Voltage Max	Common Mode Range	Slew Rate V/µs	Remarks
741		6	1500	500	25k	1		±3 ±22	±12	0.5
LM358	7.5	500	150	15k	1	±1.5	±15	V+ -15	Not Specified	Dual
LF351	10	0.2	0.1	25k	4	–	±18	–	13	Bifet
LF356	13	8	2	15k	5	±5	±18	±16	15	Bifet
5532	5	1000	200	15k	100kHz Power Bandwidth	±3	±20	±12	9	Dual Low Noise
OP07 (PMI)	75µV	±3	2.8	200k	0.4	±3	±18	±13	0.1	
RC4558 (TEXAS)	6	800	300	30k	3(Typ)	–	±15	±12	1.3	

*NOTE: Absolute maximum power supply voltage is greater than maximum operating supply voltage.

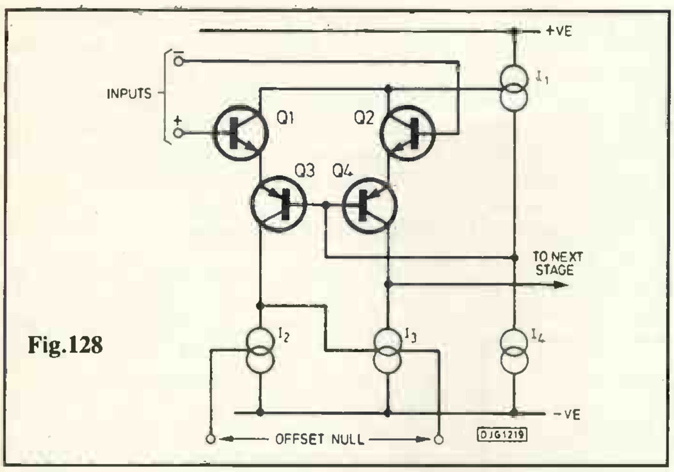


Fig.128

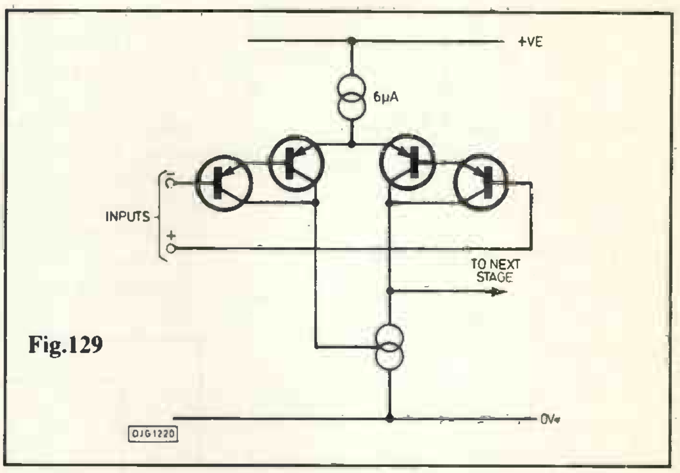


Fig.129

worthwhile aim. The problem of bias current does not stop here, however. The bias current drawn by each input is not the same, due to the normal effects of tolerance. The difference in bias current is referred to as the input offset current. Whatever voltage would appear across the dc input resistance were this current to flow in it, is the maximum amount of dc offset voltage which can be generated by the input offset current. Opamp tolerance will determine the extent of the actual offset, as well as its polarity, in any given circuit.

Even in situations where the dc resistance is low, and the bias current can be ignored, there is the input offset voltage to worry about. As one might deduce from the law of the conservation of misery, the opamps with the lowest input bias and offset currents generally have the highest input offset voltages. This is because the lowest bias current opamps normally achieve their low bias current by using fets as input transistors, and there is more tolerance on the pinch-off voltage of fets than there is on the Ve of junction transistors. This point illustrated by the figures in Table 9.

Typical opamp input stages are shown in Figs. 128, 129 and 130. The stage is a variation on the theme of the long tailed pair, with Q3 and Q4 forming the long tailed pair, and the signal being fed onto the emitters of the pair via Q1 and Q2. The total current flowing in the input stage controls current source I1, which is responsible for biasing Q3 and Q4 with a current bias. This feature stabilised the dc operating point of the circuit.

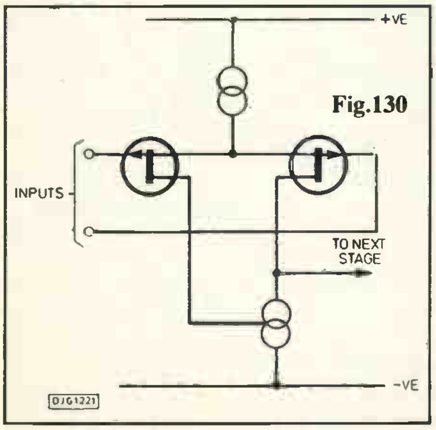


Fig.130

The input offsets may be nulled out by finely balancing the currents I2 and I3, for which terminals are provided. Additionally, I3 is controlled by the current in Q3, with I3 mirroring the changes in Q3's collector current. In this way, extra common mode rejection and extra input gain is provided. If the current sources are balanced, any increase in the collector currents of Q3 and Q4 together will cancel at the output of Q4 because I3 will sink as much extra current as Q3 sources. If Q4 sources the same amount of extra current, the net effect on the output to the next stage is zero. Similar reasoning shows that differential signals have an additive rather than a cancelling effect.

The input voltage of this type of opamp must not swing too close to the negative power supply rail, or else there will not be enough voltage across Q3 and Q4, and I2 and I3 to make them work correctly. The input voltage must not go too near to the positive supply either, or it will exceed the range of bias voltage which can be applied to the bases of Q3 and Q4.

Fig. 129 shows an opamp input circuit which can function with a common mode input voltage range down to the negative supply voltage. This type of circuitry is typical of LM324 and LM358 types of device, and is largely self explanatory.

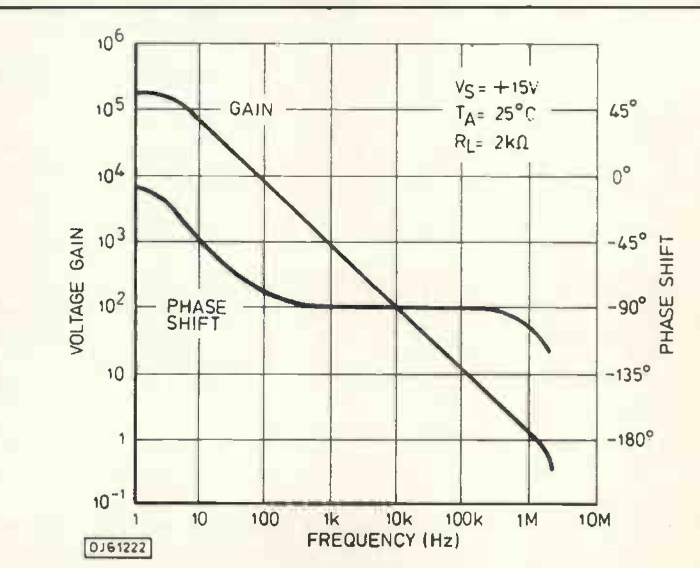
The circuit in Fig. 30 shows a junction fet input stage of the type used in LF351 bifet opamps. This is also largely self explanatory. Inspection of the circuit shows that differences in the operating voltages of the two input fets translate directly in to input offset voltage. This works acceptably because the input fets are almost identical, as a result of being made on the same substrate.

FREQUENCY RESPONSE

So far we have considered dc amplification. Perhaps the majority of opamp applications are for ac amplification. For most amateur projects, amplification over the audio frequency range is needed. Fig. 131 shows the frequency and phase response of a typical opamp. The gain of the device has fallen substantially at frequencies above a few tens of hertz. If an opamp is to be chosen for an audio application, one of the selection criteria must be that its open loop gain is much higher than the required circuit gain at the maximum audio frequency to be used.

If the opamp's gain is inadequate, two problems will be apparent. First of all, the gain of the circuit will be lower than intended at the high frequency end. Secondly, distortion of high frequency signals will become significant. This is

Fig.131



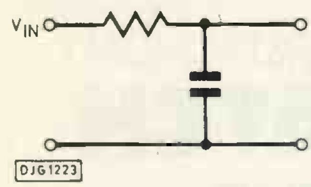


Fig.132

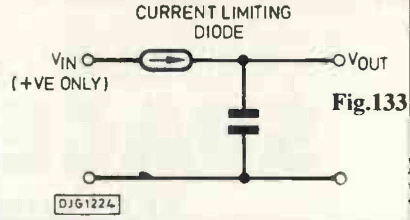


Fig.133

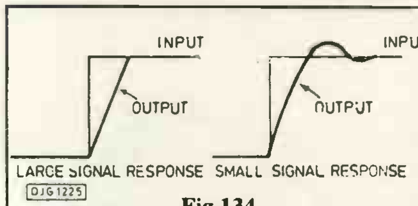


Fig.134

because the transfer characteristic of an opamp is not linear. It is only with the addition of substantial amounts of negative feedback that a circuit can be made to perform linearly. For both of these reasons, selection of an opamp to provide adequate gain at the maximum intended operating frequency is important.

Even if the opamp has sufficient gain at the intended operating frequency, it may not have a high enough slew rate to provide enough output voltage at the required frequency. Slew rate limitation is different from frequency response limitation, in that it is literally a limit on the rate of change of voltage on the output of the opamp. Simple frequency response limitation may result from single or multiple time constants operating linearly, such as the simple r/c circuit shown in Fig. 132. Though this circuit attenuates high frequencies, there is no absolute limit on the rate of change of the voltage on the capacitor – to get a specified rate of change of output voltage, it is simply necessary to provide a big enough input signal. The circuit of Fig. 133, on the other hand, has an absolute limit of the rate of change of output voltage. No matter how much voltage you feed in (short of damaging the circuit) the constant current device will not permit more than its specified current to flow. Therefore, the rate of change of voltage on the capacitor cannot exceed i/c. There effects are illustrated in Fig. 134, where the large signal response of an opamp shows an absolute limit on the rate of change of output voltage. The small signal response, on the other hand, shows the effects of linear time constants, caused by capacitances within the chip. The output slew rate limit is not reached because the amplitude of the output is small.

As well as specifying the frequency response and slew rate, some opamp data sheets also specify power bandwidth. This is the bandwidth at which useful power can be extracted from the amplifier, and is often much narrower than the bandwidth at which useful small signal gain can be extracted.

INTERFERENCE REJECTION

One characteristic of opamps mentioned earlier is common mode rejection. The meaning of this term is not that opamps should amplify only the difference in voltage between inverting and non-inverting inputs. Common mode signals, that is, those which are applied identically to both inputs, should result in no output. In practice, minor differences in response between the two inputs will result in common mode signals getting through to some extent. The higher the frequency of the common mode signal, the less it will be rejected, because different phase shifts between the two inputs will become more apparent.

Generally, however, the common mode rejection ratio (quoted in decibels) of the opamp itself, is normally much better than that of the circuit in which it is used, as we will see when we come to application circuits. The same cannot always be said of the power supply rejection ratio. Opamps are designed to function irrespective of ripple, noise, etc, on the power supply. It is certainly the case that, so long as the signal on the output does not get too close to the supply rails, and that the supplies remain adequate for correct functioning, slow variations in power supply voltage have negligible effect upon the functioning of an opamp. However, rapid variations are not so strongly rejected by the opamp, because some of its internal circuitry is quite slow. As a result of this, high frequency noise on the power supply can adversely affect the operation of circuitry. This can become significant is precision instrumentation, or low noise audio applictions.

That's enough theory for one month. In the next part, I will cover some practical opamp circuits. PE

BEWARE BATTERIES

There are some things in life that we tend to take for granted. When buying 9V batteries, how many people wonder if the contents are intact?

Recently, I bought a PP7 and on getting home found that it looked a bit dusty. Even thought the flap was in place I became doubtful and took a voltage reading. The meter showed 9.5V, which I felt to be acceptable, until I plugged the battery into the apparatus. Down went the meter to 8.7V, and continued to fall as I watched. The circuit draws only 4.5mA, and there's no way a new battery should notice current that small.

Back at the shop I spoke to the manager. Checking the remaining stock, they all looked equally dusty, so I asked for my money back. He knows I'm 'something to do with electronics', and he obliged, apologetically.

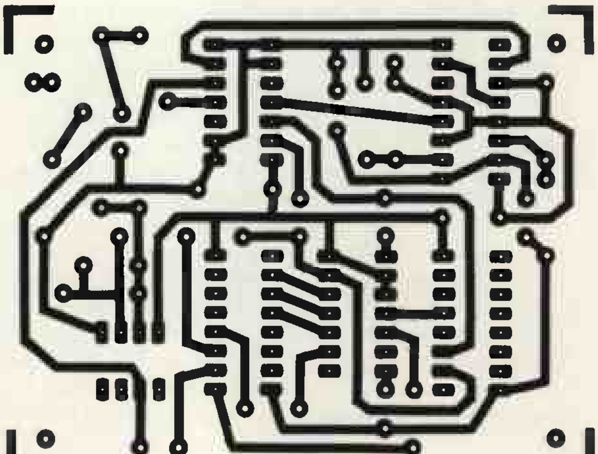
Turning to leave, I noticed him put the battery back on the shelf. "But it's as good as dead", I said, "and the rest of the batch, too, probably".

"I know", he replies, "but head office won't let me order new stock until the end of next month".

I have no way of knowing if another purchaser will unwittingly buy from that batch, but I left feeling very disturbed. Few of the shop's customers will think of checking newly bought batteries, or even have a meter to do so. **Ed.**

PCB TRACK PATTERN

THIS IS THE PRINTED CIRCUIT BOARD TRACK PATTERN FOR THE SIDEREAL CLOCK INTERFACE CIRCUIT. WHEN COPYING THE LAYOUT ENSURE THAT THE SPACING BETWEEN IC PIN HOLES IS PRECISELY 0.1 INCHES



OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE CBE

A HERCULEAN PROBLEM

Phobos I has been abandoned, but Phobos II is still healthy, Mercury may be an iron core wearing a borrowed mantle: particles from Hercules X-1 have been found, but the mystery remains.

The sale of Herstmonceux Castle has been completed. Instead of going to a buyer who aimed to turn it into a science centre, preserving the telescopes for astronomical use, it has been sold to a developer who apparently means to convert it into an hotel. What will happen to the telescopes, the library, the archives and other items remains to be seen. At any rate, the Royal Greenwich Observatory will finally move out by the spring of 1990, and a chapter in the history of British astronomy will be closed – to the profound regret of virtually the entire astronomical community all over the world. Meanwhile, the foundation stone of the new building at Cambridge has been laid by Mr Jenkins, a junior Minister. Henceforth the RGO will be to all intents and purposes an office block; we can only hope that it will retain its separate identity, at least for the moment.

At the time when I write these words (November 1988) the Russian probe Phobos 2 is still on its way to Mars, and should reach the vicinity of the Red Planet in the near future. All attempts to re-contact its twin, Phobos 1, have been abandoned; this is a failure which must be put down to human error – a faulty command was not overridden by the computer. Luckily it is Phobos 2 which carries the 'hopper' which will bound around the surface of the tiny Martian satellite, so that all is not lost. Voyager 2, en route for Neptune, is apparently in good order, and ready for its final and most demanding task. We will hope for success; if it fails, then we may have a long wait before finding out much more about the outermost giant planet.

A new theory of the origin of Mercury has been proposed by American scientists. Mercury is very dense, with a large, iron-rich core and a detectable magnetic field; it is now suggested that in its early stages it suffered collision with a 'protoplanet' about one-sixth of the mass of the proto-Mercury, so that the silicate mantle was stripped off and the iron core left. The present mantle would have been collected later. Whether this is correct or not remains to be seen, but it would certainly explain why Mercury is so much denser than Venus or, for that matter, Mars.

The Quadrantid meteors should be well seen this year, on January 3-4. This shower has a short, sharp maximum, and is not associated with any known comet. It now seems that the perihelion distance of the swarm is steadily increasing, and in 500 years or so will no longer intersect the orbit of the Earth, so that so far as we are concerned the Quadrantid shower will have a limited life.

The Sky This Month

The brilliant display of planets is now subsiding to some extent. Mercury is technically an evening object in the early part of the month, but is not likely to be seen after the first week: Saturn is out of view altogether; and though Mars is still prominent after dark, it is now fading quickly, and by the end of the month its apparent diameter will be down to below 8 seconds of arcs as against well over 20 seconds in the late summer, when the planet was almost as close to us as it can ever be.

That leaves the two most brilliant planets, Venus and Jupiter. Even Venus is past its best for the moment; it is still in the dawn sky, but by the end of January it is running into the morning light, and since the phase is over 90 per cent virtually nothing will be seen on its disk. Jupiter restores the balance to some extent; it remains in Taurus, almost stationary in the area of Aldebaran and the Pleiades cluster. This is a good time to look for the Galilean satellites, which are bright enough to be seen with any small telescope or even good binoculars.

We now know that the Galileans are fascinating worlds. Ganymede and Callisto are icy and cratered, Europa icy and smooth, and Io red and volcanic. Io's sulphur volcanoes are unlike anything else known to us, and have no doubt been in eruption ever since the early days of the Solar System. It is interesting to look at Io through a telescope and note its colour. Reports over past years have been variable - I remember that years ago (around 1955), long before the Space Age, I even wrote a paper about it, pointing out that the descriptions given by different observers did not agree at all well. Generally speaking I see Io as white, or no more than slightly 'off-white'; others may not agree.

Orion now dominates the evening sky, and will continue to do so until the spring. With its brilliant leaders, the red Betelgeux and the white Rigel, it cannot be mistaken. It is associated with its brilliant retinue – and this a good time to see Sirius, the Dog-Star, which is much the most brilliant star in the sky (though it cannot rival the brightest planets). Sirius is pure white, though ancient observers called it red; it is unlikely that there has been any real change, either in Sirius itself or in its faint, super-dense companion, but an element of mystery remains. Of course, it is the supreme "twinker' of the sky, partly because of its brilliance and partly because as seen from Britain it is never very high up. Not far from it, in the same binocular field with the fourth-magnitude, orange star Nu2 is a fine open cluster, Messier 41, which is visible with the naked eye and can be resolved with high-power binoculars.

Capella is now almost at the zenith, which means that Vega skirts the northern horizon and will probably not be seen at all. Ursa Major is in the north-east; Pegasus has almost vanished in the west, and Leo the Lion, is coming into view in the east. This is a good time to scan the Milky Way, which can be followed across the sky from Cygnus in the north down to Canis Major in the south.

THE PROBLEM OF HERCULES X-1

Of all the X-ray sources in the sky, one of the most interesting is Hercules X-1, which can be detected optically as well as in gamma-rays and X-rays. Its emission varies in three ways; a fast pulsation (1.2378 seconds), a slower intensity change (1.7 days) and a longer on-off cycle (35 days). Apparently the system consists of a small, very dense neutron star orbiting around a Main Sequence star rather larger than the Sun; the neutron star accumulates an accretion disk by pulling material away from its companion. Material in the disk falls on to the neutron star, hitting the surface at high speed and generating an X-ray beam which rotates with the neutron star and producing the fast pulsation. The netron star orbits its companion in 1.7 days, and the disk of material oscillates, hiding the netron star in the 35-day cycle.

Scientists, both British and American, have now looked for cascades of light rays and sub-atomic particles produced by the high-energy radiation crashing into our upper air. The light has been detected by using an array of 64 instruments spread over an area 100 x 100 metres in the mountains near Los Alamos, New Mexico; the particles – mainly muons – have been detected from an underground laboratory actually built for a different investigation. The light and the muons arrive at the same time, and agree with the fast pulsation period closely – but not quite; the period is 2/1000 second shorter. It may be that while the X-rays come from the surface of the neutron star, the higher energy radiation comes from a region beyond. There are, also, more muons than would be expected relative to the light emission. The energy of these particles is higher than anything which has been produced in the laboratory, and at present the reason is unclear.

Certainly Hercules X-1 has presented us with many problems. It is 15,000 light-years away, so that at all events it must be a remarkably powerful source of radiation over much of the electromagnetic spectrum! PE

Do not miss a single issue of

Astronomy Now

Britain's leading astronomical magazine

Edited by well known astronomer and regular contributor to *Practical Electronics*

Dr. Patrick Moore CBE

Place a regular order with your newsagent or for £15-00 (overseas £18-00) take out an annual subscription from Intra Press, Intra House, 193 Uxbridge Road, London W12 9RA

LEADING EDGE

Continued from page 8

width aerial could well suffer from interference.

A flat aerial is also likely to have spurious side lobes. It will pick up signal from quite different directions, well outside the nominal beam width. Again this could give problems if the side lobes happen to point in the direction of a high power broadcasting satellite.

Or the side lobes may be looking at the ground. This matters, because the earth is at relatively high temperature and effectively "glowing" with random noise radiation. This noise will degrade the picture signal, however efficient the lnb is at amplifying and frequency down converting the dbs signal. So the received picture signal may be worse than expected.

For receiving analogue tv pictures, it is dangerous policy to regard high powered transmitters in the sky as a way of reducing dish size to 30cms or even less, especially as the orbital slots get more and more crowded in the future.

Instead of going for smaller aerials, it is better to use the high power available from a direct broadcast satellite to guarantee good pictures even on rainy days from a slightly larger dish.

The small plate aerial will eventually come into its own for receiving digital radio. Because the signal is digital, the receiver can much more easily reject noise and interference from other satellites.

BSB's rival in the satellite race, Astra, has a "dish farm" at its Luxemburg base, where all types and sizes of aerial are tested.

A flat aerial was launched in a blaze of publicity at a satellite exhibition in Britain over a year ago, by US company Comsat. But it has never appeared. In Japan several companies, including Sony, sell flat plate aerials but they are relatively large and cost around £300, which is more than the price peg for the complete BSB system.

In America the satellite industry has grown very wary of claims for low cost flat aerials. Recently more than 350 satellite dealers in Colorado paid cash deposits of up to $2,500 each to one manufacturer for flat aerials which arrived late, cost more than promised and did not perform as well as claimed. Another manufacturer took deposits of $5,000 and has never delivered even a prototype.

Although BSB won publicity with its dramatic unveiling of the Squarial the dish-versus-plate debate could well soon become academic. The Astra satellite was launched in December and if all goes well it will be broadcasting several channels of entertainment, in the conventional PAL tv system without any scrambling, before the end of the year. All the major electronics companies are promising Astra dish receiver systems.

BSB is not due for launch until next autumn and it will be broadcasting encrypted programmes in the new MAC transmission system. Although the MAC system can give clearer pictures than PAL, this is of little consequence to a public which is generally content to watch poor pictures on maladjusted sets. The most important advantage of MAC is that it lays the ground work for a future of high definition television.,

Since receiving this report from Barry, Sir Clive Sinclair has produced his new 60cm flat antenna, which is the prize in this month's competition – see page 61. **Ed** PE

FOR MORE SMALL ADVERTISEMENTS SEE PAGES 58 AND 59

SERVICES

Printed Circuit Board Design, Using Computer Aided Design,

Photoplotting,
Phototype PCB's
Special reductions for new clients

Call Neville Sanderson on: 0532-870253
N.C.A. DESIGNS

For
Electronic Design and PCB Manufacture
call
PROTO DESIGN
Unit 8, Ilford Trading Estate
Paycocke Road Basildon
Essex SS14 4DR
Tel: 0268 289923

Servicing electronic products or computers. PE classified pages can bring more customers. Phone 01-743-8888 to place your advertisement.

SPECIAL OFFERS

CAMBRIDGE COMPUTER SCIENCE LTD

51/4 inch Disk Drives, 80 Track DSDD	£34.00
51/4 inch Disks, DSDD 48TPI Boxed in 10s	£3.00
	£27.00 per 10 boxes
Mono Monitors, Composite Video Input	£39.50
Dot Matrix Printers, 80 Col, Parallel, PC Compatible	£105.00

All items new and boxed. Add 15% VAT to all prices.
Postage included
374 Milton Road, Cambridge, CB4 1SU
Tel: 0223 327602

CLEARANCE SALE of components, transistors capacitors, potentiometers transformers etc. Send large S.A.E for free list. **M. Dzlubas, 158 Bradshawgate, Bolton, Lancs.**

REDUNDANT STOCK- FANTASTIC BARGAINS 10Mb Winchester £50, Sanyo MBC550 PC alike £150, 5 1/4 DS floppy drive £25, QWERTY keyboard RS232 out with info £15, RGB 20" monitor £35, Computer PCBs with 8086 etc for parts £10/Kg. Add £6.50 P&P on larger items. Send £1 for complete list. Cheques to **B. Thurlow, 64 Newman Street, London W1A 4SE**

POWER SUPPLY MODULES: High accuracy, high stability linear-mode modules, 6-way switched (3v to 15v), or continuously variable (3v to 20v). 1.5 amps, totally short-circuit proof. Requires only transformer, case & terminals to make a high quality Power Supply unit. Use two or more for multi-rail units. £11.95 each with full instructions, switch/pot ready wired. CUSTOM POWER SUPPLIES, PO BOX 558, BRISTOL BS99 1PN

KITS. Miniature VHF Transmitter with microphone, size approx. 1 1/2" x 1/2", £3.99. Telephone Transmitter, VHF, uses no batteries! £4.75. Automatic Telephone recording switch, £8.99. Prices include p&p. Access cardholders telephone 05438 71902 (24hr.). SAE catalogue. Cheque/PO to A.C. Electronics (Dept. PE), 99 Greenheath, Hednesford, Staffs.

Geiger tubes £29.00. Counters - fit your tubes £25. Silicon wafers £1.50. Universal laboratory camera £40.00. Tel. Mr Matthews on 040 - 376 236

Help PE Readers!
Put projects into practice.
Project your component image here!
Phone Claire on 01-743-8888

SURVEILLANCE

Omicron 2
17.95 inc p&p
The practical surveillance solution

- *Ideal eavesdropper or baby monitor*
- *Less than ½ matchbox size*
- *Absolutely shockproof housing*
- *Built-in sensitive microphone*
- *Battery life 72 hrs (Alkaline)*
- *Full 12 months warranty*

Simply clip Omicron 2 to battery and hide - no adjustments, no fiddling, no fuss. Hear every sound perfectly on an ordinary FM radio up to 1/4 mile away. This must be the easiest to use, best value surveillance device available.

No quibble 14 day money back guarantee.

TRADE ENQUIRIES WELCOME **MILLEA ELECTRONICS** 470-472 LEYMOOR ROAD, HUDDERSFIELD, HD7 4QF. *Tel: (0484) 460103*

NEW VHF MICROTRANSMITTER KIT, tuneable 80-115 Mhz, 500 metre range, sensitive electret microphone, high quality PCB. SPECIAL OFFER complete kit **ONLY £5** POST FREE. Access orders telephone 021 411 1821. Cheques/ P.O.'s to: **Quantek Electronics Ltd, (Dept P.E.), 45a Station Road, Northfield, Birmingham, B31 3TE**

Surveillance devices, lasers, Tesla coils, scramblers, ultrasonic and many more, over 150 designs, send SAE to: **Plancentre, Old Wharf, Dynock Road, Ledbury HR8 2HS**

BOOKS

PUBLISHERS!
Advertise your books and magazines in
Practical Electronics
Tel:01-743-8888

Electronics: Build and Learn - by well known author R. A.Penfold. Price £5.95. Available from all good bookshops or PE Book Service.

Program Now
"The one tool every programmer should have"
Available from all good newsagents or from Intra Press - Price £1-25

MISCELLANEOUS

SURPLUS/REDUNDANT ELECTRONIC COMPONENTS WANTED
I/Cs – Tuners – Transistors – Valves – Diodes etc. any quantity considered – immediate payment.
ADM ELECTRONIC SUPPLIES
Tel: 0827 873311 Fax: 0827 874835

D.O.S. TRAINING XT/AT and Amstrad Compatibles. Works on any 5 1/4 floppy or/and hard drive combination. Disks and textbooks £16.00 + £1.25 p&p. ALSO Floppy Disks, 5 1/4 premium guaranteed quality. Double sided, double density for XT - £4.00 for 10 and A.T. High density 1.2M Byte £5.25 for 10. All above disks include Box, Labels, Sleeves, Tabs. Bulk F.D. 5 1/4 £3.50 for10 DS/DD.Disks only. All disk guaranteed. Add p&p 65p per 10 disks Cheques or money orders to: **Shipman Company, Technical Training Centre, 3 Wilford Grove SKEGNESS, Lincs, PE25 3EZ.**

TV-UHF/VHF Preamplifiers, Power Units, Antenna Rotator Components. Suppliers are wanted for completely or partially knocked down parts of above products for assembly in *Nigeria*. Forward detailed technical specifications and quantity price quotations to **The Advertiser Magazine, GPO Box 5350, ABA, Nigeria.**

FOR MORE **CLASSIFIED ADVERTISEMENTS** *GO TO* ***PAGES 58 and 59***

TIME AND FREQUENCY MEASUREMENT

BY ANTHONY H. SMITH, BSc.

PART THREE: THE QUARTZ CRYSTAL TIMEBASE

"A person with one watch knows what time it is; a person with two watches is never sure." – Proverb.

When measuring any physical quantity, the precision of the measurement is ultimately dictated by the accuracy and stability of the reference quantity or "standard" with which we compare the unknown quantity. In the universal counter timer (uct) this standard is actually the timebase oscillator, and all frequency and time measurements are made by electronically comparing the input signal with the timebase frequency.

Frequency standards fall into two basic categories – "primary" standards and "secondary" standards. Primary standards are effectively "absolute" standards in that they require no other reference for calibration. Two primary standards in common use are the caesium beam resonator and the hydrogen maser. These standards produce an output frequency which is solely determined by the quantum effects associated with atomic energy level changes. As might be expected, both of these standards are extremely accurate. For example, the caesium resonator in laboratory conditions can achieve accuracies as high as part 1 in 10^{13}, equivalent to a gain or loss of only nine nanoseconds per day. It is this kind of precision which makes it possible to be 1000 times more accurate when measuring time and frequency than in the measurement of any other physical quantity.

Secondary frequency standards such as the rubidium vapour resonator and the quartz crystal oscillator differ from primary standards in that they are not self – calibrating: once constructed, a secondary standard must be compared with a caesium resonator or some other primary standard in order to set its frequency exactly.

Obviously, it seems desirable that we should use a primary standard as the time-base oscillator in a counter-timer, and, as we shall see in part four, taking advantage of the remarkable precision and stability of the caesium resonator is not too difficult.

However, just about every commercially available uct incorporates a secondary standard as its reference frequency, and almost invariably this takes the form of a quartz crystal oscillator. The popularity of the quartz oscillator is due in no small part to its simplicity, its reliability, its accuracy, and also the fact that it is relatively inexpensive.

Nevertheless, the quartz crystal does not possess magical qualities, and is subject to a variety of factors which limit its effectiveness.

Consider, for example, two 8-digit ucts used to make frequency measurements; the fact that we have eight digits gives us confidence that our measurements will be accurate to at least 1 part in 10^8. However, there is the possibility that the instruments may give different readings when measuring the same frequency: provided the ucts are performing correctly, this implies that one or both of the quartz time-base oscillators has deviated from its initial calibration frequency due to the influence of one or more electrical or environmental effects.

Consequently, it is in our interests to understand the nature and operation of the quartz resonator in order to be able to compensate for, or even eliminate, those mechanisms responsible for inaccurate behaviour.

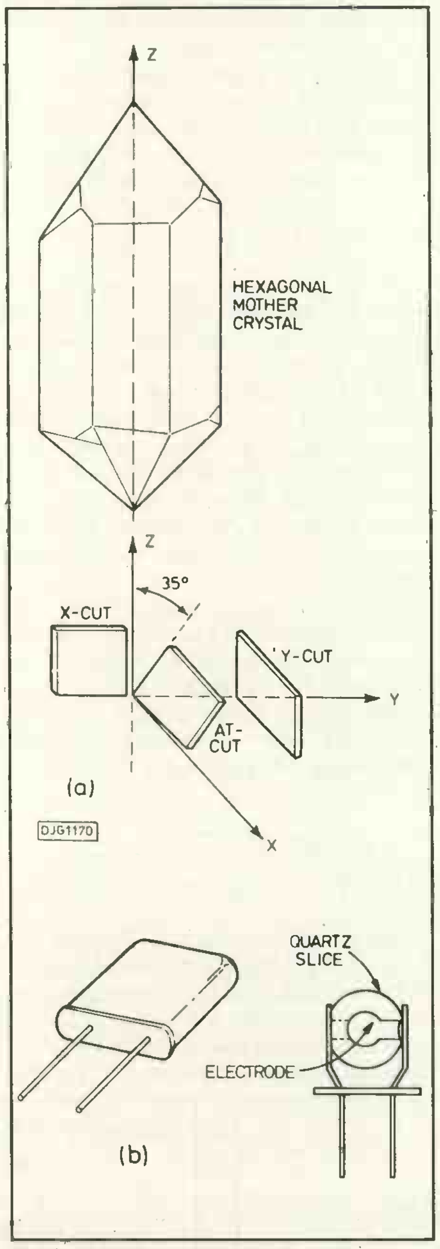


Fig.1(A) *Various cuts from the synthetic crystal.* **(B)** *Mounted crystal and enclosure.*

ABUNDANT BEGINNINGS

There are almost 3000 known minerals and of these quartz is unique in that it is the most abundant, and also provides all the properties required of a frequency control material. However, naturally occurring crystals are unsuitable for immediate use due to the presence of defects and impurities.

Consequently, raw quartz, usually shipped in from Brazil, is processed using a hydrothermal method where it is dissolved at very high temperatures and pressures in a special vessel known as an "autoclave". This method produces very pure, "synthetic" crystals having the hexagonal shape shown in Fig. 1a.

Small slices of quartz are then cut from the mother crystal and are mounted in glass or metallic enclosures (Fig. 1b).

The actual "cut" of the slice relative to the crystal axes is particularly important since it determines the Q-factor and temperature coefficient of the crystal. For example, the X- and Y-cuts both exhibit large temperature coefficients, whereas the frequency of the popular AT-cut crystal varies only slightly with changes in temperature.

The actual resonant frequency of the crystal is determined mainly by its thickness. The precision used in controlling the slice thickness dictates how close the resonant frequency is to its nominal value. Gold-plating is sometimes used in critical applications to "fine-tune" the crystal frequency; a layer just one atom thick can change the frequency by as much as 2 parts in 10^7. For AT-cut crystals, the nominal frequency can range from a few hundred

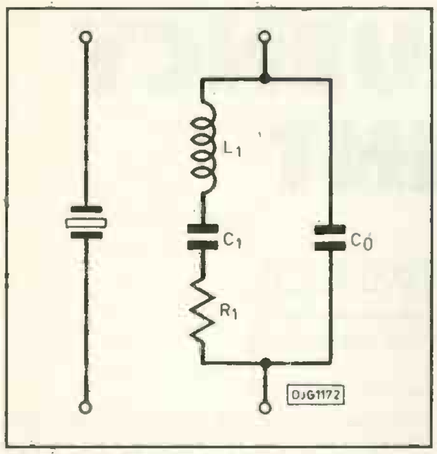


Fig.2. *Quartz crystal symbol and equivalent circuit.*

kilohertz up to around 200MHz; 10MHz is a popular choice for use in uct timebase oscillators.

THE PIEZOELECTRIC EFFECT

Several types of crystals, particularly quartz, exhibit a property known as the piezoelectric effect whereby a mechanical stress applied to the crystal generates a directionally related electric field; conversely, an electric field applied across the crystal produces a directional force within the crystal lattice. Thus, applying an alternating voltage across the crystal causes it to vibrate; this, in turn, generates an alternating electric field, and provided the frequency of the applied voltage is close to the mechanical resonance of the crystal, the generated field will be considerably enhanced, thus stabilising the frequency of the applied signal.

It is the particularly high Q-factor of the mechanical resonance which gives quartz its attractive frequency selective properties. Electrically, the crystal behaves as an LCR tuned circuit and can be represented by the equivalent circuit shown in Fig.2.

L_1 is a function of the quartz mass, C_1 is determined by the crystal stiffness, and R_1 represents the frictional losses of the crystal and its mounting arrangement. C_o represents the shunt capacitance of the crystal electrodes and the holder capacitance.

Generally, L_1 is large and C_1 and R_1 are very small in good-quality crystals; for a 2MHz crystal, L_1=520mH, C_1=0.012pF and R_1=100Ω are typical values leading to a Q-factor (given by $Q = 2\pi f L_1/R_1$) in excess of 65,000!

Because of the high Q-factor, the reactance of the crystal changes dramatically around the resonsant frequency as shown in Fig.3

At low frequencies, the reactance of L_1 is relatively small and the crystal appears capacitive. However, at a frequency f_s the $L_1C_1R_1$ branch is *series resonant*, where $\omega_s L_1 = 1/\omega_s C_1$. Thus: $f_s = 1/2\pi\sqrt{L_1C_1}$.

At this frequency, the reactance of C_o is much larger than R_1, and so the crystal impedance is essentially just the resistance of R_1 which is very small.

At a slightly higher frequency known as the *parallel resonsant frequency*, f_p, the effective reactance of the series branch has the same magnitude as the reactance of C_o: $(\omega p L_1 - 1/\omega p\, C_1) = 1/\omega p C_o$, and so:

$$f_p = \frac{1}{2\pi}\sqrt{\frac{1}{L_1}\left(\frac{1}{C_1}+\frac{1}{C_o}\right)}$$

At f_p, the crystal again appears purely resistive, but this time it presents an extremely large resistance across its terminals. For, say, a 2MHz crystal, C_1=0.012pF and C_o=4pF are typical values, and so $1/C_1 >> 1/C_o$. Thus, ignoring $1/C_o$, we see that the expression for f_p reduces to that for f_s, and so the series resonant frequency is approximately equal to the parallel resonant frequency (sometimes called the "anti-resonant frequency").

However, when dealing with the accuracy required of a uct crystal timebase, this rough approximation is simply not acceptable. For example, consider a crystal which has a series resonant frequency f_s=10MHz, and C_1=0.024pF, C_o=6.0pF. Rearranging our expressions for f_s and f_p we find that:

$$f_p = f_s\sqrt{(1 + C_1/C_o)}, \text{ and so } f_p =$$
$$10^7 \sqrt{(1 + 0.024/6)} = 10.019980 \text{ MHz.}$$

We see that f_p is almost 0.2% higher than f_s: at first sight this doesn't seem too large a difference. But, we must remember that our 8-digit uct requires a timebase frequency accurate to better than 1 part in 10^8. If the timebase is only accurate to, say, 1 part in 10^7, then the least significant digit (lsd) will be meaningless. Similarly, an accuracy of just 1 part in 10^6 means that the lsd and the next significant digit will both be meaningless, and so on. Generally speaking, the timebase accuracy must be better than 1 part in 10^n, where n is the number of digits in the display. In light of this requirement, a frequency deviation of 0.2% is *huge*, and in fact it constitutes a difference of 200,000 parts in 10^8!

This example illustrates an important consideration when designing any crystal oscillator, namely that a crystal with a nominal frequency stamped on its can will be resonant at *two* frequencies, one of which will be very close to the nominal value, whereas the other - as we have seen above - may differ considerably from it. Note, also, that the nominal value is not necessarily the series resonant frequency, and in fact for most crystals designed to operate below 20MHz, the specified value usually refers to the parallel resonant frequency.

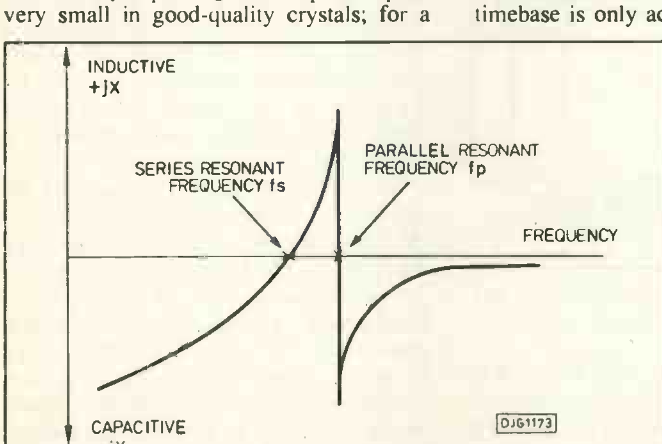
OSCILLATOR OPERATION

It is the crystal's exceptionally high Q-factor which provides much greater frequency stability than can be obtained using discrete inductors and capacitors, and Q's in excess of 10^6 can be obtained using exacting manufacturing techniques.

However, a high Q alone is by no means sufficient to guarantee stable operation at the desired frequency, and a variety of other factors must be accommodated before we can have any confidence in the oscillator accuracy.

All crystals are cut to resonate at a specified frequency under a given set of operating conditions, such as temperature, drive level, load capacitance, etc. For example, a 10MHz crystal might be cut to be parallel resonant when the external capacitance across its terminals is 32pF. Consequently, not only must we ensure that the crystal is used in a parallel-mode oscillator, but also that the capacitive loading of the crystal is as close as possible to 32pF.

Even with all the operating conditions just right, it is unlikely that the crystal will oscillate at exactly the nominal frequency, because crystals, like all other components,



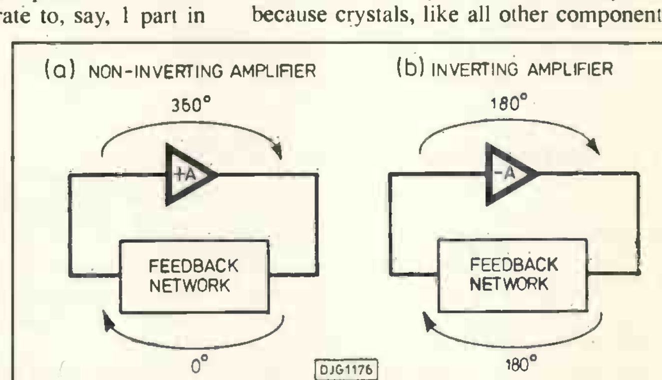


Fig.3. *(Left) Crystal impedance as a function of frequency.*
Fig.4. *(Above) Practical oscillator configurations*

can only be manufactured within certain tolerance limits. Most manufacturers use precision saws or even laser cutting techniques to cut each crystal slice, and X-ray crystallographic techniques are often employed to determine the exact angle of cut. Nevertheless, some deviation from the nominal frequency will always remain.

For example, a nominal 10MHz crystal with a frequency tolerance of ±20 ppm (parts per million) could resonate at any frequency from 9,9999,800Hz to 10,000,200Hz; consequently, all timebase oscillators must have some means of fine adjustment to allow precise calibration of the output frequency.

In practice, all oscillators fall into two groups depending on whether they incorporate a non-inverting amplifier or an inverting type - see Fig.4.

For any design to sustain oscillations, the loop gain must be greater than unity to make up for losses around the circuit, and the loop phase shift must be zero.

Thus, for the configuration of Fig.4a, the feedback network must provide zero phase shift at the operating frequency. Consequently, a crystal can be used as the feedback network since it exhibits zero phase shift at its series resonant frequency f_s. The operating frequency can be changed slightly by inserting a capacitor, equal to the specified load capacitance, in series with the crystal. This has the effect of "pulling" the series resonant frequency up towards the parallel resonant frequency, and by making the capacitor a trimmer we have a convenient means of tuning out the crystal tolerance while still maintaining a very high Q-factor.

For the configuration of Fig. 4b, the feedback network is required to provide a 180° phase inversion; a suitable arrangement is shown conceptually in Fig. 5 which represents a Pierce or Colpitts oscillator. For 180° phase shift the network requires that the sum of the two capacitive reactances cancels the inductive reactance.

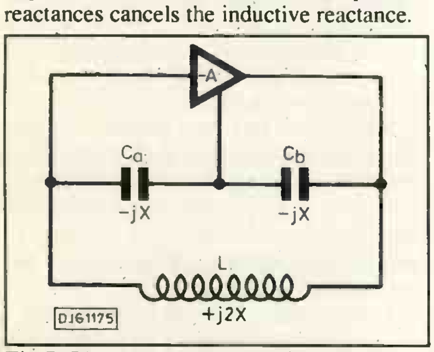
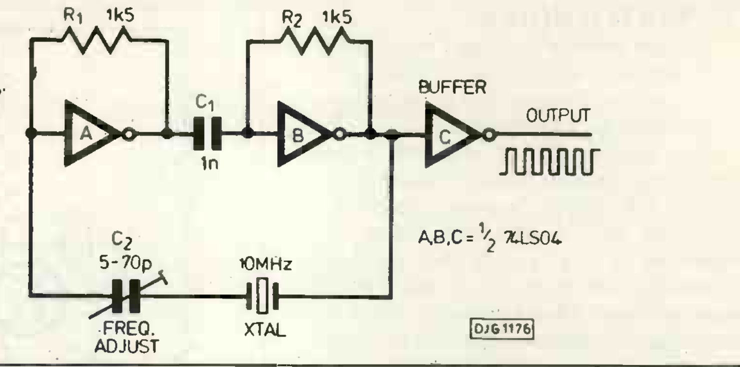


Fig.5. *Pierce or colpitts oscillator.*

Now, refering again to Fig. 3, we see that the crystal impedance is inductive over the frequency range f_s to f_p. Thus, we can substitute the crystal for the inductive reactance of Fig. 5, and provided the total capacitance (including C_a, C_b and any strays) presented to the crystal equals its specified load capacitance, the circuit will oscillate at the required frequency. By making C_a or C_b a trimmer, we can again

Fig.6. *Popular, dual-gate, TTL oscillator*



fine-tune the output frequency.

Fig. 5 can easily be adapted to represent a Hartley or Miller oscillator, and indeed there is a variety of oscillator configurations which can be designed using a crystal as the frequency selective element. Beware, however, that not all configurations are suitable as timebase oscillators, and incorporating a crystal into a poor design can actually reduce the Q-factor and thus degrade frequency stability.

TYPICAL DESIGNS

Fig. 6 shows a much-used TTL oscillator, popular, no doubt, because many digital systems have several spare inverters or gates which can be pressed into service as the active elements.

Inverters A and B are biased into the linear region by R_1 and R_2, and constitute an overall non-inverting amplifier; C_1 merely provides ac coupling. The feedback network comprises the series resonant crystal in series with trimmer C_2.

An advantage of the circuit is that the output is rectangular, not a sine wave, and so it can drive directly the digital circuitry of the uct. Unfortunately, the design has several major disadvantages. Firstly, the inverters (which were never really intended as linear amplifiers) can introduce a lagging phase shift (particularly troublesome at high frequencies) in addition to the required 360°. Consequently, trimmer C_2 must be made relatively large in order to compensate for the unwanted phase shift, as well as being necessary to tune out the crystal tolerance. Even with C_2 adjusted to cancel the phase lag, the presence of the non-linear active stages within the inverters means the lag may vary over the operating cycle, resulting in poor short-term frequency stability, or "jitter".

DRIVE LEVEL

A second disadvantage is that the high gain of the inverters often causes the crystal to be operated at an excessively high "drive level".

The drive level of the crystal refers to the power dissipated within it. With too little drive, the crystal receives insufficient energy to sustain resonant vibrations, and the circuit simply fails to oscillate.

Too much drive, however, may lead to excitation of spurious crystal modes, causing extreme frequency shift. Even when operating at the correct resonant mode, the heating effect caused by excessive power dissipation can lead to serious, but reversible, frequency shifts. Eventually, however, the excessive drive can fracture the crystal causing an irreversible change in frequency.

Obviously, then, we should not exceed the maximum drive level specified for a particular crystal (values range from a few microwatts below 100kHz to about 10mW in the 20MHz region), and precision oscillator designs usually hold the drive level constant at a value well below the maximum rating by means of an agc (automatic gain control) circuit. The need for a constant drive is important, since a change of just 10 microwatts can cause a frequency deviation of 1 part in 10^8 – large enough to distort the value of the lsd of an 8-digit uct.

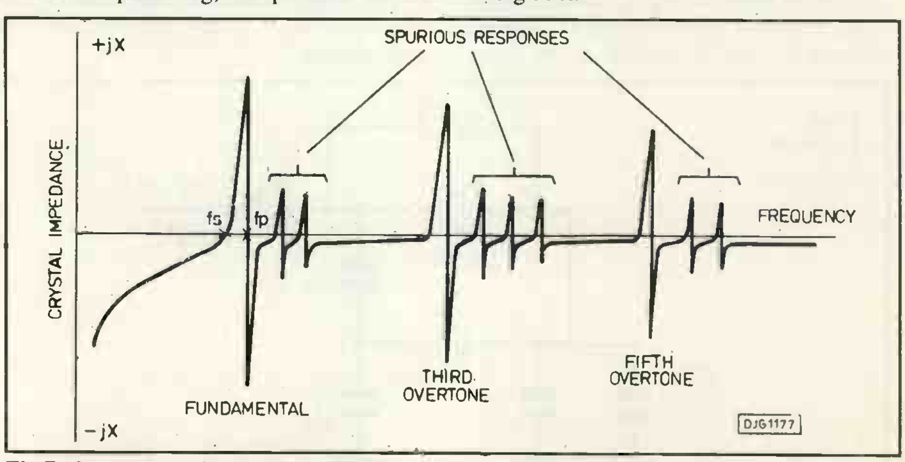


Fig.7. *Quartz crystal overtone response.*

UNWANTED MODES

Another problem associated with the TTL oscillator (and several other oscillators for that matter), is the possibility of oscillation at an unwanted resonant frequency.

We saw in Fig. 3 that the crystal impedance becomes purely resistive at the series and parallel resonant frequencies: these are the "fundamental" frequencies. However, if we extend the frequency response as shown in Fig. 7, we find that there are many other frequencies where the impedance becomes resistive, and the crystal can resonate at any of these points.

Several of these frequencies known as "overtones" are beneficial. Since the frequency of the crystal is inversely proportional to its thickness, it follows that very high frequencies require extremely thin crystal slices which are fragile and prone to damage.

An alternative, however, is to operate a relatively thick crystal at an overtone frequency, this being an approximate multiple of the fundamental frequency. Generally, third overtone crystals are used from 20 to 60MHz, and fifth overtones from 60 to 125MHz.

In addition to overtones, there are several spurious resonant frequencies, and unless carefully designed the oscillator may lock onto one of these spurii and oscillate at a frequency several hundred kilohertz different from the required value.

In order to avoid spurious oscillation, an LC tuned circuit resonant at the required frequency can be incorporated into the oscillator at a suitable point. For example, in the TTL design, C_1 can be replaced by a series lc branch resonant at 10MHz.

Note that inverter C of Fig. 6 is used to buffer the oscillator from the load. This is important in any oscillator design, since changes in the load can cause significant frequency drift. Consequently, buffering the uct timebase output is essential, since the load (ie, the number of logic devices being clocked) can vary considerably depending on the particular function selected.

CMOS PIERCE OSCILLATOR

An improvement on the dual gate oscillator is shown in Fig. 8, which depicts a Pierce oscillator (compare Fig. 5) using the high-speed cmos inverter A as the active device. This inverter provides the required gain and 180° phase shift, while the π-network comprising C_3, the crystal, and C_1 in parallel with C_2, provides the remaining 180° shift. C_4 is used simply to match the inverter output impedance to the total load, and R_1 provides dc bias for the inverter.

The 74HCU04 inverter is well suited to the application because its high input impedance does not load the π-network. Also, unlike its buffered counterpart the 74HC04, it contains only one active stage which results in better linearity and improved phase stability. Furthermore, the single stage means lower gain, thus reducing the likelihood of excessive crystal drive.

A particularly important feature of any timebase oscillator is its stability in response to supply voltage changes. For a prototype of the Pierce oscillator in Fig. 8, the frequency was found to change by only 23 parts in 10^8 when the 5V supply was varied by ±1%: bearing in mind the simplicity of the circuit, this is a particularly good figure of merit.

Nethertheless, a deviation of 23 parts in 10^8 will cause an unacceptable error in the two least significant digits of the 8-digit uct, and it goes without saying that good supply regulation is essential.

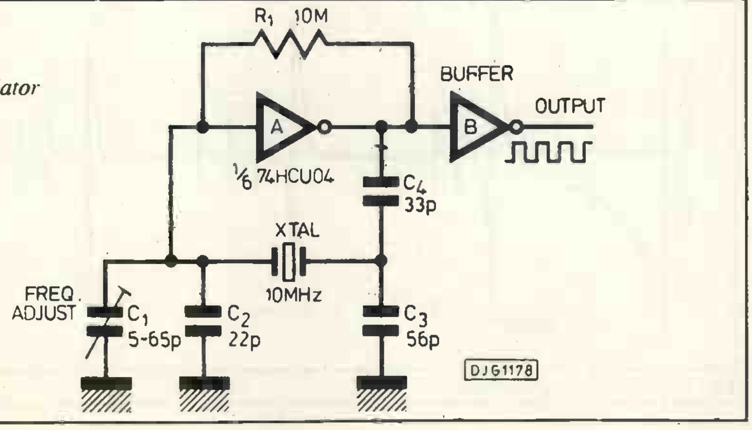


Fig.8. HCMOS *Pierce oscillator*

OPTIMISING PERFORMANCE

For more demanding applications, the circuit of Fig. 9 usually provides improved performance.

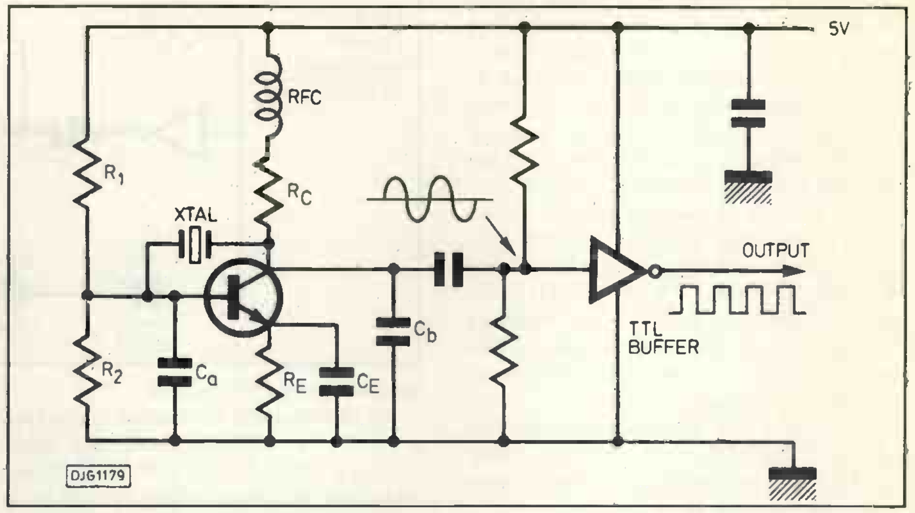


Fig.9. *Discrete Pierce crystal oscillator*

The oscillator is a Pierce type (compare again Fig. 5) with the bjt as the active device. Using a discrete transistor instead of a logic gate allows much more control over circuit parameters – particularly gain and drive level – such that the designer can optimise the overall oscillator performance.

Also, using a single bjt reduces unwanted phase shifts, and the improved linearity minimises jitter. The presence of the rf choke is not essential, but does reduce the likelihood of spurious oscillations. Note, also, how bias resistors R_1 and R_2 do not shunt the crystal: in any design, unnecessary loading of the crystal should be avoided since it reduces the Q-factor, thus degrading frequency stability.

The TTL buffer is required to provide a rectangular output and to isolate the oscillator from the load.

OFF-THE-SHELF TIMEBASE

Nowadays, a variety of manufacturers offer complete crystal oscillators housed in a 14-pin dil metal-can package. These devices usually run off a 5V supply and are convenient in that they provide a direct output and require no external components – the crystal and all oscillator electronics are housed within the can.

Futhermore, they have the advantage that all salient parameters – such as frequency tolerance, temperature characteristic, aging rate, etc – are specified within guaranteed limits. Thus, the designer is offered a ready-made timebase which operates at a defined level of accuracy.

Unfortunately, these products are not a panacea for all oscillator problems, since the quality can vary considerably from one manufacturer to another. Many of the oscillator designs suffer from the kind of problems discussed previously, and mechanical shortcomings, such as stressed wire bonds, can result in poor reliability.

Consequently, as with quartz crystals themselves, it is important to deal with a reputable manufacturer who will guarantee reliable operation under the stated conditions. PE

TO BE CONTINUED NEXT MONTH

TRAINEE RADIO OFFICERS

Are you looking for a secure shore-based job which offers a rewarding career in the forefront of modern Telecommunications technology... then consider joining GCHQ as a Trainee Radio Officer.

Training involves a 32 week residential course, (plus 6 weeks extra if you cannot touch type) after which you will be appointed RADIO OFFICER and undertake a variety of specialist duties covering the whole of the spectrum from DC to light.

We offer you: Job Security · Good Career prospects · Opportunities for Overseas Service · Attractive Salaries · and much more.

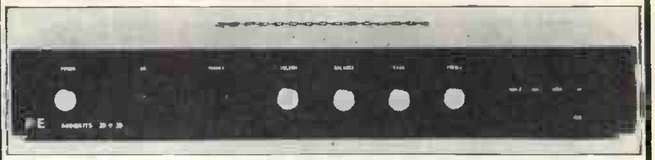
To be eligible you must hold or hope to obtain an MRGC or HNC in a Telecommunications subject with an ability to read Morse at 20 wpm. (City and Guilds 7777 at advanced level incorporating morse transcription would be advantageous). Anyone with a PMG, MPT or 2 years relevant radio operating experience is also eligible.

The Civil Service is an equal opportunity employer.

Salaries: Starting pay for trainees is age pointed to 21 years. For those aged 21 or over entry will be at £7,664. After Training and RO will start at £11,568 rising by 5 annual increments to £17,057 inclusive of shift and weekend working allowance.

Write or telephone for an application form to:–

GCHQ THE RECRUITMENT OFFICE, GCHQ, ROOM A/1108 PRIORS ROAD, CHELTENHAM, GLOS GL52 5AJ OR TELEPHONE (0242) 232912/3



PE 30 + 30 AMPLIFIER

Build this superb amplifier and enjoy high quality sound at a fraction of the cost of comparable manufactured amplifiers. Available in 3 versions.

30 + 30	STANDARD	30W	£172
	STANDARD	40 W	£185
	IMPROVED	40W	£400 p&p £6.00

PCB AND COMPONENTS AVAILABLE SEPARATELY
INTEGRATED AMPLIFIER KITS FROM £99.50
PREAMPS FROM £166
POWER AMPS FROM £195

AUDIOKITS XMAS SALE
SEND FOR OUR LIST OF BUILT & TESTED AMPLIFIERS INCLUDING DISCONTINUED MODELS, 30 + 30 KITS, MODULES etc.

NEW TO3P Mosfets 25J 162, £4.50
25K 1058 £4.50

For full details of AUDIOKITS amplifier kits and components please send SAE (overseas 3 IRC's) to

AUDIOKITS PRECISION COMPONENTS
6 Mill Close, Borrowash, DERBY DE7 3GU
Tel: 0332 674929

MORE LETTERS

STAR TRACK

Dear Ed,

As an amateur astronomer with an interest in electronics I was drawn to the front cover of your September edition with its picture of a ccd and telescope. I had not brought your magazine for several years and was pleased to note the astronomy orientated articles.

Regarding Mr Trice's letter in the same issue I was surprised that you appeared to believe a variable speed drive unit beyond the capabilities of amateurs. Like Mr Trice, I have little experience of circuit design but I'm sure your good selves would be able to come up with something. Indeed your October 1970 (yes, 1970!) edition contained a design for just such a unit (though minus joystick control). This could probably be easily updated. Also *Sky and Telescope* magazine of May 84 ran an article called 'Drive Correcting with a Joystick' which might also interest Mr Trice and others.

Keep up the good work.

Brian Stirland, Hucknall

Ah! you seem to have misread my reply – it's not the capabilities *that were questioned, its the expense of doing the job as satisfactorily as John Mason (editor of our sister magazine* Astronomy Now*) feels it should be done. I also asked readers to offer me suitable astronomy-related circuits.*

I have looked at the 1970 article, and I feel that although it was no doubt a good circuit for its time, it might be regarded as having deficiencies in this higher-tech age. For example, it cannot be computer controlled, it operates in one plane only, and is likely to suffer from speed changes with temperature variations, even though a simple compensatory circuit has been included. I cannot comment on the S and T circuit as I haven't seen it.

We will be pleased to supply photocopies of the PE 'Telescope Tracker' article of Oct 70 to anyone interested – at the normal rates of £1 to UK readers, £1.50 to overseas, including post. Local libraries may be able to get copies of the S and T article for anyone interested.

Incidentally, I briefly lived in Hucknall during the 1950s and still remember the amazing sight of the Flying Bedstead being tested by Rolls Royce – experiments that resulted in jump-jet aircraft like the Harrier.

Ed.

FRUITY TV

Dear Ed,

Mr Osibo (Letters PE Dec 88) was right! Electronics and Wireless World published an article about tv reception with a papaya tree as the antenna in July 1984.

Gerald Bettridge, Eton College Science Dept

So they did! It's a complex argument but to quote E&WW '... studies reveal that certain geometrically-shaped vegetation, due to water and chlorophyll content vis-a-vis their dynamic complex dielectric properties can sustain, propagate and radiate electromagnetic waves from their structure if suitably excited.'

My thanks to E&WW and all readers who sent me copies of this article.

Ed

IF AND RF CHIPS

Dear Ed,

Eric Cook in his letter published in PE Sept 88 asked for information on SL612 and SL613 if and rf opamps. Their equivalents SL1612 and SL1613 are available from Cirkit, 53 Burrfields Road, Portsmouth, Hants, PO3 5EB.

Anonymous Caller

CIRCUIT SUGGESTIONS

Dear Ed,

How about publishing a series on model railway control by radio?

H.A. Nichol, Braintree, Essex

I would like you to publish an article on 35MHz model aeroplane radio control systems.

S.P. Croft, Cumbria.

I should be delighted to publish circuits for both ideas if anyone offers me interesting articles on them.

Ed

PRACTICAL ELECTRONICS BOOK SERVICE

Here is your Editor's choice of books he thinks will be of interest to electronics and computer enthusiasts

BEGINNERS AND EARLY STARTERS

NEW Mini-Matrix Board Projects.
R.A.Penfold. 112 pages. £2.50.
Order Code BP99
Shows a selection of 20 useful and interesting circuits that can be built on a mini-matrix board of 24 holes by 10 copper strips in size - an ideal book for early experimenters.

NEW From Atoms to Amperes.
F.A.Wilson. 160 pages. £2.95.
Order Code BP254.
For the absolute beginner, clearly explaining the fundamentals behind the whole subject of electricity and electronics.

NEW Electronic Projects for Beginners.
F.G.Rayer. 128 pages. £1.95.
Order Code BP48
Specially for the newcomer to electronics who is looking for a book containing a wide range of easily made projects. Some circuits need no soldering and many others show actual component and wiring layouts.

Electronics Build and Learn
R.A.Penfold. 128 Pages. £5,95.
Order Code PC 101
Combining theory and practice, the book describes a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components and circuit concepts, complete with practical experiments.

Practical Electronic Building Blocks
R.A.Penfold. There are two books -
Book 1 : 128 pages. £1.95.
Order Code BP117
Book 2 : 112 pages. £1.95.
Order Code BP118
Book 1 is about oscillators and gives circuits for a wide range, including sine, triangle, square, sawtooth and pulse waveforms and numerous others from voltage controlled to customised ic types.
Book 2 looks at amplifiers, ranging from low level discrete and opamp types to ic power amps. A selection of mixers, filters and regulators is included.

30 Solderless Breadboard Projects
R.A.Penfold. Two books each of 160 pages. Book 1 : £2.25. Order Code BP107. Book 2 : £2.25. Order Code BP113.
Each project is designed for building on a Verobloc breadboard and is accompanied by a description, circuit and layout diagrams and relevant constructional notes. Many of the components are common to several projects. Book 1 covers linear devices, and Book 2 covers cmos logic chips.

Beginners Guide to Building Electronic Projects R.A.Penfold. 112 pages. £1.95. Order Code BP 227
Shows the complete beginner how to tackle the practical side of electronics and includes simple constructional projects.

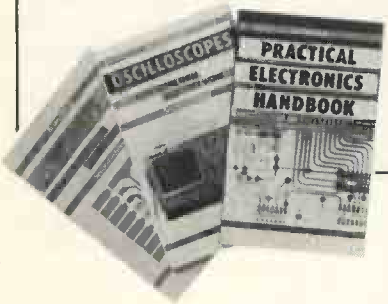
TEST AND MEASUREMENT

How to Get Your Electronic Projects Working.
R.A.Penfold. 96 pages. £2.50.
Order Code BP110.
Essential reading for anyone who wants first-time success in project assembly. Covers tracing mechanical faults as well as testing for failures of active and passive components of most types.

Modern Electronic Test Equipment
K.Brindley. £6.95.
Order Code NT4
Detailed information and discussions on analog and digital meters, oscilloscopes, signal sources, frequency, time and event counters, spectrum and logic analysers. displays and other test equipment.

Getting the Most from Your Multimeter
R.A.Penfold. 112 pages. £2.95.
Order Code BP239
There's more to what you can do with a meter than meets the casual eye. The book covers the basics of what you can do with analogue and digital meters and discusses component and circuit testing.

Oscilloscopes
I.Hickman. £6.95.
Order Code NT3
Subtitled 'How to Use Them, How They Work' the book is illustrated with diagrams and photographs and is essential reading for any one who wants to know about scopes, from first principles to practical applications.



COMMUNICATIONS

NEW Walkie-Talkie Projects
R.A.Penfold. 96 pages. £2.95.
Order Code BP186
Full of vital information and practical circuitry for the construction of low power transmitter-receivers and accessories.

An Introduction to Satellite Television
F.A.Wilson. 112 pages. £5.95.
Order Code BP195
Informative answers to many of the questions about this communications revolution. The information is presented on two levels, one aimed at the complete beginner, the other at professional engineers and serious amateur enthusiasts.

AUDIO AND MUSIC

Introducing Digital Audio
I.Sinclair. 112 pages. £5.95.
Order Code PC102
A non-mathematical introduction to the new digital technology, discussing the principles and methods involved in devices such as cd, dat and sampling.

Electronic Music Projects
R.A.Penfold. 112 pages. £2.50.
Order Code BP74
24 practical constructional projects covering fuzz, wah, sustain, reverb, phasing, tremolo etc. The text is split into four sections covering guitar, general, sound generation and accessory projects.

More Advanced Electronic Music Projects
R.A.Penfold. 96 pages. £2.95.
Order Code BP174
Complementing BP74 by covering more advanced and complex projects including flanging, chorus, ring modulation, plus a selection of drum, cymbal and gong circuits.

NEW Computer Music Projects
R.A.Penfold. 112 pages. £2.95
Order Code BP173
Shows how home computers can produce electronic music and covers sequencing, analogue and Midi interfacing, digital delay lines and sound generators.

Practical Midi Handbook
R.A.Penfold. 160 pages. £5.95.
Order Code PC103
A practical how-to-do-it book for musicians and enthusiasts who want to exploit the capabilities of Midi. Covers keyboards, drums, sequencers, effects, mixers, guitars, and computer music software.

Midi Projects
R.A.Penfold. 112 pages. £2.95.
Order Code BP182
Practical details of interfacing many popular home computers with Midi systems, and also covering Midi interfacing to analogue and percussion synths.

NEW Electronic Synthesiser Construction.
R.A.Penfold. 112 pages. £2.95.
Order Code BP185.
Even relative beginners should find the monophonic synthesiser described here within their capabilities if the book is thoroughly read. Individual aspects of the synth are dealt with separately and pcb designs are shown for the main modules.

DIGITAL AND COMPUTING

NEW A Concise Introduction to MS-DOS.
N. Kantaris. 64 pages. £2.95.
Order Code BP232
A ready-reference guide for those who need a quick insight into the essential command functions of this operating system, but who don't have the time to learn it fully.

An Introduction to Computer Peripherals
R.A. and J.W. Penfold. 80 pages. £2.50. Order Code BP170
Covers such items as monitors, printers, disc drives, cassettes, modems, etc, explaining what they are and how to use them with your computer and with each other.

Microprocessing Systems and Circuits
F.A.Wilson. 256 pages. £2.95.
Order Code BP77
A comprehensive guide to the elements of microprocessing systems, covering the fundamental principles behind this important subject.

Introduction to 6800/6802 Microprocessor Systems
R.J.Simpson and T.J.Terrell. 238 pages. £10.95. Order Code NT9
The book covers systems hardware, programming concepts and practical experimental work that will assist in understanding the 6800/6802 microprocessor, with additional information on the 6802D5E evaluation system.

NEW An Introduction to 68000 Assembly Language.
R.A. and J.W.Penfold. 112 pages, £2.95. Order Code BP184
Covers the fundamentals of writing programs that will vastly increase the speed of 68000 based machines such as the Commodore Amiga, Atari ST range, Apple Mackintosh, etc.

Getting the Most from Your Printer
J.W.Penfold. 96 pages. £2.95.
Order Code BP181
How to use the features found on most dot-matrix printers from programs and popular wordprocessors, showing examples of what must be typed to achieve a given effect.

Micro Interfacing Circuits
R.A.Penfold. Two books, each of 112 pages.
Book 1 : £2.25.Order Code BP130.
Book 2 : £2.25. Order Code BP131
Both books include practical circuits and useful background information though pcb layouts are not included. Book 1 mainly covers computer input-output techniques. Book 2 deals primarily with practical application circuits.

NEW An Introduction to 6502 Machine Code.
R.A. and R.W. Penfold. 112 pages. £2.50. Order Code BP147
Covers the main principles of machine code programming on 6502-based machines such as the Vic-20, Oric-1/Atmos, Electron, BBC and Commodore 64. It assumes no previous knowledge of microprocessors or machine code and gives illustrative programming examples.

NEW A Z-80 Workshop Manual.
E.A.Parr. 192 pages. £3.50.
Order Code BP112
A book for those who already know Basic but wish to explore machine code and assembly language programming on Z80 based computers.

Practical Digital Electronics Handbook
M.Tooley. 208 pages. £6.95.
Order Code PC 104
Nine constructional projects introduce digital circuits, logic gates, timers, microprocessors, memory and interface circuits - an essential book for anyone interested in digital devices.

GENERAL CONSTRUCTIONAL

NEW Electronic Science Projects.
Owen Bishop. 144 pages. £2.95.
Order Code BP104
A bumper bundle of experimental projects ranging in complexity and including a colour temperature meter, electronic clock, a solid state (led display) scope, an infra-red laser, a fascinating circuit for measuring the earth's electrical field strength, and many more.

Electronic Security Devices
R.A.Penfold. 112 pages. £2.50. BP56
Full of ideas for keeping your valuables safe. The circuits include designs for light, infra-red, ultrasonic, gas, smoke, flood, door and baby sensors.

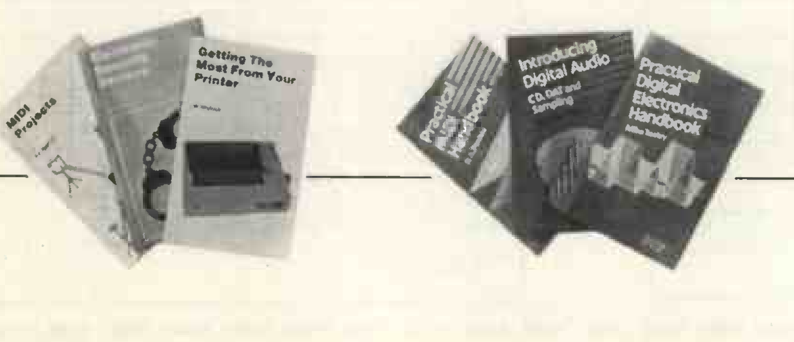
NEW More Advanced Electronic Security Projects. R.A.Penfold. 112 pages. £2.95. Order Code BP190
Follows on from where BP56 leaves off and describes a number of more up-to-date and sophisticated projects, such as pyro-sensors, infra-red and doppler-shift detection, fibre-optic loops, and many others.

NEW Electronic Projects for Cars and Boats.
R.A.Penfold. 96 pages. £1.95.
Order Code BP94
15 fairly simple projects that can be used with a car and/or boat. Stripboard constructional details are included, as are explanations of the circuit theory.

Power Supply Projects
R.A.Penfold. 96 pages. £2.50.
Order Code BP76
A selection of power supply designs, including simple unstabilised, fixed voltage regulated and variable voltage stabilised, ni-cad charger, voltage step-up, and inverter.

More Advanced Power Supply Projects
R.A.Penfold. 96 pages. £2.95.
Order Code BP192
Covers more advanced topics than BP76 and includes precision supplies, switch mode and computer controlled supplies, plus a selection of miscellaneous circuits.

NEW Popular Electronic Circuits.
R.A.Penfold. 160 pages. £2.95.
Order Code BP80
Containing a wide range of circuit designs for experienced constructors who are capable of producing working projects direct from a circuit diagram without specific constructional details.



DATA AND INFORMATION BOOKS

Digital IC Equivalents and Pin Connections
A.Michaels. 320 pages. £5.95.
Order Code BP140
Linear IC Equivalents and Pin Connections
A.Michaels. 256 pages. £5.95.
Order Code BP141
Between them these two books show equivalents and pin connections of a popular user-orientated selection of European, American and Japanese ics. They also include details of functions, manufacturer and country of origin. The Digital ICs book also quotes details of packaging and families.

Opamps
B.Dance. £6.50.
Order CodeNT2
Subtitled 'Their Principles and Applications' this interesting book is written in a simple non-mathematical style and provides a source of practical circuits that use both commonplace and more sophisticated opamps.

Electronic Hobbyists Handbook
R.A.Penfold. 96 pages. £4.95. Order Code BP233
Provides a source of useful information that the amateur enthusiast is likely to need for day-to-day pursuance of hobby electronics.

Practical Electronics Handbook
I. Sinclair. £7.95.
Order Code NT1
A useful and carefully selected collection of standard circuits, rules-of-thumb and design data for enthusiasts, students and engineers involved in radio, computing and general electronics

Newnes Electronics Pocket Book
I.E.Parr. £6.95.
Order Code NT10
Presents all aspects of modern electronics in a readable and largely non-mathematical style, and is a good source of valuable information for enthusiasts and professional engineers alike.

NEW Key Techniques for Circuit Design
G.C. Loveday. £6.95.
Order Code BM 101
Tackles the problems of designing circuits from scratch, introducing the concept of target specifications, the design sequence, device selection, rules of thumb, and useful equivalent circuits.

HOW TO ORDER

State your order code and your name and address clearly. Enclose a cheque, PO or international money order (add 50p postage per book - £1.00 for overseas surface mail), and send to:

PE Book Service
Intra House
193 Uxbridge Road
London W12 9RA

Books are normally delivered within 10 days but please allow 28 days for delivery.

Free Reader Adverts

Searching for that elusive component?
Surplus equipment to sell?
Read the rules and fill in the form below to have your free ad published in PE BAZAAR.

Twenty one 'chips, 4x7 segment displays, resistors, capacitors, power transistors, pots ets. £10. Tel: Witham 516200.

Anatomy of CPC by First Publishing Co. wanted. J. Turner, 14 Lacy Drive, Wimborne, Dorset BH21 1AZ

Computer PCB's and components, RAMs, EPROMS, CPUs etc. Really useful. Also electronic magazines SAE for details. J. Chambers, 23 Orchard Street,Nuneaton, Warks CV11 4BS.

Logic Analyzer Thurlby LA160, 3 Pods, 2 Logic Grabbers. Cost £540, sell £300ono. 091-482307.

Wanted: circuit for Radford STA25 in HiFi news June to September 1962. Also valve bases required. M. Powell, 2 Penylan Terrace, Penylan, Cardiff CF3 7EU.

Wanted: Pye radio model 39JH or A39JH with or without valves. Tel: 01-747 1271. J. Murray.

Wanted: manual for Wayne Kerr LCR Bridge CT492. Copy or loan for two days. Costs refunded. E. Turner, 74 Beech Lane, Stretton, Burton on Trent, Staffs DE13 0DU. Tel: (0283) 68547.

Approx. £100 worth components. All sorts modern stuff from reputable dealers £40 inc. post etc. Clive 01-699 5775.

Sinclair ZX81 16K RAM modules, £7 plus whatever postage. Phone Will. on (0795) 71978.

AVO multiminor £25. Fluke digital meter £50. HV probe £15 01-554 2913 6-9pm.

Thandar TM451 multimeter 4 1/2 digits, highly accurate, autorange, good condition. Cost £215. Sell for £120 ono. David V. French, 16 Hurst Close, Brightlingsea, Colchester, Essex CO7 0ER

For sale: Camputers Lynx computer 48K complete with power supply and manual as new £50.Paul Roberts, The Old School, Prickwillow, Ely, Cambs. Tel: (035388) 325.

Optical fibre video transmission system. Transmits video pictures. Requires two 9-12V supplies and optical fibres. Offers. B. Gohil, 63 Groveway, Wembley, Middx. HA9 6JS.

Rectangular LEDs green 6p red 8p each + 19p stamp to William Goss, TRAXX, 9 Ranleigh Gardens, Southampton, Hants SO1 2TH.

Scope W.W design 1964 complete data unfinished modified for 5 inch C.R.T. 3-9v/cm sensitivity T948 £45 Tel: (078) 729744, Sudbury.

PYE radio wanted. Can be minus valves type 39JH A39JH PE60 circuit. Must be complete. 01-747 1271.

Wanted: Heathkit ET3100 kit or built good order. Mr. GS Buttrick, 32 West Cliff Park Drive, Dawlish, Devon EX7 9EW. (0626) 864120.

Interested in Electronics and Pen-friendship? Write now if you don't want to miss a like-minded friend! Mamlukar Rahman, 154 Madar Bukhsh Hall, Rajshahi University, 6205 Bangladesh.

Practical Electronics 1969 to 1975 most issues plus easibinders. Will split if necessary. Offers plus p&p. 39 Tynperley Court, Kings Road, Horsham, West Sussex RH13 5SU. Tel: 0403 67080 evenings.

Wanted: leak delta 70 stereo amplifier in any condition. Tel: 01-366 4350 or please write. N.A. Dias Weerasinha, 212 Lavender Hill, Enfield, Middx. EN2 8NJ.

Will swap five 4164 drams for two 6264 static rams. BD Summers, 39A Cromer Road, Hellesdon, Norwich NR6 6LX.

I will exchange a nice gift from Iran for a mini drill. Details from Nima Yavari-Esphahan Sheikh Bahaei Ave-koye Ferdosi Kakh-No 49 Iran

Exchange. Souvenirs from Iran for a good desolder pump. Mehran Jafari, Banafsheh Shomali Avenue - 12m Sepideh No. 17 - Khaneh Esphahan - Esphahan - Post Code 81959 - Iran.

Hameg (German) HM203.5 as new, with manual and box £180 ono. G. Hobbs, 36 The Spittal, Castle Donnington, Derbys, DE7 2NQ. Tel: 0332 810024.

Apple IIE. 2 disc drives. Applesoft and manuals inc. monitor £150 CAE. Parallel printer £150. GW Goodrich, 47 Stanley Road, Brighton, E. Sussex BN1 4NH.

Wanted: Manual or info on telequipment servicescope type S32. K. Simmons, 5 Orchard Close, Little Port, Cambs CB6 1NU.

Hammond reverb unit, 96 note generator board, Maplin autochord board's full data, £40 P. Paid. Seon Smyth, "De Porres", 67 East Princes St. Helensburgh G84 7DG. Tel: (0436) 71181.

Wanted: Everyday Electronics April 1988 volume 17 No. 4 in good condition. Ian Davis, 11 Phillip Street, Pukekohe 1800, New Zealand.

Micro size telephone recording unit (ATR2). Assembled kit plus instructions, unwanted gift, £10. Mr. B. Gohil, 63 Groveway, Wembley, Middx. HA9 6JS.

Tektronix oscilloscopes RM503 S/B, £40. 545 D/B, £110. ZX81 Computer £20, Acorn Atom computer £20. Alan Pell, 15 Broadgate, Whaplode Drove, Nr. Spalding, Lincs. PE12 0TN. Tel: (0406) 330865 (evenings).

Tech R.F. signal generator £39 millivoltmeter. £24 metrix Wobbulator (R.F. sweep generator) £37. R. Hearn, 10 Speedwell Close, Pakefield, Lowestoft, Suffolk NR33 7DU. Tel: 0502 566026.

PE BAZAAR

Name & Address

Please publish the following small ad. FREE in the next available issue. I am not a dealer in electronics or associated equipment. I have read the rules.
Signature..Date..................

RULES Maximum of 16 words plus address and/or phone no. Private advertisers only (trade or business ads. can be placed in our classified columns). Items related to electronics only . No computer software. PE cannot accept responsibility for the accuracy of ads. or for any transaction arising between readers as a result of a free ad. We reserve the right to refuse advertisements. Each ad. must be posted within one month of cover date. (One month later for overseas readers).
Send this form (or a photocopy of it) to:
PE Bazaar, Practical Electronics, 193 Uxbridge Road, London W12 9RA.

TECHNOLOGICAL HUBRIS

BY TOM IVALL

WE CAN DO ANYTHING....

... even blow ourselves up with our own fail-safe devices. The torpedo won't turn round? Never mind – we'll turn the ship. We could do anything – if we knew what we were doing.

"Technology is not the problem – we can do anything", said the eminent head of an international satellite organisation at a conference I attended recently. He was actually pointing out that the major difficulties in setting up new communications satellite systems are now institutional or political rather than technological. In other words, human wishes, intentions, ideals, ambitions etc, are now the real heart of the problems that have to be dealt with. But I couldn't help feeling that the throwaway remark "Technology ... can do anything" was typical of an attitude which is very prevalent in electronics these days.

The context in which it was spoken was telecommunications. Here it's very easy to be confident about the powers of the technology, because the electronics is only required to do a job for which it is extremely well adapted – transmitting and processing information – and nothing more than that. But when the electronics is part of a larger process – say mechanical position control in aircraft or factory control systems, or stimulation of nerve fibres inside the human body – it's a very different story.

Here the electronic information processing is more subservient and very much under pressure from the conditions imposed by the physical system and its environment. For example, electronic implants inside the human body have to work reliably while permanently immersed in a warm saline solution – the natural body fluids. Can you imagine anything much worse as an environment for electrical apparatus!

What I have called technological hubris, to borrow a Greek word meaning insolent pride or security, has been greatly encouraged by the software revolution. Ever since Alan Turing showed that a computing machine can be specified completely in terms of its actions, which can be described as a set of rules of operation and in turn represented by symbols standing for both the numbers and the instructions for operation on them, we have soared gloriously above the limitations of mere physical materials. There is no metal, plastic, semiconductor material etc, to wear out, get broken, or become corroded or chemically decomposed. Software is totally reliable in the non-physical sense that it continues to provide exactly the same *function* for ten, a hundred, a thousand, a million years after it was designed. Nothing can go wrong with it, any more than the rules of logic can show signs of wear after many centuries of use.

If we have a problem to be solved and can break down the solution into a series of procedural steps we call the result – after the 9th century Arabic mathematician Abu Jafar Mohammed, whose nickname was Al-Kharizmi – an algorithm. In turn an algorithm can be implemented on a real machine as a set of instructions, or program. Nowadays the machine is likely to consist of electronic logic devices in the form of digital integrated circuits. But, as the philosopher John Searle recently remarked, it could just as well be made of old beer cans for all that this matters to the program as such.

However, we normally want to use the software for some practical purpose so old beer cans are not quite the thing. It's when we start applying the inviolable logic and reliability of the software to the messy and unpredictable characteristics of the real world – which include human failings – that we run into difficulties.

For example, a safety system was designed to prevent a torpedo from accidentally turning round in mid course and heading back to destroy the warship which launched it. This system worked by detected that the torpedo had turned through 180° and then detonating it before it could get back to the launching ship. Unfortunately, in a test of the system, the second time a torpedo was launched, with a live warhead, the driving motor failed and left the live torpedo still sitting in the launching tube. The ship's captain decided to abandon the testing and return to port. But he had forgotten the safety system. When the ship turned round to go back home the torpedo exploded in the tube.

There have been many other 'own goals' in the systems engineering world, some with disastrous consequences. One remembers nuclear power accidents and the shooting down of civilian airliners. These should be enough to restrain overconfidence in systems design, which in my view is a result of intellectual arrogance fostered by a mistaken reliance on the perfection of software.

And the business of implementing the software in hardware is not all that straightforward either. When the Royal Signals and Radar Establishment did an investigation of commercial microprocessor chips they discovered that the devices can be so complicated that even experienced designers can misunderstand some aspects of their behaviour. RSRE also found that many of these products have design errors at the silicon level, while the handbooks describe the operation codes in a way that is sometimes ambiguous and at worst gives totally wrong information.

I see that the first students have recently completed a new course in Software Engineering jointly established by the IEE and the National Computing Centre. Many colleges and training organisations are now interested in running it. Apparently the IEE/NCC certificate qualifies the students "to act as full contributing members of a software engineering development team." I'm sure these students are too intelligent to confuse software engineering with engineering in the broader, traditional sense, which always requires a wide experience and a canny awareness of the many traps that the world can set to make fools or victims of us. But their future bosses, preoccupied with other concerns, may not prove to be so clear in their minds and could make the mistake of giving them too much responsibility.

One doesn't want to make a practice of seeking out errors and disasters but we can certainly learn from them. So let's hope that a sufficiently large dossier of computer 'crashes' and other empirical knowledge of this kind will soon be amassed to act as an ever-present warning. As an older tradition taught, hubris is always followed by Nemesis. PE

FULL-TIME TRAINING COURSES

2 YEAR
BTEC NATIONAL DIPLOMA
Electronics and Communications Engineering
(TV, *Computers,Programming,IT*)

1 YEAR
BTEC NATIONAL CERTIFICATE
1. **Electronic Equipment Servicing** *(TV, Video, CCTV)*
2. **Computing Technology** *(Microprocessors, DataComms, Interfacing)*
3. **Information Technology** *(Telecomms, SatelliteTV, CD, Networks)*
4. **Software Engineering** *(Assembler, BASIC, PASCAL, CADCAM)*

COURSES COMMENCE
Monday 9th Jan./ 24th April 1989

LONDON ELECTRONICS COLLEGE
Dep: AA, 20 Penywern Road,
London SW5 9SU. Tel: 01-373 8721

PRACTICAL ELECTRONICS CLASSIFIED

Reach thousands of serious electronic and computer enthusiasts. Advertise in PE Classified pages: Rates 20p per word or £8.50 per single column cm (plus VAT). Send your advertisement with your remittance to **PE, Intra House, 193 Uxbridge Road, London W12 9RA. Tel: 01-743 8888.**

LET PE WORK FOR YOU!

Carbon Film Resistors ¼W E24 series 0·51R to10M0 – 1p
100 off per value – 75p 1000 off in even hundreds per value – £7
Metal Film ¼W 10R0 to 1M0 5% E12 series – 2p 1% E24 series – 3p
½Watt metal/carbon film E24 series 1R0 to 10M0 – 1½p
1 Watt metal/carbon film E12 series 4R7 to 10M0 – 5p
BC107/8/9 – 12p BC547/8/9 – 8p BC182L 184L – 10p
BFY50/51/52 – 20p 2N3055 – 50p TIP31A,32A – 25p TIP,41,42, – 40p

Tantalum head subminiature electrolytics (Mids/Volts)
0·1/35, 0·22/35, 0·47/35, 3·3/16, 4·7/16 – 14p 4·7/35 – 15p
2·2/35, 4·7/25, 10/5 – 15p 4·7/35, 6/8/16 – 16p 10/16,22/6 – 20p
22/16 – 30p 33/10 – 30p 47/10 – 35p 100/6 – 40p

Aluminium Electrolytics (Mids/Volts)
1/50, 2·2/50, 4·7/25, 4·7/50, 10/16, 10/25, 10/50 – 5p 22/16, 22/25 – 6p
22/50, 47/16, 47/25, 47/50 – 6p 100/16, 100/25 – 7p 100/50 – 12p
100/100 – 14p 220/16 – 8p 220/25, 220/50 – 10p 470/16, 470/25 – 11p
1000/25 – 18p 1000/35, 220/25 – 22p 4700/25 – 70p

Miniature Polyester Capacitors 250V Wkg. Vertical Mounting
·01, ·015, ·022, ·033, ·047, ·068 – 4p 0·1 – 5p 0·15, ·22 – 6p 0·47 – 8p

Mylar Capacitors 100V Wkg. Vertical Mounting E12 Series
1000p to 8200p – 3p ·01 to ·068 – 4p 0·1 – 5p 0·15, 0·22 – 6p

Subminiature Ceramic Plate 100V Wkg. E12 Series Vertical Mounting
2‰ 1P8 to 47P – 3p 56P to 330P – 4p 10% 390P to 4700P – 4p
Ceramic plate/disc E6 Series 50V 22P to .047 – 2p

Polystyrene Capacitors 63V Wkg. E12 Series Axial Mounting
10P to 820P – 3p 1000P to 10,000 – 4p 12,000P – 5p
1N4148 – 2p 1N4002 – 4p 1N5404 – 14p W01 bridge – 25p
0A91 – 6p AA143 – 8p W005 – 20p 1N4006 – 6p
Zener diodes E24 series 3V3 to 33V 400mW – 8p 1 watt – 12p
L.E.D's Red, Green & Yellow 3mm & 5mm – 10p 8mm – 35p
20mm fuse 0·1A to 5A quick blow – 5p Anti Surge – 8p
High Speed drills 0·8mm, 1·0mm, 1·3mm, 1·5mm, 2mm – 30p
Expo Reliant drilling machines 12V d.c. with improved 3-jaw chuck 6.50
Nicads AA – 80p HP11 – £2 PP3 – £4.20 Universal Chargers – £6.50
Glass reed switches single pole make contacts – 8p Magnets – 12p

VAT inclusive. Return postage 25p (free over £5). Lists free.

THE C.R. SUPPLY CO.,
127 Chesterfield Road,
Sheffield S8 ORN. Tel. 557771.

Cooke International

GOOD USED **TEST EQUIPMENT** ALWAYS AVAILABLE
SCOPES ANALYSERS SIG GENS BRIDGES COUNTERS POWER METERS RECORDERS

Sample of current stock;
Tektronix 465 dc-100Mhz dual beam with delay portable scope £750.00
AVO 8 analogue multimeters a few from £40.00
Marconi TF144H/4 Standard Signal generators £55.00
H.P. 1725A DC-275Mhz dual trace with delay scope and DMM £1500.00
Bryans BS272 2 pen XY-T recorder as new £450.00
Full stock lists available

UNIT 4 FORDINGBRIDGE SITE, MAIN ROAD, BARNHAM, BOGNOR REGIS, WEST SUSSEX PO22 0EB
Tel: 0243 68 5111/2. Fax: 0243 68 2457

Resistors 1/4 W 5% carbon (E12) 1p metal film 1% (E24)3p
Resistor Pack 85 different E12 values + zero ohm link total contents 1000 resistors £8.95
LEDs red/green 3/5mm 6p each. Yellow 11p
Cable ties 75mm 1p each £5.95/1,000 £49.50/10,000
Power transistors TIP35C (NPN), TIP36C (PNP)
100v 25A TOP3 plastic case £1.56ea
100dB piezo buzzer £1.50 standard buzzer £0.80
Solar cells 0.45v 100mA £1.48 700mA £3.50
Stepping motor 4 phase 12v 7.5 step 50 ohms £8.95
SAA1027 stepping motor driver chip £3.95
Miniature FM transmitter Kit 100-108 Mhz high quality sound Ideal for cordless microphones or guitars etc £7.48
Metal latching XLR line plug £1.35 line socket £1.48
Ferric chloride pack for mixing with 1/2L water £1.40
Automatic squeeze action wire strippers £3.45

Special offers Limited Stock

Computer Grade Capacitors with screw terminals
58000uf 60v £4.00 4700uf 63v £1.50
38000uf 20v £1.95 87000uf 10v £1.50
Stereo LW/MW/FM Tuner pre-amp assembly complete with volume/tone controls and tuning scale
Brand new in makers carton £5.95, faulty £1.95
Circuit diagram description and setting up procedure for tuner assembly described above £0.50
LCD display 16 digit 7x5 dots dot matrix £2.50
CMOS TTL 74HC 74F Linear transistors kits capacitors resistors tools etc always in stock

Please add 75p P&P per order VAT included
JPG Electronics 276 Chatsworth Road Chesterfield S40 2BH
Access orders (0246) 211202. Callers welcome

COMPONENT KITS RESISTORS, CAPACITORS, FUSES, DIODES ETC
Save time, trouble and expense on that project by having the components you require to hand.
Our kits are ideal for the Development Lab, service engineer, Repair Shop, Tech College and hobbiest alike. The components supplied in our kits are new and to full specification. They come individually packed in handy re-usable plastic tubes, all contained within a storage unit.

RESISTORS 1/4w C.F. 5%
KIT 25E12-20 12R-1MEG (60 values, 20 of ea.) 1200 = £12.00
KIT 25E24-20 12R-1MEG (120 values, 20 of ea.) 2400 = £21.00
Replacement tubes complete with Resistors 25p ea.

RESISTORS 1/2w C.F. 5%
KIT 50E12-10 12R-1MEG (60 values 10 of ea.) 600 = £13.75
Replacement tubes complete with Res. 25p ea.

RESISTOR TWIN KIT 1/4w and 1/2w C.F.
KIT 25E12-20 12R-1MEG (60 values, 20 of ea.) = 1200
KIT 50E12-10 12R-1MEG (60 values, 10 of ea.) = 600 £25.00
FUSE KIT 20 x 5mm. 25-10amp SB & QB 10 of ea. (300) = £26.50

ZENER DIODE KIT
400mW KIT Z12-10 2.7-V 10 of ea. (150) = £12.00
1.3w KIT Z12-10 2.7-27V 10 of ea. (150) = £19.00

ZENER TWIN KIT
KIT Z12-TWIN-10 2.7-27V 10 of ea. (300) = £30.00

DIODE KIT
400mA IN4148 (200) 1Amp4002,4007 (50 ea)
3amp 5401,5408 (25 ea) Total 350 = £12.00

Any kit can be put together, if you or your company have a requirement for special or mixed kits we will be happy to quote. Please send s.a.e for full component and product list. Please add 50p P&P and 15% VAT to all orders. MAIL ORDER ONLY.

A.D.A.M. Electronics
P.O. Box 24, Church Crookham, Aldershot
GU13 0DH Tel 0252-617193

(0734) 341835 CSS Ltd (0734) 341835

256K DRAMS 100 n/s Ex-equipment 500 £5.00 each
256K DRAMS 120 n/s Ex-equipment 600 £4.00 each
256K DRAMS 150 n/s Ex-equipment 800 £3.80 each
64K DRAMS 120 n/s Ex-equipment 100 £1.00 each
64K DRAMS 150 n/s Ex-equipment 250 £0.80 each
64K DRAMS 200 n/s Ex-equipment 1,000 £0.50 each
64K DRAMS 120 Brand new 112 £2.00 each
1 TELEX CHEETAH £500.00
1 H/P 722IC 8-COLOUR PLOTTER CALL:

(0734) 341835 CSS LTD (0734) 341835

ELECTRONIC COMPONENTS

EVERYTHING FOR YOUR NEXT PROJECT
THE BIGGEST DISPLAY IN THE SOUTH IS AT

FRASER ELECTRONICS

42 ELM GROVE ★ SOUTHSEA ★ HANTS
Telephone: 0705-815584

Barclaycard Access

OMNI ELECTRONICS

stock a wide range of electronic components at
174 Dalkeith Road
Edinburgh EH 16 5DX
Tel: 031 667 2611
Open Mon-Fri 9am-6pm
Sat. 9am-5pm
Send 2x18p stamps for NEW CATALOGUE!

L.F. HANNEY

77 Lower Bristol Road, Bath, Avon.
Tel: 0225-24811

Your electronics component specialist for
AVON, WILTS. & SOMERSET
Open every day, except on Thursday

A & G ELECTRONICS LTD

If you are buying Electronics Components elsewhere you are almost certainly paying too much!. Write to us for a free 1989 catalogue and start saving money. Please send two 19p stamps towards postage.
P.O. Box 443 London E14 6JU Tel:01-519-6149

DEANSGATE ELECTRONICS

We stock a large range of electronic components, test equipment,telephone accessories, computer accessories, microphones, speakers, discolighting, mixers, meters, stylus, so call in and have a look around.
263 Deansgate, Manchester
Telephone: 061-834 1185

HYBRID POWER CONTROLS

☆ **BF HYBRID** — £7.95
12 Amp 240 Volt complete Zero Voltage Proportional Heater Control (no radio interface).

☆ **PC1R** — £3.45
1 Amp 240 Volt Phase Angle Controller - Light Dimmer (requires 220k pot.)

☆ **PC12R** — £6.95
12 Amp 240 Volt Phase Angle Controller - Light Dimmer, Drill Speed, Heater Control. (Requires 220k pot.)

Prices include VAT + p&p. 62 PARK ROAD, SWANAGE, DORSET, BH19 2AE
SAE for details on above products. TELEPHONE: 0929 426400
Full range of Thyristors, Triacs, Fuses, Heatsinks & Firing Circuits etc.
Trade enquiries welcome

Sutronics

WALTONS OF WOLVERHAMPTON

Established since 1947

Offering a complete range - IC's, transformers, switches, pots, capacitors, resistors, kits, speakers, test equipment, books and lots, lots more!

Come and see us at:

55A Worcester Street, Wolverhampton
Mon-Sat: 9-6 pm Tel: 0902 22039

TURN YOUR SURPLUS

ICS transistors etc into cash, immediate settlement. WE also welcome the opportunity to quote for complete factory clearance. Contact:

COLES-HARDING & CO.
103 South Brink, Wisbech, Cambs.
ESTABLISHED 15 YEARS
Tel: 0945 584188
Fax: 0945 588844

THE SCIENTIFIC WIRE COMPANY
811 Forest Road, London E17. Telephone 01-531 1568

SWG	1lb	8 oz	4 oz	2 oz
ENAMELLED COPPER WIRE				
8 to 34	3.63	2.09	1.10	0.88
35 to 39	3.82	2.31	1.27	0.93
40 to 43	6.00	3.20	2.25	1.61
44 to 47	8.67	5.80	3.49	2.75
48	15.96	9.58	6.38	3.69
SILVER PLATED COPPER WIRE				
14 to 30	10.10	5.20	2.93	1.97
TINNED COPPER WIRE				
14 to 30	3.97	2.41	1.39	0.94

Post Free. Please add V.A.T. at 15%. Orders under £3.00 add 50p
SAE for list of copper and resistance wire.
Dealer enquiries welcome.

PLS

16 Central Road
Worcester Park
Surrey KT4 8HZ
Tel: 01-330 6540
Programmable device specialists. (PAL's PROM's, PLD's etc). Many other components in stock

Make money in 1989!

use Practical Electronics classified pages for your small ads

Phone Claire on 01-743-8888

Eproms ex equip all blank and tested: 2764, £1 ea., £9 for 10; 2756, £2 ea.., £19 for 10; 200 step, stepper motors, 24/12 volts, £3 ea. Add £1 p&p.
EXTECH, THE COMPUTER CENTRE
53 Queen Street, Morley LS27 8DB
Tel: (0532) 537219

Phone Claire Hanson

with your classified ad!

01-743 8888

We now accept payment by Access and Visa

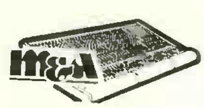
You can also use PE Fax Line: 01-743-3062

SPECIAL OFFERS

Cassette Motor large and small.	2 for £1.00
Mono and stereo cassette heads.	2 for £1.00
Auto-Reverse heads. £2.00 each. Small speakers	2 for £1.50
Microphone small for cass. tel. etc.	2 for £1.00

Please add 75p p&p. VAT inc Access card accepted. Golden Orange Supplies, Brockhollands Road, Woodside, Bream, Lydney Glos.. Tel: 0594-563009.

★ **Series X Mixer Kits**
★ up to 1,000 inputs
★ on-board mic input
★ 6 auxiliaries
★ versions for recording PA, radio, disco
★ **From £9.92**



Send 19p for catalogue to:
K. Tek, P.O. Box 172a, Surbiton, Surrey KT6 6HH. Tel:01-399-3990

"SUPERTRONICS"

Speakers, components and test equipment (new and used) at very competitive prices.
Come and see us at
BIRMINGHAM
65 HURST STREET
BIRMINGHAM B5
TEL: 021-666 6504
9-6pm

FACTORY CLEARANCE SALE

Printed Circuit Boards, 48" by 48" Sheets, single-sided, double-sided, glass and paper. 1/32" + 1/16" + 8" + many off cuts
1000 off contactors, 4 pole x 110volts AC - unused, as new.
1000 off compressed air valves, single coil, single port, also double coil, double port 110 volt AC unused, as new.
1000 off modules in McMurdo plug-in boxes with 110 volt transformers, relays and transistors. Ideally converted to time units etc.
Many more items available, telephone or write for free stock sheets.
ELECTECHNIQUES Selsley, Stroud, Glos GL5 5JY Tel: (04536) 3129. Fax: (04536)

BARGAIN'S TO CLEAR

Resistor's 1/4 W 2% METAL FILM 1.5 p each or 500 for £6 (50 DIFF VALUES). COPPER CLADDING 18in x 10in x 0.6 mm THICK. D/SIDED F/GLASS £3 each. MIXED DIALECTRICS - 0.1μF, 0.047μF, o.o33μF CAPACITORS; PK40 FOR £1. ZENER DIODES 12v, 1w - 5p each. 2732, 2716 EPROMS. PRO/ONCE £1 EACH. 8085 M.P.U £4. P/SUPPLIES - 5v, 45A £20, 12v, 18A - £20. 5v 100A - £30. 0.1" P.C.B EDGE CONNECTORS 54 PIN - £4 EACH ADD 50p P&P TO B.K, 22 NORTH STREET, NEWCASTLE, STAFFS. ST5 1BD

Do you service electronic products or computers? If so, than advertise in **PE classified pages!**

SERVICES

Sample our quality with

A FREE P.C.B

PAYNE ELECTROPRINT LIMITED
15 years **PRINTED CIRCUIT** manufacture
☆**Single/double sided**
☆**Plated Through Hole**
☆**Small or large quantities**
Write to : Dept A, Marcus Road, Dunkeswell, Nr. Honiton, Devon, EX14 8TT

PCB Services. PCBs draughted on Autocad. We will make drilled PCBs to your specifications. 1 offs to small production runs. Send your Artwork or circuit diagrams. Cost 6p/cm² single sided 12p/cm² double sided, 2p/cm² for Artwork production. For further details contact **Tommy Knight, Production Dept., Intec (Inverclyde) Ltd, 5 East Blackhall Street, Greenock PA15 1HD.**

ART WORK. Layout of track design to your circuit specifications by C.A.D. System. For further details contact **R.D. ELECTRONICS, 12 WHITEOAKS ROAD, OADBY, LEICESTER LE2 5YL. Tel: 0533 716273.**

CALIBRATION

Need not cost a fortune. For a free quote on your D.M.M., oscilloscope or frequency counter. Send type of instrument, Make and Model details to:-

3 1/2 DIGIT D.M.M. FROM £5.00 (calibrator to BS5750)

Calibration Lab, Bluehorrow Limited, Brookside Cottage, Main Road, Brighstone, I.O.W. PO30 4DJ
Tel: 0983 740845

PRINTED CIRCUIT BOARDS, **prototype and production. Quick turnaround, competitive prices. Details from Sherwood Circuits, Welbeck St., Nr. Worksop, Notts S80 4TW**

HEATHKIT U.K. Spares and service centre. **Cedar Electronics, Unit 12, Station Drive, Bredon, Tewkesbury, Glos. Tel (0684) 73127**

TECHNICAL INFO SERVICES (PE)
76 Church St., Larkhall, Lanarkshire ML9 1HE
Phone 0698 884585 Mon-Fri, 9-5
any other time 0698 883334 FOR FAST QUOTES
WORLD'S LARGEST COLLECTION SERVICE MANUALS Most unobtainable elsewhere. Prices range from only £4.50 - large s.a.e. any quotation, no obligation to buy.
WORLD'S SOLE Suppliers of TV & Video Repair manuals, etc. from TV TECHNIC, Thorn etc. Every published service sheet in stock, supplied full size, not bits & pieces. CTV's or any combination £3.50 plus Lsae, any other single item £2 50 plus Lsae. Complete Circuit Sets for most Videorecorders only #7 set (no serv shts made).
LSAE for QUOTATIONS plus GIANT CATALOGUE NEWSLETTERS BARGAINS FREE S/Sht as available.
Comprehensive TV Repair Manual £9.50. Complete Radio Service and Repair Course £9.50. Complete Repair & Service Manuals Mono TV £12.50; CTV £17.00; Video £19.50. Complete Repair Data with circuit - Mono TV £9.50; CTV £12.50; Video £10.50.
£3.00 plus LSAE BRINGS THE ONLY COMPREHENSIVE SERVICE SHEETS & MANUALS, CATALOGUES plus FREE CHASSIS GUIDE and £4.00 OF VOUCHERS

FOR MORE CLASSIFIED ADVERTISEMENTS GO TO PAGE 48

READY-MADE P.C. BOARDS

Simplify your project assembly – use a ready-made printed circuit board. All are fully drilled and roller tinned. Just slot in the components as shown in the project texts, and solder them. **PCBs are the professional route to project perfection.**

MAIL ORDERING

Select the boards you want, and send your order to
PE PCB SERVICE, PRACTICAL ELECTRONICS, 193 UXBRIDGE ROAD, LONDON W12 9RA.

Prices include VAT and postage and packing. Add £2 per board for overseas airmail. Cheques should be crossed and made payable to **Intra Press.**

Quote the project name and PCB Code Number, and **print your name and address in Block Capitals.** Do not send any other correspondence with your order.

TELEPHONE ORDERS (OPEN 24 HOURS)

Use your Access card and phone your order to

0268 289923

clearly stating your name and address, card number, and order details.

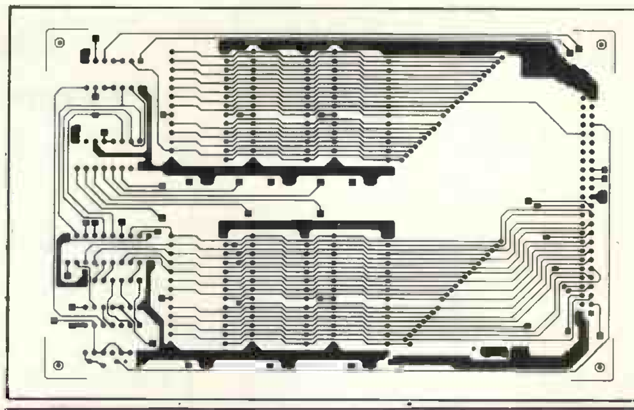
All orders receive priority attention, but allow 28 days for delivery in case a PCB is temporarily out of stock.

WE CAN ONLY SUPPLY THE PCBS LISTED HERE

CHECK LATEST ISSUE FOR PRICES BEFORE ORDERING

PHOTOCOPIES OF THE TEXTS MAY BE BOUGHT FROM THE EDITORIAL OFFICE AT £1.00 EACH PART (£1.50 OVERSEAS), P&P INCLUSIVE.
COMPONENTS ARE AVAILABLE FROM ADVERTISERS.

JULY 86		
PASSIVE IR DETECTOR – burglar detection	115	£3.90
200MHZ COUNTER – professional specification	00D	£30.88
SEP 86		
FIBRE-OPTIC LINK – computer comms.	ODE	£10.14
OCT 86		
DRUM SYNTHESISER	121	£7.67
MAINS DELAY TIMER – selectable 15 to 120 mins. Set of 2 PCBs.	122	£7.92
MAINS DIMMER – touch control up to 400W.	123	£3.90
NOV 86		
REMOTE JOYSTICK – infrared computer controller. Set of 2 PCBs.	124	£10.86
BABY ALARM – through-the-mains transceiver.	125	£10.71
DEC 86		
VIDEO ENHANCER – manually adjustable video improvement.	126	£8.76
JAN 87		
VIDEO FADER – simple inexpensive video mixer	127	£4.50
VOICE SCRAMBLER – confidential trans.	128	£8.06
MAR 87		
4 CHANNEL ENHANCER	135	£4.60
LIGHT PEN – uses fibre optics for accuracy	136	£4.10
ULTRASONIC TAPE MEASURE	138	£9.50
APR 87		
VIGILANTE CAR ALARM – keeps cars alert	139	£5.90
INDUCTIVE LOOP TRANSCEIVER – remote control for models:	143/144	£7.80
MAY 87		
BRIGHT FUZZ – Foot operated overdrive	145	£3.90
JUN 87		
AUDIO SIGNAL GENERATOR	146	£10.20



JUL 87		
WORD GENERATOR – 16-bit binary words	147	£13.42
SCOPE STORE oscilloscope add-on data storage	148	£11.94
SEP 87		
SPEECH PROCESSOR – clarifies speech	150	£5.86
GCSE TIMER UNIT – versatile variable delay	151	£5.18
FUNGEN – triple waveform signal generator	152/153	£9.69
LIGHT CONTROLLER – delayed switching	154	£4.64
OCT 87		
TEACHER LOCKER – digital lock control	155	£7.50
POWER SUPPLY – stabilised ±15V	156	£7.50
GUITAR TO SYNTH – music interface	157A/B	£9.95
NOV 87		
DUAL POWER SUPPLY – GCSE	158	£6.20
MIDI EXPANDER – Music Interface	159	£5.04
DEC 87		
RS 232C TO MIDI	160	£6.43
TEACHER RADIO – GCSE	161	£5.58
JAN 88		
EGG TIMER	162A-C	£12.44
LEGO BUGGY DRIVER	163	£6.42
FEB 88		
TEACHER TALKBACK – GCSE	164	£6.36
DC MOTOR SERVO	165	£7.53
MAR 88		
APPLIANCE TIMER	166A/B	£9.38
TEACHER LIGHTSHOW – GCSE	167A/B	£9.09
LOGIC ANALYSER – Double-sided	168	£20.65
APR 88		
LIGHT METAL EFFECTS	169	£7.10
TEACHER COUNTER	170	£4.95
	171	£4.92
MAY 88		
RF SPEECH PROCESSOR	172	£6.26
JUN 88		
AMSTRAD ROM EXPANSION	173	£10.80
MAINS MODEM	174	£4.27
JULY 88		
VOCALS ELIMINATOR	175	£4.31
AUGUST 88		
SPEAKING CLOCK	176	£16.75
SEPT 88		
BBC MULTIPLEXER	177	£4.50
OCT 88		
METAL DETECTOR	178	£6.50
DEC 88		
PLD PROGRAMMER	179	£9.90
	180	£4.90
PANNING MIXER	181	£7.80
JAN 89		
CHRISTMAS FLASHERS:		
RUDOLPH'S NOSE	182	£6.25
ANGEL'S HALO	183A/B	£9.40
CANDLE FLICKER	184	£6.25
PULSATING STAR	185A/B	£13.00
RANDOM PUDDING	186	£6.25

IT'S AN ASTRA-NOMICAL TRIPLE ENTER-PRIZE!

THREE ASTRA SATELLITE TV DISHES TO BE WON!

WORTH AROUND £180 EACH!

BE AMONG THE FIRST TO OWN THE NEW CAMBRIDGE ASTRA-RECEIVING ANTENNA

IT'S A TECHNOLOGICAL BREAKTHROUGH!

SIR CLIVE SINCLAIR'S BOFFINS AT CAMBRIDGE COMPUTERS HAVE DESIGNED THIS STYLISH FLAT AERIAL TO RECEIVE ASTRA TV BROADCASTS ALL OVER THE UK - IT'S JUST 60CMS ACROSS, INCLUDES THE RECEIVER AND TUNING UNIT, HAS A REMOTE CONTROL FOR ARMCHAIR CHANNEL CHANGING, AND PLUGS INTO YOUR OWN TV.

IT'S SO NEW IT'S NOT YET IN THE SHOPS (PRODUCTION IS DUE TO START EARLY 1989).

SIR CLIVE'S FLAT OUT FOR ASTRA

HOW TO ENTER

Ed's shown a little list, and nothing should be missed - in what order of priority do you rate the equipment? In the right hand column put 1 for your first choice, 2 for your second, and so on throughout the entire list.

If your top-six choice matches the majority top-six choice of other entrants we'll put your name in our special Prizeworthy Wobbulator. The first three names zapped out will each win one of the aerials. 12 month's free subscription to PE will be awarded to the next three names.

Don't be late entering - the draw takes place on FEBRUARY 28TH 1989. The winners will be announced in the May 1989 issue, on sale from April 7th.

THE EDITOR'S DECISION IS FINAL!

Send the entry form to : Practical Electronics Aerial Competition, Intra House, 193 Uxbridge Road, London W12 9RA.

ASTRA AERIAL ENTRY FORM

- ☐ Capacitance checker ☐
- ☐ Continuity checker ☐
- ☐ Eprom programmer ☐
- ☐ Frequency analyser ☐
- ☐ Frequency counter ☐
- ☐ Logic analyser ☐
- ☐ Multimeter ☐
- ☐ Oscilloscope ☐
- ☐ PCB making gear ☐
- ☐ Power supply ☐
- ☐ Semiconductor tester ☐
- ☐ Signal generator ☐
- ☐ Signal tracer ☐

Also, Ed would like to know which items of equipment you already own or have access to - put a tick in the left hand column. The answers in this column will not affect your entry into the draw, and will remain confidential.

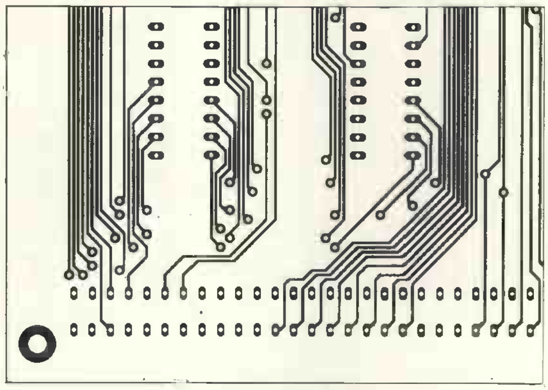
Name(in caps)________________

Address________________

MAKING ELECTRONICS C.A.D. AFFORDABLE

PCB LAYOUTS AND SCHEMATICS

EASY-PC AND TINY-PC



Excellent quality from dot matrix printer

Are you still using tapes and a light box.
Have you access to an IBM PC/XT/AT or clone incl. Amstrad 1640 & 1512?
Would you like to be able to produce PCB layouts up to 17" square?
With up to 8 track layers and 2 silk screen layers?
With up to eight different track widths anywhere in the range 002 to 531?
With up to 16 different pad sizes from the same range?
With pad shapes including round, oval, square, with or without hole?
With up to 1500 IC's per board, from up to 100 different outlines?
That can be used for surface mount components?
That is as good at circuit diagrams as it is at PCB's?
Where you can learn how to use it in around half an hour?
Standard output to dot matrix printer. Pen-plot and Photo-plot drivers available.

Price: TINY-PC £95.00 + VAT
EASY-PC £275.00 + VAT

CIRCUIT ANALYSIS BY COMPUTER

ANALYSER I AND ANALYSER II

PEN-PLOT & PHOTO-PLOT DRIVERS NOW AVAILABLE

For IBM PC/XT/AT and clones inc. Amstrad 1512, 1640, R.M. NIMBUS, BBC B, B+, and Master, Spectrum & Amstrad CPC series.

"ANALYSER II" – Analyses complex circuits for GAIN, PHASE, INPUT IMPEDENCE, OUTPUT IMPEDANCE and GROUP DELAY, over a very wide frequency range.
Can save days breadboarding and thousands of pounds worth of equipment.

Prices from £20 – £195.00 +VAT

Write or phone for full details:

Number One Systems Ltd 1

REF PE
Harding Way, St. Ives, Huntingdon
Cambs. PE17 4WR. Tel: St. Ives (0480) 61778

INDEX TO ADVERTISERS

PLEASE MENTION PRACTICAL ELECTRONICS WHEN REPLYING TO ADVERTS

TRANSFORMERS

12/24V or 12·0·12V
2 x 12V Secs Pri 240V

24V		12V	£	P&P
0.15		0.03	3.13	1.70
0.25		0.5	3.31	1.70
0.5		1	3.97	11.70
1		2	5.53	1.90
2	A	4	6.38	2.00
3	M	6	10.99	2.15
4	P	8	11.70	2.20
6	S	12	14.20	2.40
8		16	16.90	2.80
10		20	22.75	3.20
15		30	28.28	3.30
20		40	40.37	3.75
30		60	57.96	4.45
41		83	66.74	5.75

MAINS ISOLATORS
Pri 120V x 2 or 220/ 240V or 415/440V.Sec 440 or 240V or 110V Centre Tapped

20VA	£ 7.58	P	2.28
60	12.37	&	2.45
100	14.43	P	2.65
200	20.45		3.20
250	24.73		3.30
500	38.10		3.85
1000	69.10		4.85
1500	89.13		5.95
2000	107.24		5.95
3000	150.38		O.A
6000	321.20		O.A

50/25V or 25-0-25V
2 x 25V Tapped Secs
Volts available: 5, 7, 8, 10, 13,17, 20, 25, 33, 40, 50, 20-0-20,25-0·25V

50V		25V	£	P&P
0.5		1	5.38	1.90
1	A	2	6.5	42.00
2	M	4	11.65	2.50
3	P	6	13.48	2.50
4	S	8	18.46	2.95
6		12	23.47	2.95
8		16	33.20	3.25
10		20	39.40	3.70
12		24	47.16	3.90

Stock items by return
Send stamp for lists

30/15V or 15-0-15V
2 x 15V Tapped Secs
Volts available:3,4,5, 6,8,9,10,15,18,20,27,30V or 15.0V

30V		15V	£	P&P
0.5		1	4.14	1.65
1		2	5.63	1.80
2	A	4	9.10	2.00
3	M	6	10.55	2.20
4	P	8	12.59	2.30
5	S	10	16.11	2.40
6		12	17.65	2.65
8		16	23.59	2.75
10		20	27.22	2.95
12		24	30.39	3.05
15		30	34.03	3.65
20		40	46.46	5.95

AUTOS
105,115,220,230,140V
For step-up or down

80VA	£6.29	P	1.75
150	9.12	&	1.90
250	11.14	P	2.10
500	17.32		2.80
1000	30.94		3.35
1500	36.73		3.80
2000	54.92		4.65
3000	93.39		5.75
4000	121.23		O/A
5000	141.17		O/A
7500	217.91		O/A
10kVA	257.49		O/A

CASED AUTOS
240V Cable Input, Inst: Input.3-pin 115V USA Ski Outlet

20VA	£8.96	P	1.85
80	12.17	&	1.95
150	15.77	P	2.35
250	19.21		3.25
500	31.51		3.25
1000	44.23		4.55
2000	78.82		5.58
3000	113.15		O/A

110V to 240V Cased Autos now available

EX STOCK

60/30V or 30-0-30V
2 x 30V Tapped Secs
Volts available: 16,18, 36,40,60V or 24-0-24V or 30-0-30V

60V		30V	£	P&P
0.5		1	6.11	1.90
1	A	2	9.32	2.00
2	M	4	11.98	2.30
3	P	6	17.32	2.40
4	S	8	19.75	2.50
5		10	24.97	2.90
6		12	28.48	3.10
8		16	40.04	3.75
10		20	46.62	4.00
12		24	53.72	4.75

INVERTERS
12/24V DC to 240V AC
Sine-wave or Square Wave

STAND BY UPS SYSTEMS,AUTO CHARGERS & MAINT-FREE BATTERIES

CONSTANT VOLTAGE
Transformers for Spike-free Stable Mains

Also Valve Mains Output & Matching Transformers

TRANSFORMER 3VA to 18KVA WINDING SERVICE

AVO's & MEGGERS Full range
TOROIDALS Wound to Order

Please add 15% to all items after P&P

PE oscilloscope transformer 71 £12.82 incl.p&p & VAT.

Unit 211 Stratford Workshops Burford Road, London E15 2SP

BARRIE ELECTRONICS LTD
Tel: 01-555 0228 (3 lines)

OMP POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

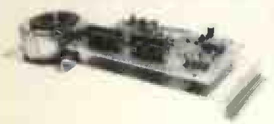
*** PRICES INCLUDE V.A.T. * PROMPT DELIVERIES * FRIENDLY SERVICE ***
LARGE S.A.E., 30p STAMPED FOR CURRENT LIST.

OMP POWER AMPLIFIER MODULES

Supplied ready built and tested.

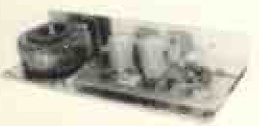
OMP POWER AMPLIFIER MODULES Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market. i.e., Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre P.C.B. and Drive circuits to power compatible Vu meter. Open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

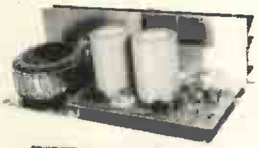


OMP100 Mk 11 Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz – 30KHz –3dB, T.H.D. 0.01% S.N.R. –118dB, Sens. for Max. output 500mV at 10K, Size 355 × 115×65mm.
PRICE £33.99 + £3.00 P&P.

NEW SERIES II MOS-FET MODULES



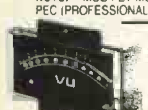
OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz –3dB, Damping Factor, >300, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. –125dB. Size 300 × 123 × 60mm.
PRICE £39.99 + £3.00 P&P.



OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz –3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. –130dB. Size 300 × 155 × 100mm.
PRICE £62.99 + £3.50 P&P.

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz –3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. –130dB. Size 330 × 175 × 100mm.
PRICE £79.99 + £4.50 P&P.

NOTE:— MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS, STANDARD — INPUT SENS, 500mV BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATABLE) — INPUT SENS. 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC



Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm.
PRICE £8.50 + 50p P&P.

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE S.A.E. (30p STAMPED) FOR COMPLETE LIST.

McKENZIE:— INSTRUMENTS, P.A., DISCO, ETC.

ALL McKENZIE UNITS 8 OHMS IMPEDENCE

8" 100 WATT C8100GPM GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID., DISCO.
RES. FREQ. 80Hz. FREQ. RESP. TO 14KHz. SENS. 99dB. .... **PRICE £28.59 + £2.00 P&P.**
10" 100 WATT C10100GP GUITAR, VOICE, ORGAN, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 70Hz. FREQ. RESP. TO 6KHz. SENS. 100dB. .... **PRICE £34.70 + £2.50 P&P.**
10" 200 WATT C10200GP GUITAR, KEYBOARD, DISCO, EXCELLENT HIGH POWER MID.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 103dB. .... **PRICE £47.48 + £2.50 P&P.**
12" 100 WATT C12100GP HIGH POWER GEN. PURPOSE, LEAD GUITAR, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 98dB. .... **PRICE £36.66 + £3.50 P&P.**
12" 100 WATT C12100TC TWIN CONE) HIGH POWER WIDE RESPONSE, P.A., VOICE, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 14KHz. SENS. 100dB. .... **PRICE £37.63 + £3.50 P&P.**
12" 200 WATT C12200B HIGH POWER BASS, KEYBOARDS, DISCO, P.A.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 100dB. .... **PRICE £64.17 + £3.50 P&P.**
12" 300 WATT C12300GP HIGH POWER BASS LEAD GUITAR, KEYBOARDS, DISCO, ETC.
RES. FREQ. 45Hz. FREQ. RESP. TO 5KHz. SENS. 100dB. .... **PRICE £85.79 + £3.50 P&P.**
15" 100 WATT C15100BS BASS GUITAR, LOW FREQUENCY, P.A., DISCO.
RES. FREQ. 40Hz. FREQ. RESP. TO 5KHz. SENS. 98dB. .... **PRICE £53.70 + £4.00 P&P.**
15" 200 WATT C15200BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. .... **PRICE £73.26 + £4.00 P&P.**
15" 250 WATT C15250BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. .... **PRICE £80.53 + £4.50 P&P.**
15" 400 WATT C15400BS VERY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 102dB. .... **PRICE £94.12 + £4.50 P&P.**
18" 400 WATT C18404BS EXTREMELY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 27Hz. FREQ. RESP. TO 3KHz. SENS. 99dB. .... **PRICE £167.85 + £5.00 P&P.**

EARBENDERS:— HI-FI, STUDIO, IN-CAR, ETC.

ALL EARBENDER UNITS 8 OHMS EXCEPT EB8-50 AND EB10-50 DUAL 4 AND 8 OHM.
BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED FOAM SURROUND

8" 50 WATT EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 97dB. .... **PRICE £8.90 + £2.00 P&P.**
10" 50 WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40HZ. FREQ. RESP. TO 5KHz. SENS. 99dB. .... **PRICE £12.00 + £2.50 P&P.**
10" 100 WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz. FREQ. RESP. TO 3KHz. SENS. 96dB. .... **PRICE £27.50 + £3.50 P&P.**
12" 60 WATT EB12-60 BASS, HI-FI, STUDIO.
RES. FREQ. 28Hz. FREQ. RESP. TO 3KHz. SENS. 92dB. .... **PRICE £21.00 + £3.00 P&P.**
12" 100 WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz. FREQ. RESP. TO 3KHz. SENS. 93dB. .... **PRICE £32.00 + £3.50 P&P.**

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

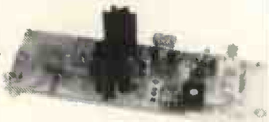
5¼" 60 WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz. FREQ. RESP. TO 20KHz. SENS. 92dB. .... **PRICE £9.99 + £1.50 P&P.**
6½" 60 WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz. FREQ. RESP. TO 20KHz. SENS. 94dB. .... **PRICE £10.99 + £1.50 P&P.**
8" 60 WATT EB8-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz. FREQ. RESP. TO 18KHz. SENS. 89dB. .... **PRICE £12.99 + £1.50 P&P.**
10" 60 WATT EB10-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 35Hz. FREQ. RESP. TO 12KHz. SENS. 86dB. .... **PRICE £16.49 + £2.00 P&P.**

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W FM TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 × 123mm, SUPPLY 12V @ 0.5AMP, PRICE £14.49 + £1.00 P&P

FM MICRO TRANSMITTER (BUG) 100-108MHz VARICAP TUNED COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 × 46mm, SUPPLY 9V BATT, PRICE £8.62 + £1.00 P&P



3 watt FM Transmitter

POSTAL CHARGES PER ORDER £1.00 *MINIMUM*. OFFICIAL ORDERS WELCOME FROM SCHOOLS, COLLEGES, GOVT. BODIES, ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA ACCESS ACCEPTED BY POST, PHONE OR FAX.

OMP VARISPEED TURNTABLE CHASSIS

★ MANUAL ARM ★ STEEL CHASSIS ★ ELECTRONIC SPEED CONTROL 33 & 45 ★ VARI PITCH CONTROL ★ HIGH TORQUE SERVO DRIVEN DC MOTOR ★ TRANSIT SCREWS ★ 12" DIE CAST PLATTER ★ NEON STROBE ★ CALIBRATED BAL WEIGHT ★ REMOVABLE HEAD SHELL ★ ½" CARTRIDGE FIXINGS ★ CUE LEVER ★ POWER 220/240V 50/60Hz ★ 390×305mm ★ SUPPLIED WITH MOUNTING CUT-OUT TEMPLATE.

PRICE £59.99 + £3.50 P&P.

OPTIONAL MAGNETIC CARTRIDGES

STANTON AL500 — PRICE £16.99 + 50p P&P
GOLDRING G850 — PRICE £6.99 + 50p P&P

OMP MOS-FET POWER AMPLIFIERS, HIGH POWER, TWO CHANNEL 19 INCH RACK

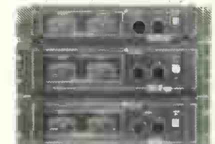
THOUSANDS PURCHASED BY PROFESSIONAL USERS

NEW MXF SERIES OF POWER AMPLIFIERS
THREE MODELS:— **MXF200** (100w + 100w)
MXF400 (200w + 200w) **MXF600** (300w + 300w)
All power ratings R.M.S. into 4 ohms.

FEATURES: ★ Independent power supplies with two Toroidal Transformers ★ Twin L.E.D. Vu meters ★ Rotary indended level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 Fan Cooled with D.C. Loudspeaker and Thermal Protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:— MXF 200 W19"×H3½" (2U)×D11"
MXF 400 W19"×H5¼" (3U)×D12"
MXF 600 W19"×H5¼" (3U)×D13"



PRICES: **MXF200 £171.35**
MXF400 £228.85
MXF600 £322.00

SECURICOR DELIVERY £12.00 EACH

OMP LINNET LOUDSPEAKERS

THE VERY BEST IN QUALITY AND VALUE

MADE ESPECIALLY TO SUIT TODAY'S NEED FOR COMPACTNESS WITH HIGH OUTPUT SOUND LEVELS, FINISHED IN HARDWEARING BLACK VYNIDE WITH PROTECTIVE CORNERS, GRILLE AND CARRYING HANDLE, INCORPORATES 12" DRIVER PLUS HIGH FREQ. HORN FOR FULL FREQ. RANGE: 45Hz-20KHz BOTH MODELS 8 OHM, SIZE H18" × W15" × D12".

CHOICE OF TWO MODELS

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET

OMP 12-100 (100W 100dB) PRICE £159.99 PER PAIR
OMP 12-200 (200W 102dB) PRICE £209.99 PER PAIR

SECURICOR DEL.:— £12.00 PER PAIR

OMP SLIDE DIMMER 1K WATT & 2.5K WATT

CONTROLS LOADS UP TO 1KW & 2.5KW, SUITABLE FOR RESISTIVE AND INDUCTIVE LOADS BLACK ANODISED CASE, READILY FLUSH MOUNTED THROUGH PANEL/CABINET CUT-OUTS. **ADVANCED FEATURES INCLUDE:—**

- ★ FULL 65mm SLIDE TRAVEL
- ★ NEON MONITOR INDICATOR
- ★ FLASH OVERRIDE BUTTON
- ★ HIGH & LOW LEVEL PRESETS
- ★ FULLY SUPPRESSED TO BS 800

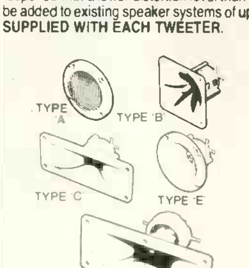
SIZES:—
1KW H128×W40×D55mm
2.5KW H128×W76×D79mm

PRICES:— 1K WATT £15.99
2.5K WATT £24.99 + 60p P&P

PIEZO ELECTRIC TWEETERS-MOTOROLA

PIEZO ELECTRIC TWEETERS — MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £4.90 each + 50p P&P.**

TYPE 'B' (KSN1005a) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. **Price £5.00 each + 50p P&P.**

TYPE 'C' (KSN6016A) 2"×5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £6.99 each + 50p P&P.**

TYPE 'D' (KSN1025A) 2"×6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £9.99 each + 50p P&P.**

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £5.99 each + 50p P&P.**

LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket. 85×85mm. **Price £3.99 + 50p P&P.**

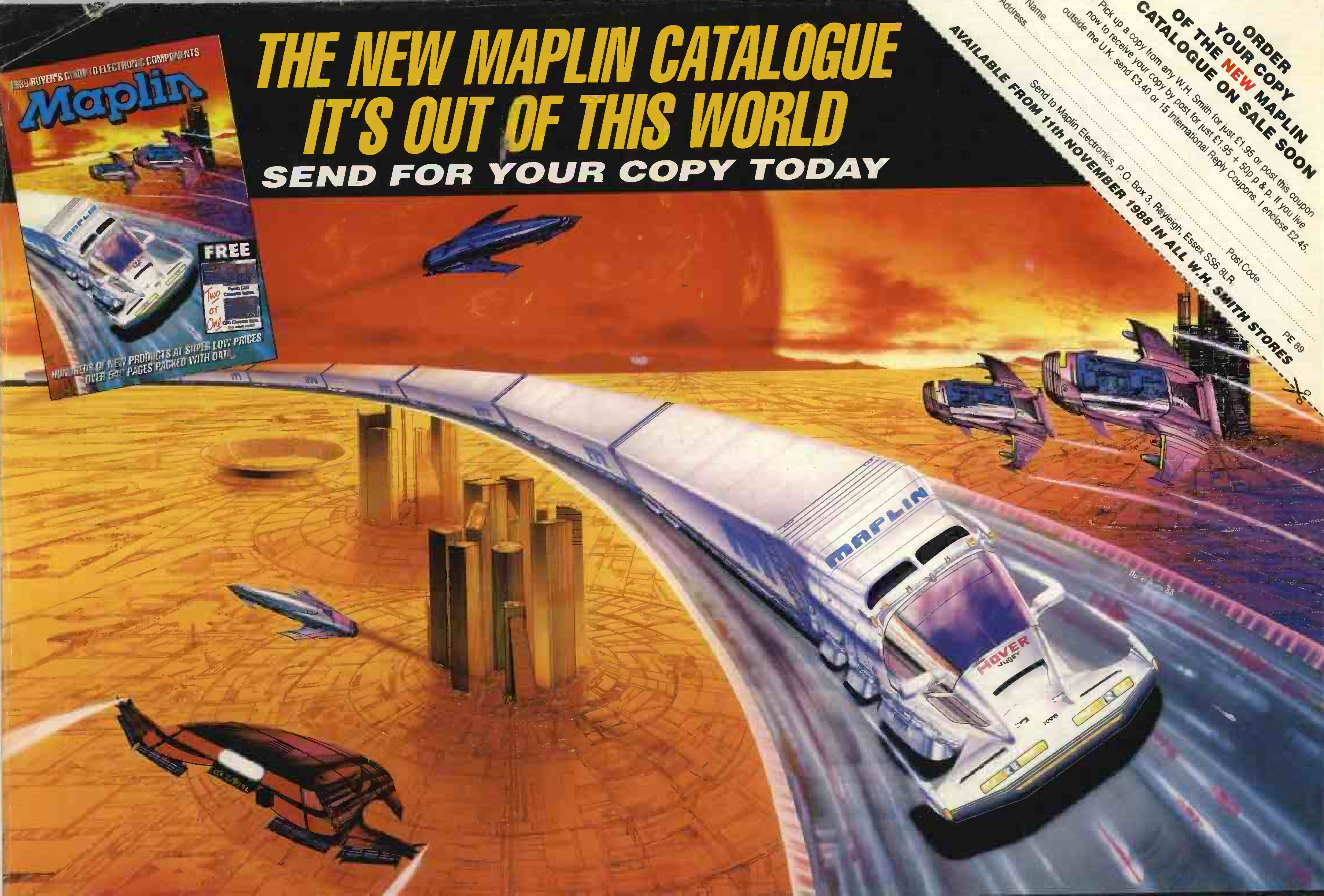
STEREO DISCO MIXER

STEREO DISCO MIXER with 2 × 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many outstanding features** 5 Inputs with individual faders providing a useful combination of the following:— 3 Turntables (Mag). 3 Mics. 4 Line including CD plus Mic with talk over switch Headphone Monitor. Pan Pot L. & R. Master Output controls. Output 775mV. Size 360×280×90mm. Supply 220-240v.

Price £134.99 — £4.00 P&P

B. K. ELECTRONICS Dept PE

UNIT 5, COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR
TEL: 0702-527572 FAX: 0702-420243



THE NEW MAPLIN CATALOGUE
IT'S OUT OF THIS WORLD
SEND FOR YOUR COPY TODAY
ORDER YOUR COPY OF THE NEW MAPLIN CATALOGUE ON SALE SOON
Pick up a copy from any W.H. Smith for just £1.95 or post this coupon now to receive your copy by post for just £1.95 + 50p p & p. If you live outside the U.K. send £3.40 or 15 International Reply Coupons. I enclose £2.45.
Name........................
Address........................ Post Code........................
Send to Maplin Electronics, P.O. Box 3, Rayleigh, Essex SS6 8LR
PE 89
AVAILABLE FROM 11th NOVEMBER 1988 IN ALL W.H. SMITH STORES
Maplin
FREE
MAPLIN
HOVER