RESTRAIN YOUR DIGITS!
Digital delay line for musical effects

PLUS
- Capturing TV pictures
- Experimenter's memory expansion card
- Spectrum Centronics interface

TECH TIPS SPECIAL
Eight pages of readers' ideas
Powertran's educational robots and the remarkable Cortex microcomputer have been tried and tested in universities, colleges, schools and homes throughout the world.

Our own experience in the field of electronics kits has been supplemented by the Feedback Group's 25 years of supplying technical equipment to the Educational sector. Our first year as a member of the Group has seen numerous improvements to our already popular products.

All the products illustrated can be supplied either in kit form for added economy or factory-built. Contact our Sales Office for details.

(Prices quoted are exclusive of VAT and apply to the UK only.)
DIGEST .................................. 7
ETI dusts off a few more press releases.

READ/WRITE .......................... 67
ETI responds to the latest batch of data which has arrived in the input port.

TECH-TIPS SPECIAL .............. 39
Eight pages of un-alloyed ingenuity from our ever-clever readership.

MIND YOUR HEAD ................... 49
Vivian Capel explains the ins and outs of tape transducers in terms which won't be above anybody's head.

DIGITAL DELAY LINE ............ 16
Just the thing for musicians with restless digits.

ACTIVE-8 LOUDSPEAKER ......... 24
Barry Porter completes his description of the basic Active-8 system and goes on to offer some encouragement for those with sensitive ears and sympathetic bank managers.

EXPERIMENTER'S DRAM CARD ....... 31
The 64 K DRAM board we described in September last year proved very popular but there were a number of problems with it. Phil Walker has designed an improved version and also come up with a modification which can be added to existing boards.

SPECTRUM CENTRONICS INTERFACE ...... 57
We seem to have produced Cen-
tronics interfaces for micros right across the computer spectrum, so it would be a shame not to cater for this one.

TV FRAMESTORE .................. 61
For a mere couple of hundred pounds or so (!) we can put you in the picture about video storage techniques.

VARIO UPDATE ..................... 71
Lindsay Ruddock takes his vertical speed indicator to even greater heights of sophistication.

Our apologies to readers who have been holding their breath since last month in anticipation of John Linsley Hood's promised distortion meter design. Due to lack of space we have decided to hold part one over until next month when we will present both parts together.
OMP POWER AMPLIFIER MODULES

OMP POWER AMPLIFIER MODULES

BURGLAR ALARM

VINI LUNET NOUDSPEAKERS

LOUDSPEAKERS

5 to 15 INCH UP TO 300 WATTS

R. M. S. All speakers 8 ohm Impedance.

POWER RANGE

6" 50 WATT R. M. S. Hi-Fi/Disco
20 or magnet 1½". All voice coil. Ground all welding on socket. Res. Freq. 40KHz. Freq. Resp. to 60KHz. Sensitivity 500mV. S.N.R. -120dB. Size 300 x 132 x 60mm. PRICE £79.99 + £4.00 P&P.

10" 100 WATT R. M. S. Hi-Fi/Disco

15" 200 WATT R. M. S. Multi Array Disco etc

MEZ ELECTRIC TWEETERS MOTOROLA

BRS P256 TURNTABLE

PRICE £24.99 + £4.00 P&P

TYPE B (KNS6005A-) 3" poly horn. For general purpose speakers, disco and P.A. systems etc. PRICE £24.99 + £4.00 P&P

TYPE C (KNS6016A-) 3" 2½" wide dispersion horn. For quality Hi-Fi, stereo systems and quality disco etc. PRICE £69.99 + £10.00 P&P

Stereo Disco Mixer

STEREO DISCO MIXER with 4 band graphic equaliser and 3 and 12 segment L.E.D. V.U. Meters. Many outstanding features.

3 way ground with individual 360° phase alternate input. Price: £41.00 + £5.00 P&P

Amp: 2 Way balanced. Price: £47.99 + £7.00 P&P

OUTPUTS: 2 Mic. input, Talk over switch. Price: £55.99 + £5.00 P&P

E.T.I. DECEMBER 1984

POSTAGE CHARGES PER ORDER £1.00 minimum. OFFICIAL DISTRIBUTORS: WOODS, COLLEGE, GOVERNMENT, BUSINESSES, ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER VISA ACCEPTED.
DIGEST

BT Voice Mail

Is your phone call a shot in the dark? You know the situation: you call them but they’re not there so you leave a message. They call back but you’ve nipped out for a few minutes and so it goes on.

For a mere £30,000 the basic VM600 Voice Mail system could revolutionise your communications. The system works like an electronic pigeon hole array in which voice messages can be dictated, edited to get the sense right and deposited in the machines memory. At some later date the intended recipient can call up the memory and will receive whatever messages have been left.

The hardware consists of a free-standing equipment rack which contains the heart of the system and a number of pocket tone generators. The system can be connected directly between an existing push-button telephone system and the PABX without the need for any extra equipment. Users of the attached telephones can then access the VM600 using a personal password to place and retrieve messages. From other telephones or when calling in over the public network, the small tone generator is used.

When access to the system has been gained, spoken messages guide the user through the process of leaving or locating messages. This removes the need for typing or other skills, allowing the whole procedure to be carried out using only a button.

The VM600 is built around a dedicated microcomputer and gives 32M byte disc store which caters for up to 60 users and gives three hours worth of message storage. The system can be expanded to handle up to 600 users and give 30 hours of storage time. A separate console which can be sited up to 100m away from the main unit is used to set up the passwords and the facilities available to each user, and it can also be used to obtain statistics on usage and other operational information.

In addition to the facilities outlined above, the VM600 can send stored messages to up to sixty users or can be instructed to leave a message dormant until a certain date and time. For authorised users there are useful facilities like giving one message priority over others, checking that a message has been received, repeat calling for urgent messages and security coded messages for sensitive information.

The system is expected to be of interest to companies with sales or service staff who spend a lot of time away from the office but frequently need to send back information or receive instructions. It would also be useful for companies who deal regularly with customers who may spend a lot of time away from the office and need to send messages to them but only at certain times.

For more information on the Voice Mail contact the local British Telecom sales office or ring 01-725 5577.

Personal Radiation Monitor

Impulse have recently introduced a simple to use, pocket-sized personal radiation monitor. Monitor 4 combines new electronic techniques with simplicity to provide an effective radiation alert which gives maximum user protection.

Monitor 4 has no external wires or probes and is sensitive to a broad spectrum of ionizing radiation including alpha, beta, gamma and X-rays. The level of radiation is indicated by a red and white meter, a count light and a beeper that can be switched off for silent monitoring.

The monitor reads in three ranges from 0-50mCi/h and uses an industry standard halogen-quenched GM tube with a mica end window. It is easily calibrated and runs for up to 2,000 hours on one 9V alkaline battery at background radiation levels.

The unit detects alpha down to 2.5 MeV and typical detection efficiency at 3.6 MeV is more than 80%. Beta is detected at 50 keV with 35% typical efficiency; typical efficiency of 150 keV is 75%. Gamma and X-rays are detected down to 10 keV typically through the end window and 40 keV minimum through the case.

For further information contact Impulse Sales & Marketing, 29a Egerton Street, Chester CH1 3ND.

Don’t look now, but that handsome bloke standing between Cirkit Chief Executive Christopher Sawyer (right) and Richard Bolgin, Head of Consumer Services, is your own very own editor, Dave Bradshaw. The occasion was the launch of Cirkit’s first catalogue which contains all the products listed by their predecessors, Ambit, as well as a number of new lines. It costs 85p and includes three vouchers worth one pound each when presented with orders worth £15 or more. The catalogue is on sale at branches of W.H. Smith throughout the country or maybe obtained direct from Cirkit, Park Lane, Broxbourne, Hertfordshire EN10 7NQ, tel 0992-444111.

AM/FM Radio

Upon reflection, we realise that we should have quoted the order numbers for the inductors and filters in this project as they’re rather hard to find in Cirkit’s catalogue! The order numbers are as follows:

YMRS 16726 (14) 35-6760 (42p); CPU05/0D (15) 16-05006 (84p); YMCS 2A740 (16) 35-07400 (42p); CLNS 30569 (17) 35-05690 (66p); SFE10.7MA (F1) 16-10735 (45p); CD10.7MA (F1) 16-10770 (84p). Prices quoted here are taken from Ambit’s most recent catalogue, but need VAT and p&p.
Rotary Coded Dilswitches

A range of 10 position and 16 position ERG dual-in-line switches for PCB mounting is now available from Semiconductor Supplies International. The switches are expected to find employment in a wide range of control applications, and their memorability has been further enhanced by the adoption of a punning title almost worthy of ETI - they are to be called dial-in-line switches!

Three types are available, two with knob operation and one with a screwdriver slot. One type is suitable for vertical or horizontal mounting on the edge of a PCB and all are fully sealed and suitable for flow soldering and solvent cleaning.

Contact ratings are 125 mA, 30 VDC with an initial contact resistance of typically 50 mΩ maximum at 10 mVDC/10 mA. The insulation resistance is 100 MΩ minimum at 240 VDC for one minute, and the life within rated load is 20,000 rotary detent steps.

The dimensions are 10 x 10 x 6 mm for screwdriver operation and 10 x 10 x 11 mm for the switch with the large knob. Maximum contact resistance found when testing to five million dry circuit switching operations monitored at 10 mVDC/10 mA was less than 20 mΩ.

Semiconductor Supplies International Ltd, Dawson House, 128-130 Carshalton Road, Sutton, Surrey SM1 4RS, tel 01-643 1126.

Sound Moves

The re-organisation of A.F. Bulgin and Company PLC, one of the results of which is the recent re-appearance of Ambit under the new name of Cirkit, continues apace. Soundex Ltd, manufacturers of peak programme meters, drive amplifiers and audio measuring sets, have been purchased by Bulgin by professional broadcast equipment suppliers Allo trope Ltd. Allo trope plan to extend the Soundex range with the addition of complementary products in the near future and have appointed Cirkit as distributors. The reorganisation allows Bulgin to concentrate on its traditional manufacturing interests and the newly-formed Power Conversion Division while Cirkit Holdings PLC undertakes distribution.

Allo trope Ltd, 114 Wardour Street, London W1V 3LP, tel 01-434 3344. A.F. Bulgin and Company PLC, Bypass Road, Barking, Essex IG11 0AZ, tel 01-594 5588.

BBC Loudspeaker Agreement

The BBC has signed a licence agreement with the two British companies, Spendor Audio Systems Ltd and Swisstone Electronics Ltd, which allows them to manufacture the medium size, high quality, LSS/9 Studio Monitoring Loudspeaker. The agreement will enable these two companies to market the loudspeaker worldwide.

The LSS/9 cabinet is only a quarter of the volume of the BBC's principal, much larger, high quality monitor the LSS/8, but the sound reproduction is a close approximation. The dimensions are 280mm wide, 460mm high, and 275mm deep, and the weight is only 14kg. As a result it is ideal for use where portability is required or where space is limited.

The loudspeaker uses two drive units with a passive crossover, and an equaliser which provides a flat free-field axial response over the range 50 Hz to 16kHz. The tweeter is a proprietary soft dome type and the low frequency unit is a BBC design which uses a polypropylene diaphragm. The levels of coloration and harmonic distortion are very low. A 50W amplifier is required to obtain the maximum sound level output of 105dB relative to 20μPa at 1m.

Engineering Information Department, BBC Broadcasting House, London W1A 1AA, tel 01-927 5432.

Hybrid Protector Modules

Zenith have introduced a range of overvoltage protection modules (OVPs) which are designed to protect sensitive electrical and electronic circuits from supply voltage transients. The modules come in nine standard voltage trip ratings and simply connect across the output terminals of any current-limited DC supply.

The modules employ circuitry that contains hybrid thick-film integration and are potted in epoxy compound for thermal stability. There are four basic models available rated at 3, 5, 15 and 25 amps, each of which can be supplied with any of the nine standard trip voltage ratings between 5 and 30 V DC. Special versions operating at other voltages are also available to order. The modules measure 30 x 20 x 15mm and connection is via twin Molex connector pins or 6mm spade terminals.

Zenith Electronics, 21 Station Road Industrial Estate, Hailsham, East Sussex BN27 2EW, tel 04333-2647.

* Marco Trading have issued a 124-page catalogue which lists their range of electrical fittings, connectors, test equipment, semiconductors and general components and even valves. The catalogue comes with an order form, reply-paid envelope and special offers list and is available from Marco Trading, The Maltlings, High Street, Wem, Shropshire SY4 5EN, tel 0939-32763.

* Rockwell International have brought out the second edition of their 1984 data book, Its 1362 pages cover their entire line of solid-state devices and board-level micro-computer products and there are sections on Board 16 bit microprocessors, memory products, intelligent display controllers and integral and stand-alone modems, Contact Rockwell International Ltd, Semiconductor Products Division, Heathrow House, Bath Road, Hounslow TW5 9QO, tel 01-759 2366.
Mitsubishi MSX Micros

Mitsubishi Electric (UK) Limited, the UK manufacturing and marketing Division of the Mitsubishi Electric Corporation, has announced its version of the MSX range of home computers. Developed in conjunction with Microsoft in America, the MSX range was conceived to provide a common standard in home computing and Mitsubishi is the only company so far to offer a choice of MSX computers.

The two systems — ML-F80 and ML-F 48 — are based on a Z80-equivalent chip. The ML-F 80 has 64KB RAM, the ML-F 48 32KB, and both systems have 32KB ROM, with the ML-F 48 being expandable to its larger stablemate. The keyboards are ASCII layout and include full alphanumeric and special characters. There are also five special function keys, which, using the shift key, give the home programmer ten possible programmable functions.

The screen display is 40 characters X 24 lines in text mode and 192 x 256 dots in graphics mode. Both systems also provide a range of sound effects. A number of socket outlets are incorporated on the computers, including a Centronics printer interface. Others are for joystick, ROM cartridges, audio, video and cassette units and of course TV.

A range of games software is already available for MSX computers, and the fact that Mitsubishi offers two systems provides the user with a greater choice of programs. Software packages include home budget, word processing and database programs, language courses and games. The computers also run Microsoft extended Basic.

Mitsubishi’s two MSX systems will be available from its existing video and hi-fi outlets from November, at £299 for the ML-F 80 and £249 for the ML-F 48. Mitsubishi Electric (UK) Limited, Hertford Place, Denham Way, Maple Cross, Rickmansworth, Herts WD3 2BJ, tel 0923-770000.

Multipurpose Function Generator

New from Global Specialities Corporation is the Model 2005 multipurpose function generator which provides sine, triangle, square, ramp and TTL pulse waveforms with variable amplitude, symmetry and offset over a 50MHz to 5MHz frequency range. The output can be continuous, gated or triggered either by an external signal or by a front panel manual switch.

When the instrument is used as a sweep generator, an internal ramp with a variable duration provides a recurring linear sweep over a 1000:1 (linear) or 10,000:1 (logarithmic) frequency range. The maximum output amplitude is 20V into an open circuit or 10V into 50Ω and the signal can be attenuated at 20dB, 40dB or 60dB.

Other features include an adjustable DC offset voltage of ±10V into open circuit or ±5V into 50Ω, and the ability to be frequency modulated with an external signal using Vco IN as the frequency modulation input. With a dial accuracy of ±5% of full scale and jitter of less than 0.1%, the instrument has a 1ms to 5s sweep rate and a sweep output of 0 to 5V ramp.

The Model 2005 costs £632.50 inclusive of VAT and postage and is available from Global Specialties Corporation, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ, tel 0799-21662.

Portable Butane Soldering Iron

Greenwood Electronics is launching a new butane powered portable soldering iron, the Oryx Portasol. Little bigger than a felt tip pen, the Portasol works on entirely different principles from conventional gas-powered irons. There is no flame during operation, the chemical energy of the butane gas being converted directly to heat by means of a patented catalytic converter in the solder tip. Conversion rate is adjustable to provide control over tip temperature and, at its maximum setting, the iron delivers power equivalent to a 60 watt electric soldering iron, the tip temperature being adjustable between 250 and 450°C.

The Oryx Portasol iron will run for up to 60 minutes on its internal gas supply and refuelling, which takes seconds, is identical to filling a gas cigarette lighter. The same principles that make gas cigarette lighters safe are applied to the Portasol.

The Portasol can be carried in the pocket. It is supplied with a protective cap and is immediately ready for use, the cap including an igniter to start the catalytic conversion.

The dimensions of the Portasol are 175mm long X 19mm diameter, and replacement tips, which are available from Greenwood Electronics, Portman Road, Reading, Berkshire RG1 1NE, tel 0734-395844.
for low-cost training in
real-life robotics

The advanced design of the Neptune 2 makes it the lowest cost real-life
industrial robot.
It is electro-hydraulically powered, using a revolutionary water based
system (no messy hydraulic oil!)
It performs 7 servo-controlled axis movements (6 on Neptune 1) – more
than any other robot under £10,000.
Its program length is limited only by the memory of your computer.
Think what that can do for your BASIC programming skills!

And it’s British designed, British made.

Other features include:
- Leakproof, frictionless rolling diaphragm seals.
- Buffered and latched versatile interface for BBC VIC 20 and Spectrum computers.
- 12 bit control system (8 on Neptune 1).
- Special circuitry for initial compensation.
- Rack and pinion cylinder couplings for wide angular movements.
- Automatic triple speed control on Neptune 2 for accurate ‘homing in’.
- Easy access for servicing and viewing of working parts.
- Powerful – lifts 2.5 kg. with ease.
- Hand held simulator for processing (requires ADC option).

Neptune robots are sold in kit form as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neptune 1 robot kit (inc, power supply)</td>
<td>£1250.00</td>
</tr>
<tr>
<td>Neptune 1 control electronics (ready built)</td>
<td>£295.00</td>
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<tr>
<td>Neptune 1 simulator</td>
<td>£45.00</td>
</tr>
<tr>
<td>Neptune 2 robot kit (inc. power supply)</td>
<td>£1725.00</td>
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<tr>
<td>Neptune 2 control electronics (ready built)</td>
<td>£475.00</td>
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<tr>
<td>Neptune 2 simulator</td>
<td>£52.00</td>
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<tr>
<td>ADC option (components fit to main control board)</td>
<td>£95.00</td>
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<tr>
<td>Hydraulic power pack (ready assembled)</td>
<td>£435.00</td>
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<tr>
<td>Gripper sensor</td>
<td>£37.50</td>
</tr>
<tr>
<td>Optional extra three fingered gripper</td>
<td>£75.00</td>
</tr>
<tr>
<td>BBC connector lead</td>
<td>£12.50</td>
</tr>
<tr>
<td>Commodore VIC 20 connector lead and plug-in board</td>
<td>£14.50</td>
</tr>
<tr>
<td>Sinclair ZX Spectrum connector lead</td>
<td>£15.00</td>
</tr>
</tbody>
</table>

All prices exclusive of VAT and valid until the end of March 1985

desk-top robot

This compact, electrically powered training robot has 6 axes of movement, simultaneously
servo-controlled. It gives smooth operation, and its rugged construction makes it ideal for
use in educational establishments. Other features include long-life bronze and nylon
bearings, integral control electronics and power supply, special circuitry for inertial
compensation, optional on-board ADC, and hand-held simulator as the teaching pendant.
Like Neptune, Mentor’s program length is limited only by your computer’s memory.
Programming is in BASIC.

Mentor is all-British in design and manufacture and comes in kit form at an astonishingly low
price:

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentor robot kit (inc. power supply)</td>
<td>£345.00</td>
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<tr>
<td>Mentor Control electronics (ready built)</td>
<td>£135.00</td>
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<tr>
<td>Mentor Simulator (requires ADC option)</td>
<td>£42.00</td>
</tr>
<tr>
<td>ADC option (Components fit to control electronics board)</td>
<td>£19.50</td>
</tr>
<tr>
<td>BBC connector lead</td>
<td>£12.50</td>
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<tr>
<td>Commodore VIC 20 connector lead and plug-in board</td>
<td>£14.50</td>
</tr>
<tr>
<td>Sinclair ZX Spectrum connector lead</td>
<td>£15.00</td>
</tr>
</tbody>
</table>

All prices exclusive of VAT and valid until the end of March 1985

PORTWAY TRADING ESTATE, ANDOVER, HANTS SP10 3ET
TEL: (0264) 50093 Telex: 477019
2kV Isolation DIL Relays

C. P. Clare have introduced two new dual-in-line relays to complement their established DIL product families. Both versions have 2000 VAC isolation between coil and contact to cater for the growing number of applications where a high isolation is required.

The first type, designated MSS7, incorporates a unique MM8 mercury reed capsule which is completely non-position sensitive, thus allowing full PCB mounting flexibility for OEM equipment. MSS7 is rated at 30VA switching with a maximum contact resistance of 100 milliohms throughout its life of 200 million expected operations.

Both relays have single, normally open contacts and are available with nominal operating voltages of 5, 12 and 24V DC. An optional modification, the addition of a transient suppression diode to the coil, is available on both types.

For further information contact Ron Bannister, C.P. Clare Division, General Instrument (UK) Ltd, tel 08956-39901.

Carrying Bags for Apples, Apricots and Acorns

F or people who really can't put their micros down, Inmac now stock a series of specially designed carrying bags for the Apple II, Apple II Plus, Apple IIE, Apricot and BBC Micro Computers.

Made from strong, tear-proof Cordura nylon and thick, high density foam padding, these bags are tailored to provide a safe means of transportation. The wide-grip handles and the adjustable shoulder strap are made of seat-belt strength webbing for safety, and the zips are heavy duty industrial grade that will not rust and open completely for easy loading.

A matching bag is available for the Apple II disk drive which can carry two drives and has a foam lined 'wallet' that protects cables and provides padding between the drives. There is also a matching bag for an Apricot Monitor. All bags are lined with anti-static material and prices range from £17.00 to £27.50 each.

Delivery is ex-stock and can be same day for the London, Greater Manchester and Merseyside areas or next day for the rest of the country. The bags are available on a thirty day, risk-free trial period and are guaranteed for a year.

Further details can be found in Inmac's full-colour catalogue of over 1000 accessories for mini- and micro-computers which is available free from Inmac UK Limited, Davy Road, Astmoor, Runcorn, Cheshire WA7 1PZ, tel 09285-67551.

Auto IC

M otorola have added a high-energy ignition circuit to their range of automotive linear ICs. Originally designed to suit Delco five-terminal ignition applications, the MC3334 is said to meet the circuit timing and current control requirements of modern advanced ignition systems and offers optimised spark energy at minimum power dissipation.

The circuit is designed to process a control signal from a reductor (magnetic) type pick-up and generates a precisely-controlled ignition coil drive voltage via an external Darlington transistor. Features include adjustable dwell angle for optimum stored energy with minimum waste, adjustable peak output coil current and a rugged design which has input and output transient protection to reduce the risk of damage to the IC and Darlington. Very few external support components are required and none of the resistors are critical.

The MC3334 is available in an 8-pin plastic DIP package for PCB mounting, a chip version and a 'flip' or 'bumped chip' version for inverted reflow assembly. Motorola claim that the pin-out adopted suits both thick-film and printed circuit module designs and allows layouts to be produced without crossovers.

Also new from Motorola is a series of DC-DC converter ICs which are said to offer twice the output current capability of existing 8-pin DIP DC-DC converters. The MC34063 series are intended for step-up or step-down voltage conversion over the range 2.5 to 40 volts and offer an output current of 1.5 amps. Quiescent current is a mere 2.4mA. All functional circuitry is contained within the ICs including temperature-compensated reference, oscillator, cycle-by-cycle current limiting and feedback sense for voltage regulation.

For information on these devices contact Motorola, quoting release number 30/84 for the ignition IC and 32/84 for the DC-DC converters. Motorola Ltd, European Literature Distribution Centre, 88 Tanners Drive, Blakenalls, Milton Keynes MK14 5BP, tel 01908 8836.

ETI DECEMBER 1984
**DISC DRIVES**

These are fully cased and wired drives with slim line mechanisms of high quality, Shugart A400 standard interface. Drives supplied with cables and manuals and formatting disc for the BBC computer suitable. TEAC 30 track drives are supplied with 40/50 track switching as standard. All drives can operate in single or dual density format.

- **1x200K T55A T5110**
  - £115.00

- **2x100K T55E T5110**
  - £230.00

- **2x100K T55E T5110**
  - £230.00

**3M 5¼" FLOPPY DISCS**

High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

Price per pack of ten:
- 40T SS DD £15.00
- 80T SS DD £24.00

**DRIVE ACCESSORIES**

FLOPPICLENE Disc Head Cleaning Kit with 20 disposable cleaning discs ensures continued optimum performance of the drive.

- **Single Disc Cable** £8.00
- **10 Disc Library Case** £12.00
- **30/40 Disc Lockable Box** £16.00

**MONITORS**

**MICROVITEC 14" RGB:**
- Kaga Green XXI 201G
  - £195.00
- Kaga Amber XXL 201 A
  - £118.00
- Santo Green DM812CX
  - £399.00
- Swivel Stand for Kaga Monochrome
  - £225.00

All monitors are supplied with leads suitable for the BBC Computer. Spare leads available.

**ATTENTION**

Please add carriage 50p unless indicated as follows:
- (a) £8.00
- (b) £5.00
- (c) £1.50
- (d) £1.00

**SPECIAL OFFER**

- **276-24**
  - £4.90
- **27128-25**
  - £18.00
- **27128-30**
  - £18.00
- **6526-15**
  - £28.00
- **6526-12**
  - £35.00

**CONNECTOR SYSTEMS**

**EDGEn CONNECTORS**

- **AMPHENOL CONNECTORS**
  - 36 way pin Centronics (molded 500/500) £475.00 (T175A) £500.00
  - 50 way pin IBM £475.00 (T175B)
  - 50 way pin IBM £475.00 (T175C)
  - 50 way pin IBM £475.00 (T175D)
  - 50 way pin IBM £475.00 (T175E)
  - 50 way pin IBM £475.00 (T175F)
  - 50 way pin IBM £475.00 (T175G)

**EURO CONNECTORS**

- **RS 232 JUMPERS**
  - 24 way £5.00
  - 24 way £5.00

**CABLES**

- **Sockets**
  - 24 way £5.75
  - 24 way £5.75

**TEXTILE ZIP**

- **For 2 x 16 way please specify spacing (A+B, A+C)**
<table>
<thead>
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<th>LINEAR ICs</th>
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<tbody>
<tr>
<td><strong>74 SERIES</strong></td>
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<tr>
<td>7400A 700</td>
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**COMPUTER COMPONENTS**

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<th><strong>LINES</strong></th>
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<tr>
<td><strong>LOW PROFILE</strong></td>
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<td><strong>SMD</strong></td>
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ETI DECEMBER 1984
DIGITAL DELAY LINE

Delay things a little — or anything up to a few seconds — by building this versatile, quality delay unit. Design and development by Ray Lowe.

This delay line has been designed and developed with value for money as the pre-requisite, and the unit presented must be the best value around for the ambitious music maker or sound recordist. It is a high quality unit and contains some novel circuitry in the digital/analogue conversion stages which could be useful elsewhere.

The unit offers some features not found on many lower-end commercial products such as percussion, freeze and full control over bandwidth versus maximum delay time.

Words
The input signal is represented as nine bit data words. This has been found to give good dynamic performance without resorting to compression and its undesirable 'pumping' or 'breathing' type side effects. The minimum memory requirement is 4K, ie the number of memory chips that have to be present for the unit to operate is two, which helps keep minimum construction cost low.

This minimum configuration gives a maximum useful delay of a couple of hundred milliseconds, plus associated effects such as chorus, flanging, etc. However, the basic PCB can accept a further 13K bytes, enough for 350 milliseconds at a full bandwidth of about 16.5 kHz through to (continuously variable) 1.3 seconds at 5 kHz bandwidth.

An optional memory expansion board may be easily added, giving a total of 36K bytes capacity which will double the above delay figures.

Effects
Many interesting and useful effects can easily be obtained including chorus, flanging, vibrato, reverb (pseudo), slapback and long echoes, single or multiple echoes decaying over many seconds, scrambling, double tracking, etc. In addition, a sound from any source may be sampled and frozen in memory, much like a continuous tape loop, to be recalled or triggered either internally or externally (by a sequencer or drum contact for example) at any time; also there are various ways that the same can be modified. On a different tack, if you have a scope then, by using the freeze facility, you could give it audio frequency storage capability!

Inputs
Since it has a high input impedance, the unit will accept inputs from most sources, including electric guitar, synthesiser, microphone, hi-fi tape output, and many others. Input signals in the range 200mV to 2.5V P-P are suitable.

The frequency characteristics of the pre-emphasis used have been tailored for electric guitar as well as normal signals so as to keep quantisation distortion at bay on low strings (see later for more details) whilst a hi-fi tape signal will be virtually indistinguishable from the original when using the maximum bandwidth setting.

A switch is also available which doubles the nominal sampling rate; this can be used for special effects or for enhanced fidelity when using only short delay.

Emphasising Pre-emphasis
The average music signal, or voice, is bass-heavy as far as amplitude is concerned, although most information is carried by mid-range frequencies. This is in general terms, and a far spread exists in the power spectrums of everyday audio signals.

In the case of electric guitar, the process of converting mechanical to electrical energy strongly favours the thicker, lower strings. A strong twang on a low string may well overload an input stage, whereas the same twang power on a top string will generate a much smaller voltage. However, the signal amplitude produced will decay very rapidly (exponentially) with time so that, unless a sustain/compression unit is used, the guitar signal has a large dynamic range.

This problem is especially relevant if the circuitry following the input has a limited dynamic range that it can handle, which is the case when using relatively short data words to represent musical signals in an analogue to digital conversion. Compact disc players use 16 bits per sample word to achieve their dynamic range but the design presented here uses nine. Why not use more? Because the cost of A/D converters escalates rapidly above eight bits.

In order to give both high and low frequencies a better chance of simultaneously being within dynamic range, high frequencies are boosted, with special consideration given to the mid-range; in other words, the signal is pre-emphasised before the analogue to digital conversion stage. The
When the digital code is converted back to analogue, the resultant errors are like excursions away from the original waveform — see Fig. 1.

These error excursions sound like noise, called quantisation noise, accompanying the signal proper. Since these error excursions have fast leading edges, the resultant noise has a wide frequency spectrum (from elementary Fourier analysis) and it is particularly objectionable when superimposed upon low frequency sinusoidal type waveforms, emerging as an annoying buzz in the background.

**Buzz Off!**

Use of pre-emphasis before A/D conversion obviously requires that de-emphasis be used after D/A conversion. Fortunately this 'treble cut' operates on the quantisation noise as well, thus reducing its high frequency content and therefore its overall unpleasantness.

---

**Quantisation**

Use of pre-emphasis has another benefit, namely that of killing off most of the quantisation noise. Quantisation noise arises as a result of the finite number (2^n, where n is the word length) of analogue levels available with which to represent real (continuous) signals using pulse code modulation. Real signals are thus rounded up in the conversion process to the nearest discrete value mapped by a digital code. When the digital code is converted back to analogue, the resultant errors are like excursions away from the original waveform — see Fig. 1.

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**Sampling Complications**

There is a well-known theorem, called the Nyquist sampling theorem, which says that to get an accurate representation of a signal as a stream of sample values, the samples must be taken at a rate that is at least twice the maximum frequency present in the signal. Failure to meet the requirement of the theorem will result in a phenomenon known as aliasing, which is demonstrated in Fig. 2. Although this diagram misses out many of the technical niceties (for instance, the reconstructed signal would not be a nice, clean sine wave), it does show what happens — that if a frequency higher than half the sampling frequency is input, it will actually appear at the output as a different, 'alias' frequency, which is lower than half the sampling frequency. In audio terms, the sound becomes noticeably 'gurgled'; obviously, we must limit the bandwidth of the signal before it is sampled.

In this design, the sampling rate and the bandwidth limit are coupled by the choice of a switched-capacitor filter to do the low-pass filtering. The same master clock is used to drive both the filter and the sampling, so that as one changes, the other changes to keep pace; the particular filter used is configured as a sixth-order low-pass filter.

In the real world, infinite cut-off filters are not available, so some aliasing always exists; however, with the filter used here, the level of the aliasing is such that it is masked by other imperfections such as quantisation distortion.

---

**The Unit Together**

The block diagram of the whole unit is shown in Fig. 5. The pre-emphasis and anti-aliasing filters have already been explained. To make signal-handling easier, the signal is made unipolar (ie, rectified) and a polarity bit, bit 9 (or D8), is generated by the polarity remover. It may seem rather a waste of effort to do this here, but the equivalent would be to use a nine-bit A-to-D rather than an eight-bit device (obviously the D-to-A would also have to be nine-bit too), and this would add quite a lot to the cost.

The final analogue stage before conversion is the sample and hold and the purpose of this unit is to ensure that the A-to-D sees a steady voltage while it is doing a conversion; this will help to prevent errors occurring.

The next stage in the signal path is the A-to-D itself; this is a continuous approximation device, which means that it works by testing to see which bits should be on or off, starting with the most significant bit (MSB) and working to the least significant (LSB). It takes about 10 µs to do a conversion. The converted signal is passed to the static memory.

The address counter points to the memory location in use at any one time, and while the unit is working normally it will con-
Fig. 3 Circuit diagram of the logic board.
This makes Fig. 5 more understandable.

The block diagram of the complete digital delay unit is shown in Fig. 5. The delay control, for example, allows the user to select the delay time for the output signal.

The user can also select the polarity of the input signal. The polarity restorer uses bit 9 to restore the signal's negative-going section.

The clock filter removes the clock pulses from the audio. A switched-capacitor filter is used here because this can be automatically locked to the A-to-D conversion rate in the same way as the anti-aliasing filter; the anti-aliasing filter will have removed any audio signals above this break-point, so anything above this frequency at the input to the clock filter will be an artefact of the system, and should be removed.

The final elements in the audio chain are the de-emphasis and buffer stages; however, there are a few controls that might bear examination. Firstly, the repeat control allows a portion of the delayed signal to be fed back to the start of the system. The mix control allows you to mix the delayed signal with the undelayed signal. And the remote effect on-off input allows the output from the delay section to be muted entirely.

The control of the unit is performed by the timing and control section, and the speed at which this operates is set by the frequency of the variable frequency oscillator (VFO). This is controlled by the bandwidth/delay control, but this can be modulated by the low-frequency oscillator (LFO) to give various effects.

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**PROJECT: Delay Line**

**Fig. 7 Circuit diagram of the power supply.**
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PRACTICAL DESIGN OF DIGITAL CIRCUITS
ACTIVE-8 LOUDSPEAKER

Warning! This introduction contains a pun which may be harmful to readers of a sensitive disposition! Barry Porter sets his active imagination to work once more and brings this series of articles to a tri-amp-haut close (Ouch! — Ed.)

Once completed, the units should be tested. Initially, remove the plug-in boards, switch on and ensure that the correct voltages appear where they should. Having established that the mother board is operating correctly, in particular that the 15-0-15V supply rails are present, the plug-in boards should be inserted one at a time. It should be possible to connect a signal generator to the input and verify that each board is working by checking its output. If any problems appear, make sure that the IC voltages are correct — namely that +15V and -15V are on the supply pins and that both inputs and the output are within a few mV of 0V. Non-working stages should be carefully inspected for faulty soldering and component insertion, and if no obvious error can be seen, the IC should be changed.

Once everything is working, the response of the two outputs should be plotted and compared to similar measurements taken from the second unit. If these agree to within about 0.25dBm, it is safe to assume that no major errors are present, and proceed with the final connection to the speakers.

The high and low frequency outputs of the filter unit are connected to the two channels of a stereo power amplifier. A number of factors will probably decide the choice of amplifiers, not the least being cost. It is important that the four power stages of a stereo pair of Active-8 units are as identical as possible.

### PARTS LIST

#### DELAY UNIT

<table>
<thead>
<tr>
<th>RESISTORS (all 1/2W 1% metal film)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>R32, 34, 35, 37, 38, 33k</td>
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<tr>
<td>40, 41, 43</td>
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</tr>
<tr>
<td>R33, 36, 39, 42 10k</td>
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<tr>
<td>R44 430R</td>
<td></td>
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<tr>
<td>R45 1k</td>
<td></td>
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<tr>
<td>R46, 47 22R</td>
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<table>
<thead>
<tr>
<th>CAPACITORS</th>
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<tbody>
<tr>
<td>C36-39 1nF polystyrene</td>
<td></td>
</tr>
<tr>
<td>C40 100n polycarbonate</td>
<td></td>
</tr>
<tr>
<td>C41 22µ 16V non-polarised</td>
<td></td>
</tr>
<tr>
<td>C42, 43 100µ 25V radial electrolyc</td>
<td></td>
</tr>
<tr>
<td>C44, 45 100n polyester</td>
<td></td>
</tr>
</tbody>
</table>

| SEMICONDUCTORS                    |   |
| IC6, 7 NE5532                     |   |

| MISCELLANEOUS                     |   |
| PCB, 10-way PCB socket.           |   |

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Fig. 1 The missing link — the PCB overlay we didn't have room for last month.
possible. Regarding amplifier power, the speakers will operate at their best when driven by good quality units in the 100-150 watts region; anything below 50 watts per channel should be avoided, as transient clipping is likely to happen too often for comfort. At the top end, providing they are used with caution, there is no reason why 200 or 250 watts should cause any problems.

Before making the final connections the protection relay RL1, should be fitted — preferably inside the cabinet where, if an octal based version is used, the base can be screwed to the cabinet with 20mm chipboard screws passing through 10mm tubular spacers.

Once everything is connected up, the complete unit should be tested, making sure that both relays operate correctly so that a delay of about 6 seconds occurs at switch-on, and RL1 is released before RL2 when the units are switched off.

If everything is working, connect the speakers to your pre-amplifier using good quality screened cable. When fed from a balanced output, the connecting cable should contain a twisted pair of conductors within an outer screen. The conductors carry the signal to the inverting and non-inverting inputs, the screen being connected to the 0V contact. For unbalanced operation, the signal should be applied to the non-inverting (+) input, and the inverting (−) contact of the connecting plug should be connected to the cable screen. If you are using a pre-amplifier with a high output capability it may be advantageous if there is less gain in the system, and this can be achieved by leaving the inverting input unconnected. Some amplifiers (such as the Quad 303 and 405) invert the signal phase, so if you are using such a power stage the overall phase integrity may be maintained by connecting the pre-amplifier output to the inverting input of the buffer amplifier, with the non-inverting and N contacts joined to the screen of the connecting cable. Of course, if your pre-amplifier is also of the inverting type, this will cancel the power amplifier inversion, in which case the non-inverting input of the buffer should be used.

All that now remains is to put stylus to groove, sit back, and discover the joys of being 'Active-8-ed'!
This requires that the tuning vent length becomes almost 500mm which is likely to be a problem. A quick calculation shows that a vent with a 50mm internal diameter should be 207mm long, which is a bit more manageable. You will find that if you select the appropriate grade of plastic pipe, one with a 50mm internal diameter will slide comfortably into a 75mm one. It also has sufficient wall thickness of glue the outer end to a new escutcheon, so it is quite possible to have interchangeable 4th and 6th order alignments.

![Fig. 4 Circuit for a second-order filter.](image)

The 2nd order filter shown in Fig. 4 should be inserted in the low frequency path in place of the closed box equalisation circuit. It is tuned to 24.5 Hz (\(f = 1/2\pi RC\)) with a Q of 2 being set by the gain of 2.5 from the relationship:

\[
\text{Gain} = 3 - (1/Q)
\]

The main problem with a 6th order system is the amount of phase shift that it introduces. Although this can cause some types of bass sound to become less solid, there is no sign of this with low organ notes, so perhaps this alignment is best recommended to those who are turned on by that sort of thing.

**References**


Linkwitz S.H., Active Crossover Networks for Noncoincident Drivers. JAES January 1976


Snyder P.F., Design of Vented Loudspeaker Systems. JAES reprint 1307

Thiele A.N., Loudspeakers in Vented Boxes, JAES, May & June 1971
THE USUAL PROBLEMS OF MAN MEETS WOMAN

solved by Dateline!

Michael Wheeler is an articulate, good-looking businessman in his mid-thirties. Born and bred in London, his work has taken him all over the world. Despite his busy life-style he found time to marry, but unfortunately his marriage failed and he found himself back in London, trying to rebuild his social life.

'My cousin, who lives in London, suggested that I should join Dateline. I must admit, I found the idea appealing because I was aware of Dateline. In fact, I had been a member way back in the sixties. I found no great romantic successes at that time but many, shall we say, nice encounters, so when my cousin suggested the idea again I thought 'Why not, I'm only going to live once, why not make the best of it?'

Michael didn't join Dateline to find 'the woman of my dreams.' I joined because after a long absence from a city like London you tend to find that your friends and acquaintances have married or moved away. Although I obviously missed female company. I also found that I had no circle of friends left at all.'

'When my first list of names from Dateline arrived and I began to receive calls from women with whom I had been matched on the computer, my social life improved out of all recognition almost overnight! My only problem was time, because all of the women I spoke to were so pleasant that I felt I had to meet them. In the end, I met four from my first list of names. Two I felt I could quite happily be friends with: the other two meant rather more.

Michael doesn't mind people knowing he is a member of Dateline. 'There's not the adverse reaction from family and friends that I think some people may expect,' he said. 'I did perhaps feel, as many people probably do, that there's some sort of stigma about admitting to feeling lonely. But that's rubbish as loneliness affects every person at some stage of their life, no matter what their circumstances. It's something that has to be overcome by any means available to us. Dateline may sound cold-blooded to some people, but I have found it certainly isn't. It may perhaps be more socially acceptable to meet people of the opposite sex in pubs or clubs, but really Dateline wins above those places. I don't like competing with smoke and noise, and it's far nicer to know that the woman you're telephoning has the interests and desires you're looking for. It provides a basic understanding before you even say hello. Obviously, all the usual problems of man meets woman are still there, but you have conquered quite a few of the barriers that so often make a relationship fail before its really started.'

He stopped to consider for a moment. 'I don't know what you need from life. All I really want is happiness, and a large part of the happiness I seek is the happiness that can be gained from the relationship between a man and a woman. At least two of the women I have met directly through Dateline have become friends and it's good to know that if I am at a loose end there's someone I can 'phone for a chat or to arrange an evening out.'

Michael has recently suspended his membership of Dateline. He has met a young woman who is a friend of one of his Dateline introductions. Their relationship has blossomed into love and they are now engaged to be married.

If you would like to be one of the many thousands of people nationwide who have been enjoying a new social life, and finding love and happiness through Dateline, complete the simple questionnaire below. We will send you confidentially and completely free, full details about Dateline and how it works, and details of just one of the Dateline members who are compatible with you. Send to: Dateline Computer Dating, 23 Abingdon Rd., London W.8. Tel: 01-938 1011.

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   c) Adventurous
   d) Shy
   e) Family type
   f) Clothing-conscious

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   b) Fashion
   c) Pubs
   d) Sport
   e) Pets
   f) Folk music
   g) Jazz
   h) Travelling
   i) Cinema
   j) Good food

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   a) Male
   b) Female
   c) Your height

4. Your age
   a) Years
   b) You would like to meet

5. Christian Name
   a) Surname

6. Address

7. Nationality

8. Occupation

9. Religion

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. . . or just those of you who sometimes think “I could do better than that!”

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EXPERIMENTERS' 64 K DRAM CARD

Gnosis: knowledge of spiritual mysteries (Concise Oxford Dictionary); Gnos-ex: expandable memory system (ETI Dictionary). Phil Walker tries again for the obscure pun of the year award.

The ETI GNOS-EX is the expandable, flexible dynamic memory system for the keen experimenter. Using the 4416 16K X 4 dynamic memory devices, the system can be populated and configured for from 16K to 64K blocks with the capability of deleting or including memory in 1K blocks.

Last time we published a DRAM card for the 6502, we used the 74LS608 memory controller. Since then, we've discovered there are problems with this device (don't worry if you're trying to get that board working - we're working on a fix). So this system was designed to do without any very special control devices and rely, so far as possible, on absolutely standard ICs which will be (we hope!) readily available for some time to come and cheap. In the final design the most unusual devices are the 4416 memories and the PROM. This latter device is not actually absolutely essential for the operation of the project and could be replaced by suitable logic.

The layout of the PCB is intended to be such that it will plug into a Microplan system bus, although at the time of writing this it has not been tested. The original development work was carried out on the author's Ohio Superboard, somewhat modified with the processor running at 1.25MHz.

The Circuit

The basic ideas behind this project are much the same as any other which makes use of dynamic memories. There are two distinct phases of operation; the first, and most important as far as the user is concerned, is the reading or writing data, i.e. actually using the memory. The second is the periodic refreshing of the stored data to make sure that it is remembered correctly. Ideally, the refresh operation should not be apparent to the user, and so it must take place when the processor is not using the memory. In the case of the 6502 microprocessor, for which this project is designed, the processor is concerned with accessing the memory for only half the time. The remaining time can be used for refreshing the memory with no effect on the processor. With the 6502 running at 1 MHz there is about 500ns in which the processor will read or write data as necessary, followed by 500ns or so in which the processor is doing internal operations and not interested in the outside world; this is the time we use to do a refresh operation.

The 4416 specification requires that the whole memory be refreshed at least every 4ms. To do this, 256 different addresses must be put on the address lines and the RAS input pulsed low for a certain time for each one. All this must be done within the 4ms allowed. In this design it will be done every 256µs with a 1 MHz processor clock.

The circuit consists of several elements. First, there is an address multiplexer which takes the 16 address lines from the processor and switches them to the eight address lines of the memories during the processor access cycle. Only 14 of the address lines are used, eight are latched into the memory ICs by the RAS signal and six by the CAS signal.

Second, and allied to the above, there is the refresh address counter and buffer. The eight-bit counter is incremented at the end of each refresh cycle and provides the 256 addresses necessary for the complete operation. The tri-state bus buffer puts the output from the counter on the memory address pins starting midway through the previous processor.

Fig. 1 Block diagram of the card
HOW IT WORKS

In this section we shall dispose of the simpler functions first. IC1 is an eight bit bi-directional data buffer. Its direction of transmission is determined by the state of the output 0/R and V signal from the processor. It is enabled by the SEL signal from the address decoding PROM which select the address access.

The address decoder PROM is about the easiest way of providing full decoding of the address space into 1 K byte blocks. As supplied by the manufacturers the TBP24510 has all its memory cells at a logic high level. In this project the PROM is decoupled from the bus. Since the PROM has four bits per location, three more memory maps can be blown into the device to cater for future modifications to your system and link LK1 moved to use the appropriate bit. Also, since only six of the eight address lines are used, SW1 and SW2 are used to provide so that you can have up to four address maps for each location.

If the decoding of the PROM is difficult for you then one of the eight selector IC1 can be used to simulate some of its operation.

In order to ensure that the circuit starts up correctly when power is applied, R4 and C3 together with IC17a and b form a power-on reset circuit which gives a logic high level to SW1 and SW2 as shown. This provides so that you can have up to four address maps for each location.

If the decoding of the PROM is difficult for you then one of the eight selector IC1 can be used to simulate some of its operation.

IC16 finishes its pulse. The delay network RV2, R7 and C5 is reset quickly via D2 ready for the next RAS cycle. As the Q output or RAS signal goes high it also clocks IC18. This transfers the state of the φ signal to its outputs which in turn control the outputs of the refresh buffer and processor multiplexers.

If φ is high the next RAS cycle will be a refresh and IC13 will be enabled. If φ is low the next RAS cycle will be a processor access if required and the outputs of IC2 and 3 will be enabled.

Note that the power-on reset cycle ensures that the control logic starts up with the same state as the RAS generator disabled and the multiplexers enabled. It must be arranged that the software has at least eight RAS only cycles of the memory before it is activated. This would normally occur while the processor registers are being initialised.

The remaining logic is concerned with the reading and writing the memories. The design of the project does not aim for maximum power consumption so the memory accesses are distributed during each cycle. However, to read data from one pair of memories its G input must be low. This signal is derived by simply inverting the R/W signal from the processor and passing its through IC19a. This is half of a one-to-four demultiplexer and its output is determined by the states of the two most significant address lines. The selected output then enables one of the four pairs of memories and allows it to output its data.

To write data into the memories, the WE input must be taken low. To accomplish this, the R/W signal is gated with the inverted φ signal from IC17a and the CAS signal. This is done to ensure that it cannot occur at the wrong time. The outputs from IC15c and d then enable IC19b which routes it to the WE inputs of the pair of memories determined by the states of A14 and A15 of the address bus. This arrangement also delays the write command a little and allows a little extra time for the data to arrive from the processor.

The last components on the PCB worth a mention are the resistor pack R9, 10 and C6. These are provided to terminate the address lines and suppress reflections of the signals travelling back along them. On this size of board, they may well be necessary. The final point to note is that the top address lines A15 and A14 are multiplexed onto the memory address inputs during the CAS cycle, but the memory ICs ignore them. This may prove useful if 64K by 4 bit devices become available (with eight multiplexed address pins) in the near future.
cycle until mid-way through the refresh cycle. During this time, the outputs from the multiplexer ICs are made high impedance to avoid conflict.

The next section, and possibly the most important as far as this design is concerned, is the RAS generator. This is basically a monostable but with extra logic to make it trigger from both rising and falling edges of the \( \phi \) signal. The \( \psi \) signal is the main timing output from the 6502 processor. The dual triggering capability enables the circuit to generate the row address strobe (RAS) signal for both refresh and processor access with one device and one adjustment.

Following on from the RAS generator, there are two functional blocks, one of which determines the memory address source for the next cycle from the current state of the \( \phi \) signal. The other provides a short delay in which the first eight bits of the processor address are made steady before switching over to the next six bits in readiness for the CAS signal.

The delay circuit also triggers the column address strobe (CAS) generator which, if all input conditions are correct, will provide a low output signal to the end of the cycle. Note that this signal will only occur if \( \phi \) is high and the select logic output is low. The state of the select logic is sampled after a delay from the RAS signal falling edge; if it is low then the CAS output may go low. If, however, \( \phi \) is low then CAS will stay high. This occurs during a refresh cycle. If during a processor cycle, the CAS output goes low it will remain low until the end of the cycle when \( \phi \) going low will force it high again. This allows data to remain available at the output of the memories until the end of the processor cycle without the use of a separate latch.

The last major section of the circuit consists of the read/write select logic. This also performs the function of selecting which pair of memory chips is accessed. Each memory device has a write enable (WE) input and an output control (O). The latter has the effect of allowing data to be output from the device only when this line is low. The former causes data to be written into the memory matrix when it is taken low provided that the RAS and CAS signals have been properly set up. The WE signal is allowed to be generated only if a CAS signal is present, and so will occur only in a processor cycle when the select logic output is low and the R/W is also low.

In order to keep the loading on the processor data bus low and to avoid handling problems due to static on the memory data pins, a data buffer is provided. Its direction of transmission is determined by the state of the R/W line and it is enabled when required by the SEL signal from the select logic.

The select logic on the board is intended to be a TPJ 24S10 256 x 4 bit PROM. Only the six MSBs of the address bus are connected to the PROM and thus only 64 of

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**Programming The PROM**

As already stated, the PROM address lines are not used in order, the connections are as follows:

<table>
<thead>
<tr>
<th>Address Line</th>
<th>PROM Pin</th>
<th>PROM Pin Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A15</td>
<td>5</td>
<td>A0</td>
</tr>
<tr>
<td>A14</td>
<td>4</td>
<td>A3</td>
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<td>A13</td>
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<td>A11</td>
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<td>A4</td>
</tr>
<tr>
<td>A10</td>
<td>2</td>
<td>A5</td>
</tr>
</tbody>
</table>

When you come to do the programming program one location at a time. The manufacturers do not recommend manual programming of this device, but you may get away with it. The recommended programming procedure is as follows:

1. Address the word to be programmed, apply 5 volts to \( V_{cc} \).
2. Verify the status of a bit location by checking the output level.
3. Decrease \( V_{cc} \) to 0 volts.
4. For bit locations that do not require programming skip steps 5 through 11.
5. Increase \( V_{cc} \) to \( V_{ccpd} \) with a minimum current capability of 250 milliamperes.
6. Apply \( V_{ccpd} \) to all the S, E or G inputs. \( I_{ccpd} \) 25 milliamperes. Active-high enables may be left high.
7. Connect all outputs, except the one to be programmed, to \( V_{cc} \).
8. Apply the output programming pulse for 20 microseconds. Minimum current capability of the programming supply should be 250 milliamperes.
9. After terminating the output pulse, disconnect all outputs from \( V_{cc} \) conditions.
10. Reduce the voltage at S, E, or G inputs to \( V_{il} \) at a time.
11. Decrease \( V_{cc} \) to 0 volts.
12. Return to step 4 until all outputs in the word have been programmed.
13. Repeat steps 2 through 11 for each word in memory.
14. Verify programming of every word after all words have been programmed using \( V_{cc} \) values of 4.5 and 5.5 volts. Note that registered PROMs must be locked to verify the output condition.

\[
V_{ccpd} = 6 \pm 0.25\text{V} \\
V_{ppd} = 9.75 \pm 11\text{V} \\
V_{il} = 0 \text{ to } 0.5\text{V}
\]
the locations are available. SW1 and SW2 can be used to gain access to three others sets of 64 locations. Also, only one of the four output bits of the PROM is used — selected by LK1 — so a total of 16 different memory maps can be held by each PROM. Note that unlike a previous design for a memory board using this device, the output of the PROM must be programmed LOW to enable the appropriate part of the memory map. Note also that the address lines are not used in order.

If desired it should be easy to wire one or two chips to a 16 pin DIL plug for use in place of the PROM.

Construction

This stage of the project is not difficult but just seems exceedingly tedious. Step one is to check that all the components will fit their holes. Note that the DIL 41612 connector usually needs 1 mm holes for its leads as does C7. All the other components, except RV1 and 2 which need 1.2 to 1.3 mm holes, will fit into 0.8 mm holes.

Step two is to take all the components off the PCB (you didn’t solder them on — did you?) and make all the through-board links. The easiest way we know of doing this cheaply is to take a length of 22 swg tinned copper wire, stretch it a little to make it straight and stiff, squeeze the very end with pliers to flatten it out so that it will not fall through the holes in the PCB and then cut off about ¼ inch (6mm). Repeat this process until you have enough pieces to go through all the link holes.

Support the PCB near the top with the component side uppermost. Working from one end of the board, put about a dozen of the links in the proper holes and solder them in place. Turn the board over and put it flat on the table with a piece of kitchen tissue for protection, and solder all the links on this side as well. Clip off all excess wire and repeat until all the links are made.

Step three is to fit all the IC sockets. Note that IC5 to 12 are the opposite way round to the others. Then fit the DIL 41612 edge connector and the other passive components except R9. Make sure that the diodes and electrolytic capacitors are the right way round.

At this stage it is advisable to check that there is not short circuit on the power supply lines. If this test is OK then R9 can be fitted. Check also that 0V and +5V supplies are connected to each IC socket. Examine the PCB tracks carefully, especially around the edge-connector socket, for breaks or solder bridges, as these will be very difficult and possibly expensive to find later.

Step four is to insert IC15, 16, 17 and 18. Apply power to the board and check that it does not draw more than 100mA or so.

Now connect a 1 MHz TTL compatible square wave signal to the test point. With an oscilloscope (or otherwise, as equipment allows) monitor the illustration test point and adjust RV1 such that the high time is about 150ns. If this cannot be done, check your PCB again and verify the component values of RV1, R5 and C4. Also check that there are two pulses per 1µs — check C1, 2 and 3 if not. CAS testpoint should be continuously high.

If you have got this far successfully, remove power from the PCB and link X to E. Reapply power and check the signal again. Now check that the CAS testpoint has a low pulse while the φ signal is high. Adjust RV2 if necessary to see this. If this signal does not appear check RV2, RV7, D2 and C5 and the signals at IC17c and d.

If all is correct, adjust RV2 such that the φ signal goes low about 100ns after the CAS signal goes low. This should set the main timing to about the right area for normal operation.

Switch off the power again and insert IC2, 3, 13, 14 and 19. Switch on again and check that all eight outputs of IC14 are counting. Check that the outputs of IC16a are switching on the rising edge of the φ signal. Check also that IC19 pin 4 is permanently low and all other outputs from IC19 are high. Now connect the R/W input to the board to 0V and check that all outputs from IC19 except pin 9 are permanently high. Pin 9 should be pulsing low with approximately the same signal as that on the CAS testpoint. Pulling A14 or A15 inputs low should alter the pin numbers but not the signal.

If you have got this far successfully there is only one more thing to do before inserting the memory devices. This is to check the power-on-reset circuit. Incidentally if this does not work correctly it could have given you problems earlier. Temporarily short-circuit C3 and remove the output of IC17b. This should be low. Remove the short from C3 and check that the output of IC17b stays low for at least 200ms (probably nearer 500ms). During this time the RAS and CAS signals will be high. Note that the φ line should be present as early as possible to ensure that the CAS signal is forced high, although the φ line being low will also accomplish this.

The last thing to do now is to insert the 4416 memory devices and IC1. The memory ICs are accessed in pairs, so if you are not using the full complement you must insert IC8/9, IC7/10, 6/11 and 5/12 in pairs. This is also the order in which they appear in the memory space. Remove the X-E link and insert a TBP24S10 suitably programmed into the IC4 socket and link X to A, B, C or D as appropriate. Alternatively, plug a 16-pin header into IC4 socket with, for example, a 74LS151 connected up to select the memory in 8K blocks. However you do it, the SEL signal at X must be low to read or write to or from the board.

A feature of this design is that the SEL signal needs to be low only a short time before the CAS signal is generated in order to activate the memory control but must be held until the end of the φ cycle for a read operation or the end of the RAS signal for a write cycle in order for valid data to be read or written by a 6502 processor. This should not be a problem for any normal address decoder logic.
ETI DECEMBER 1984

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TRACK TAPES
Precision slit black crepe tapes (1 roll/pack).

<table>
<thead>
<tr>
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<th>Price</th>
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<tr>
<td>HB209</td>
<td>200&quot;</td>
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<td>HB211</td>
<td>301&quot;</td>
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<td>HB215</td>
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<td>HB216</td>
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PADS
Pre-printed dense black on .012 acetate film (500/roll)

<table>
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<tr>
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<td>I/D</td>
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<tr>
<td>HB224</td>
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</tr>
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<td>.125</td>
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<td>HB226</td>
<td>.250</td>
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</tr>
<tr>
<td>HB227</td>
<td>.400</td>
<td>£3.05</td>
</tr>
<tr>
<td>HB228</td>
<td>.200</td>
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</tr>
<tr>
<td>HB229</td>
<td>.250</td>
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IC PACK (Dual-in-line)
Pre-printed dense black on .0012 acetate film (125 symbols/pack)

<table>
<thead>
<tr>
<th>Ref</th>
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<tbody>
<tr>
<td>HB281/B</td>
<td>16 Pin DIL</td>
<td>£3.20</td>
</tr>
<tr>
<td>HB281/C</td>
<td>16 Pin DIL</td>
<td>£3.45</td>
</tr>
<tr>
<td>HB284/C</td>
<td>16 Pin DIL</td>
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<tr>
<td>HB285/C</td>
<td>16 Pin DIL</td>
<td>£4.00</td>
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<tr>
<td>HB286/D</td>
<td>18 Pin DIL</td>
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<tr>
<td>HB287/D</td>
<td>18 Pin DIL</td>
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CONNECTORS
Polyester Film-Strips 420mm Long

<table>
<thead>
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<th>Ref</th>
<th>Width</th>
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<tr>
<td>HB232</td>
<td>Conn/D1.0</td>
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<tr>
<td>HB235</td>
<td>Conn/D2.0</td>
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<tr>
<td>HB236</td>
<td>Conn/L1.0</td>
<td>£7.10</td>
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<tr>
<td>HB327</td>
<td>Conn/M2.0</td>
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ARTWORK ACCESSORIES

<table>
<thead>
<tr>
<th>Ref</th>
<th>Name</th>
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<tbody>
<tr>
<td>HB202</td>
<td>Artwork Film A4 (5)</td>
<td>£1.78</td>
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<tr>
<td>HB/CKGA3</td>
<td>Precision Grid A3 (1)</td>
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<tr>
<td>HB352</td>
<td>Artwork Knife (1)</td>
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<tr>
<td>HB353</td>
<td>Blade (3)</td>
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<tr>
<td>HB354</td>
<td>Blade (5)</td>
<td>£0.50</td>
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PLAIN COPPER CLAD PCB
Top Quality FR4 Fibreglass

<table>
<thead>
<tr>
<th>Ref</th>
<th>Width</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB019</td>
<td>S/Sided 3&quot;x4&quot;</td>
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<tr>
<td>HB020</td>
<td>S/Sided 4&quot;x4&quot;</td>
<td>£1.68</td>
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<tr>
<td>HB021</td>
<td>S/Sided 6&quot;x9&quot;</td>
<td>£1.89</td>
</tr>
<tr>
<td>HB026</td>
<td>D/Sided 6&quot;x4&quot;</td>
<td>£2.92</td>
</tr>
<tr>
<td>HB027</td>
<td>D/Sided 6&quot;x9&quot;</td>
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VEROBOARD
Pre-Pierced Stripboard

<table>
<thead>
<tr>
<th>Ref</th>
<th>Width</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB137</td>
<td>V Board 63x95mm</td>
<td>£1.10</td>
</tr>
<tr>
<td>HB138</td>
<td>V Board 63x127mm</td>
<td>£1.27</td>
</tr>
<tr>
<td>HB140</td>
<td>V Board 95x431mm</td>
<td>£5.00</td>
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</tbody>
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UV EXPOSURE UNIT
PHOTO-RESIST & FOTOTOOL materials require exposure to UV light - the type of light used determines the quality of reproduction - this simple-to-make D.I.Y. kit comes complete with UV lamp, holder, shade etc. and full working instructions to build your own glass contact frame - KIT HB/UV1 D.I.Y. EXP. UNIT £27.00

PHOTO-RESIST PCB MATERIALS
Top Quality, Positive Photo-Resist PCB

<table>
<thead>
<tr>
<th>Ref</th>
<th>Width</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB301</td>
<td>Pos S/Sided 3&quot;x4&quot; (3)</td>
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<td>HB302</td>
<td>Pos S/Sided 6&quot;x4&quot; (2)</td>
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<td>HB305</td>
<td>Pos S/Sided 6&quot;x9&quot; (1)</td>
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<td>HB309</td>
<td>Pos D/Sided 3&quot;x4&quot; (3)</td>
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<td>HB404</td>
<td>Pos D/Sided 6&quot;x4&quot; (2)</td>
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<tr>
<td>HB508</td>
<td>Pos D/Sided 9&quot;x6&quot; (1)</td>
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<tr>
<td>HB602</td>
<td>Positive Developer (1)</td>
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<tr>
<td>HB112</td>
<td>Ferris Etchant (1)</td>
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<tr>
<td>HB114</td>
<td>Process Tray (1)</td>
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<tr>
<td>HB117</td>
<td>Copper Cleaner (1)</td>
<td>£1.49</td>
</tr>
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FULL PHOTO RESIST KIT
HB/2 Complete Photo Resist Kit £29.00

PHOTO-TOOL MATERIALS
PCB photo masters made to highly professional standards. UV Exposure. High intensity image. Pos or neg for simplicity of multi-imaging.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Type</th>
<th>Price</th>
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<tbody>
<tr>
<td>HB3</td>
<td>Fotool Kit Complete</td>
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<tr>
<td>HB105</td>
<td>Fotool pos film 1x20cm (6)</td>
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<td>HB106</td>
<td>Fotool neg film 1x20cm (6)</td>
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<td>HB107</td>
<td>Fotool neg film 2x20cm (6)</td>
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<td>HB108</td>
<td>Fotool neg film 2x30cm (6)</td>
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<tr>
<td>HB109</td>
<td>Fotool Developer (1)</td>
<td>£2.90</td>
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<tr>
<td>HB111</td>
<td>Fotool Fixer (1)</td>
<td>£1.89</td>
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</table>

LABEL & PANEL MATERIALS
Convert Fotool masters into highly professional labels and panels. Simple process – durable finish. Packs include laminating film and Double sided adhesive.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Width</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB114/YELL</td>
<td>Yellow Focolam 20x30 (3)</td>
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<tr>
<td>HB114/BLUE</td>
<td>Blue Focolam 20x30 (3)</td>
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<tr>
<td>HB114/BAL</td>
<td>Brushed Aluminium 20x30 (3)</td>
<td>£5.17</td>
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ELECTRONIC PROJECT KITS
A special selection of popular electronic projects from Argus Publications is now available. A wide choice of interest is covered including Computing, Robotics, Music, Speech, etc.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Project Name</th>
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<tr>
<td>HB195</td>
<td>Address Decoder</td>
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<tr>
<td>HB196</td>
<td>Computing Kit</td>
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<td>HB197</td>
<td>Music Kit</td>
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<tr>
<td>HB198</td>
<td>Speech Kit</td>
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<tr>
<td>HB199</td>
<td>ROBOTICS Kit</td>
<td>£2.02</td>
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PRINTED CIRCUIT DRILL
COMPACT 2-SPEED PCB DRILLING M/C
MAINS POWERED
PRECISION MACHINE FOR PRECISION DRILLING.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Diameter</th>
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<tbody>
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<td>HB185</td>
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<td>HB190</td>
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<tr>
<td>HB191</td>
<td>1.1mm (1)</td>
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<tr>
<td>HB192</td>
<td>1.2mm (1)</td>
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<tr>
<td>HB193</td>
<td>1.3mm (1)</td>
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<td>HB194</td>
<td>2.0mm (1)</td>
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<tr>
<td>HB195</td>
<td>3.0mm (3)</td>
<td>£5.22</td>
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COMPUTER ADD-ONS
A comprehensive range of add-on Kits

<table>
<thead>
<tr>
<th>Ref</th>
<th>Name</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>HB192</td>
<td>ROBOTICS</td>
<td>£2.06</td>
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<tr>
<td>HB193</td>
<td>Music</td>
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</tr>
<tr>
<td>HB194</td>
<td>Speech</td>
<td>£1.89</td>
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</tbody>
</table>

COMPUTER LEADS & CABLES
A comprehensive range of Ribbon connectors, cables and connectors is available for most popular computing applications.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Name</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>HB196</td>
<td>Address Decoder</td>
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<tr>
<td>HB197</td>
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</tr>
<tr>
<td>HB198</td>
<td>Music Kit</td>
<td>£2.86</td>
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<tr>
<td>HB199</td>
<td>ROBOTICS Kit</td>
<td>£2.02</td>
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Easy add-ons for ZX Spectrum
Explicitly detailed book to build address decoder and 17 electronic add-on projects.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Name</th>
<th>Price</th>
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<tbody>
<tr>
<td>HB200</td>
<td>BOOK + DECODER KIT</td>
<td>£24.00</td>
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</table>

KELAN ENGINEERING LTD.
Circuit Products & Components Division.
37-39 Leafield Lane, Harrogate.
North Yorkshire HG2 8JX.
Tel: (0462) 878926.
<table>
<thead>
<tr>
<th><strong>Discomixer Phonic 6050</strong></th>
<th><strong>Discomixer Phonic MX7700</strong></th>
<th><strong>Discomixer Phonic SM 501</strong></th>
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<tbody>
<tr>
<td>2 mag deck i/p</td>
<td>2 mag deck i/p</td>
<td>Full headphone monitor</td>
</tr>
<tr>
<td>2 line i/p</td>
<td>2 switchable mic/line inputs</td>
<td>2 x line i/p</td>
</tr>
<tr>
<td>1 mic i/p</td>
<td>5 band graphic</td>
<td>2 x mag deck i/p</td>
</tr>
<tr>
<td>7 band graphic</td>
<td>led vu meters</td>
<td>1 x mic i/p</td>
</tr>
<tr>
<td>twin vu meter</td>
<td>cross-fade</td>
<td>twin vu meters</td>
</tr>
<tr>
<td>headphone monitor</td>
<td>separate record output</td>
<td>mains operated</td>
</tr>
<tr>
<td>mic over ride</td>
<td>mains operated</td>
<td></td>
</tr>
<tr>
<td>mains operated</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Howland &amp; West MX950 Microphone Mixer</strong></th>
<th><strong>Howland &amp; West MX850 Stereo Graphic Equaliser</strong></th>
<th><strong>Phonic EQ1005 Stereo Graphic Equaliser</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>six mic i/p/s</td>
<td>7 bands/channel</td>
<td>5+4 equaliser bands</td>
</tr>
<tr>
<td>stereo line i/p</td>
<td>12db boost or cut</td>
<td>led vu meters</td>
</tr>
<tr>
<td>headphone monitor</td>
<td>tape monitor button</td>
<td>tape monitor</td>
</tr>
<tr>
<td>stereo/mono sw</td>
<td>mains operated</td>
<td>meter level controls</td>
</tr>
<tr>
<td>master fader</td>
<td></td>
<td>connections by phono plugs</td>
</tr>
<tr>
<td>mains operated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DEI Analog Echo Machine</strong></th>
<th><strong>Stereo 2 &amp; 3 way Electronic Crossovers</strong></th>
<th><strong>Echo Microphone</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>BBD echo system</td>
<td>2 way</td>
<td>echo volume</td>
</tr>
<tr>
<td>mic i/p</td>
<td>* cross over frequency 500 Hz</td>
<td>control</td>
</tr>
<tr>
<td>line i/p</td>
<td>* level control for low and high</td>
<td>echo on/off</td>
</tr>
<tr>
<td>foot switch ski</td>
<td>* 19&quot; rack mount</td>
<td>battery operated</td>
</tr>
<tr>
<td>output attenuator</td>
<td></td>
<td>10ft cable</td>
</tr>
<tr>
<td>peak led</td>
<td></td>
<td>vinyl carrying case</td>
</tr>
<tr>
<td>mains operated</td>
<td></td>
<td></td>
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<table>
<thead>
<tr>
<th><strong>27 Band Mono Graphic Equaliser</strong></th>
<th><strong>Cassette Recorder for VIC20/64</strong></th>
<th><strong>1,000 Watt Stereo Slave Amp</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>27 separate sliders</td>
<td>pre set levels</td>
<td>500 watts per channel</td>
</tr>
<tr>
<td>By pass switch</td>
<td>save led</td>
<td>twin vu meters</td>
</tr>
<tr>
<td>LED overloads indicator</td>
<td>simple operation</td>
<td>Jack inputs</td>
</tr>
<tr>
<td>12db Boost or cut</td>
<td>plugs direct into VIC20/64</td>
<td>Cannon outputs</td>
</tr>
<tr>
<td>19&quot; rack mount</td>
<td>tape counter</td>
<td>19&quot; rack mount</td>
</tr>
<tr>
<td>Low distortion 0.05% TYP</td>
<td></td>
<td>cooling fan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>short circuit protection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>250W Power Amp</strong></th>
<th><strong>400W MOS-FET Power Amp</strong></th>
<th><strong>700W Power Amp</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>125w per channel into 4ohms</td>
<td>2 x 200W 5Hz to 30kHz + 1 db frequency response</td>
<td>2 x 350W/channel into 4 ohms</td>
</tr>
<tr>
<td>20KHz frequency response</td>
<td>latest mosfet technology twin o/p meters fully short circuit proof</td>
<td>20Hz to 20KHz frequency response</td>
</tr>
<tr>
<td>open &amp; Short circuit proof</td>
<td>x19&quot; rack mount</td>
<td>cooling fan</td>
</tr>
<tr>
<td>cannon i/p &amp; o/p</td>
<td>x19&quot; rack mount</td>
<td>cannon i/p</td>
</tr>
<tr>
<td>level control for each channel</td>
<td>twin o/p meters</td>
<td>o/p connectors</td>
</tr>
<tr>
<td>twin vu metres</td>
<td>mains operated</td>
<td>twin vu meters</td>
</tr>
</tbody>
</table>

20KHz frequency vu each Short response 
Short circuit protection 
19" rack mount 
"x19" rack mount 
2 x 350W/channel into 4 ohms 20Hz to 20KHz frequency response cooling fan cannon i/p o/p connectors twin vu meters

FOR MAIL ORDER 
48 Dalston Lane, 
London, E8 
Tel 01-249 4814 
Open 7am to 9pm Mon-Fri 
9:30am to 10:30pm Sat

THE MUSIC MAKERS

ALL OFFERS ARE SUBJECT TO AVAILABILITY
TRADE ENQUIRIES WELCOME
TAKE ADVANTAGE OF THE HY-TEK PRICE POLICY

ETI DECEMBER 1984
TECH TIPS

Tape Noise Reducer

W. Wirth
Sri Lanka

Amateur-made multi-track recordings often suffer from tape noise caused by the accumulated noise floors of individual tracks and multiple generations of tape to tape transfers. Encode/decode units like Dolby and dbx are effective but are costly and critical in alignment and use. Playback only noise reducers are also sensitive to alignment errors and have side effects such as “breathing”.

This simple circuit uses the principle of pre- and de-emphasis to obtain its noise reduction. The treble frequencies are boosted during recording and given a complementary cut on playback so that the signal remains flat but high frequency noise is reduced by 8-10 dB.

IC1 is a high impedance buffer which prevents loading of the input and interaction with the reactive components R2, 3, 4 and C1, 2 which are configured around IC2. Switch SW1a, b selects either the boost or cut mode. SW2 chooses a turnover frequency of 800 or 1600 Hz.

Fixed frequency/amplitude units such as this work best on signals with restricted high frequency content like bass, acoustic guitar and vocal tracks. The greatest noise reduction (10 dB @ 10 kHz) can be obtained with these signals using a turnover of 800 Hz. Drum, synth, and similar high frequency content signals can be processed but it would be best to use the 1600 Hz turnover and set the recording level conservatively.

C3 reduces gain at very high frequencies to help avoid saturation. Its presence in both boost and cut modes causes a tracking error resulting in a 3 dB loss at 20 kHz. This was felt to be insignificant. Although any op-amp can be used, best results are obtained from low noise devices; an RC4136 is a good choice for a two channel unit.

Quiz Machine

G. J. Phillips
Durham

The circuit shown has been designed for use in a quiz where each contestant has a button and the first person to press causes his light to illuminate, thereby cueing the question master. The circuit can be used for any number of buttons from two to ten. The design features automatic reset after a preset time delay so that no intervention is required by the question master.

IC1 (pins 1 to 6) is connected as an astable multivibrator which feeds the clock input of a decade counter IC2. As the counter cycles, each of its outputs Q0, Q1, etc goes to logic 1 in turn.

When a contestant presses his button, the bistable formed by IC1 (pins 8-13) is reset thereby inhibiting the clock of IC2 and effectively freezing the counter at the Q output associated with the button pressed. For example if button PB1 is pressed, the counter freezes at Q0 causing Q2 to turn on. Q1 is turned on also irrespective of which button is pressed. Lamp LP1 is therefore lit indicating that PB1 has been pressed. LP1 remains lit for a time period set by C1, R4 (approx. 3 seconds) after which the bistable is set via pin 8. Lamp LP1 is then extinguished and the circuit is ready for another round.

The cyclic nature of IC2 ensures that two or more lamps can never be lit simultaneously. It may be argued that the circuit is unfair in that if the counter has just cycled past Q0 and PB1 is pressed before say PB3, then PB3 will win even though it was pressed later. In practice, however, the counter is cycling very fast and the “who pressed 1st” judgement is made in a fraction of a millisecond, many times faster than human judgement can be made.

A buzzer is connected between the collector of Q1 and the +15V rail to give audible indication that a button has been pressed.
Shunt Regulated Spectrum Power Supply

A. S. Hughes Holywell

The Sinclair Spectrum power supply unit has an unregulated output which is capable of operating the computer and the Sinclair printer. Consequently, when it is used to power the computer alone, the supply voltage can rise to well above 9 volts. A friend of mine has 12 volts supplied to his 16K model.

Since the computer takes about 0.8 A, the internal 5 V regulator has to dissipate \((12 - 5) \times 0.8 = 5.6\) watts. This, together with high ambient temperatures causes the computer to become very warm. This shunt regulator circuit, when interposed between supply and computer, will reduce the Spectrum working temperature.

As we all know, the 5 volt regulator is perfectly happy with an input voltage of 8 volts. I have also learnt that the printer does not object to 8 volts either. It therefore makes sense to supply the Spectrum with 8 volts to achieve the lowest possible operating temperature.

The advantage of shunt regulation, as opposed to the more usual series regulation, is that there is no significant voltage drop across the supply circuit in series with the computer. Therefore, on full load, when there is no voltage to spare, this circuit can cope.

Q1 emitter is clamped at 5.6 volts below the positive supply rail. The base of Q1 goes to the potential divider formed by R5 and RV1. If the supply voltage should rise, the bias to Q1 increases, causing Q2 collector current to rise, which in turn increases Q3 collector current. The large current taken by Q3 tends to keep the supply voltage down. If the load current should increase, Q3 reduces its collector current to compensate.

D1 drops 0.8 volts thereby ensuring that the Sinclair supply unit is not overloaded. R4 reduces the dissipation in Q3 to less than 3 watts. If the unit is left switched on with no load connected the power dissipated in R4 will be about 8 watts.

I took the opportunity to include a few luxuries in this circuit, such as the power on indicator (LED1) and extra smoothing capacitor C2.

To set up the circuit, connect the output to an 8 ohm 10 watt power resistor (R7 and R3 in series) and adjust RV1 for an output of 8.2 volts.

---

 Loudness Control

R. Leach Reading

Most audio amplifiers equipped with a loudness control employ a tapped volume control to allow bass and treble boost at low volume settings. This is intended to account for the non-linearity of the ear at these levels.

The circuit shown allows the same effect to be obtained using only an ordinary 50K dual-gang potentiometer. A four-gang potentiometer would be required for stereo operation (Cirkit supply one) or alternatively two dual-gang ones could be used, one for each channel.

The IC could be a 741 or any similar device but for best results a high quality op-amp such as the TL071 is preferable. The gain of the circuit is effectively unity at 1kHz but approximately 10 dB bass boost is provided at 100Hz and high frequency attenuation in the feedback loop gives approximately 5 dB gain at 10kHz. As the setting of volume control RV1 b is increased, so also is that of RV1a which reduces the effects of the frequency selective networks around the op-amp. At maximum volume the amplifier frequency response is flat over the audio spectrum.

The unit could be arranged so that it might be switched in and out, either by re-routing the signal path or by inserting a switch at point A. This would isolate the frequency selective networks from ground and leave the IC functioning as a unity-gain amplifier with a flat frequency response.
Memory Map Simplification

P.M. Buckley
Leeds

Although very simple, this idea speeds up I/O processing and shortens machine code programs considerably.

In microsystems using the 6821, selection of the internal registers in the PIA is usually achieved by attaching A0 & A1 of the address bus to RS0 & RS1 on the 6821. This gives the memory map shown in Table 1.

<table>
<thead>
<tr>
<th>A1</th>
<th>A0</th>
<th>REGISTER SELECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>DDRA and I/O REGISTER A</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>CONTROL REGISTER A</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>DDRA and I/O REGISTER B</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>CONTROL REGISTER B</td>
</tr>
</tbody>
</table>

Table 1

This is awkward as the I/O registers are two bytes apart, which means 16 bit registers such as the index register in the 6800 cannot be used to read and write to the I/O ports. Instead two eight bit operations have to be used.

By simply swapping over the connections to RS0 and RS1 the memory map changes to that shown in Table 2.

<table>
<thead>
<tr>
<th>A1</th>
<th>A0</th>
<th>REGISTER SELECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>DDRA and I/O REGISTER A</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>CONTROL REGISTER A</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>DDRA and I/O REGISTER B</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>CONTROL REGISTER B</td>
</tr>
</tbody>
</table>

Table 2

Square/Triangle Generator with Variable Mark/Space Ratio

P. J. Thompson
Lancashire

The problem with most methods of obtaining a variable mark-space ratio from normal asstable circuits is the tendency of the ratio to alter with frequency and vice-versa. With this circuit both adjustments can be made independently of the other. It also produces constant amplitude outputs.

IC1a, IC1b and associated components form a fast (non-saturating) Schmitt trigger. Trigger voltage is set by the current, to virtual earth, through R2 multiplied by the input resistance RV2a and R8.

The potentiometer RV1, IC1c, C1 and associated components control the mark-space ration. The rate at which C1 charges is controlled by the resistance between the output of the Schmitt (IC1b) and the virtual earth of IC1c. Hence over one cycle the average value of resistance equals (RV1/2) + R7 eliminating the effect of this control on the frequency.

When the output of IC1c rises to the positive trigger voltage IC1b's output switches to a positive value determined by R3 and R4, thus the output of IC1c starts to fall as it discharges C1. Upon reaching the negative trigger voltage IC1b switches to its negative value (R5 and R6) so IC1c's output starts to rise, and the cycle is repeated.

The frequency is controlled by RV2a, which determines the trigger voltages and hence the time taken to charge (discharge) C1. (Large RF1a = Large trigger voltages = Long times = Low frequency).

The triangle (ramp) waveform is derived from the output of IC1c. However, as the amplitude at this point is determined by the trigger voltages, use is made of a dual-ganged potentiometer. The first side (RV2a) controls the frequency, and the second (RV2b) corrects the triangle amplitude; the peak input current to the Schmitt trigger equals the current through R2. (a constant) and as RV2a should equal RV2b the peak current into IC1d's virtual earth is constant, and therefore so is the output amplitude. As R2 = R10 the square and triangle amplitudes are the same.

It is recommended that FET input op-amps are used because of their superior slew-rate; a poor slew-rate would degrade the high frequency performance and cause the mark-space to alter the frequency.
Simple ZX80/81 Tape Mod.

S. Beet
West Kirby

The recently published ZX80/81 tape mods are both simple and cheap, but I have used an even simpler and completely free modification for several months without any problems.

Most of the problems associated with saving programs on cassette, are due to mains-induced hum in the connecting leads. The ETI mods overcome this by increasing the signal level so that the mains hum becomes less significant. However, by transferring the 1 kΩ resistor from across the output of the ZX80/81 to the input of the tape recorder, the hum is still attenuated by a similar amount but, since the mains hum is much smaller than the 5V logic level, the input signal-to-hum ratio becomes very large and reliable data transfer is much more likely.

Ideally the 47 nF capacitor should also be removed, but its impedance at 50Hz is negligible so this is not usually necessary.

The resistor can either be placed inside the cassette recorder or in the plug at the cassette end of the lead.

Signal/Peak Indicator

R.M. Bland
Rugby

This circuit was designed as a cheaper version of the normal LED bargraph type VU meters and uses only two LEDs. The green one is a "signal present" indicator which starts to glow with an input signal of about -30dBm and glows progressively brighter with increasing input signal. At around 0dBm the red "peak" indicator switches on.

The input is AC coupled into 220k ohms to avoid loading the signal source. The op-amp is any standard 741 type (non-latching), and functions as a half-wave rectifier with a gain of about 7. The signal is then smoothed by C2. Q1 functions as a voltage controlled current sink and controls the brightness of LED1. Q2 operates in the switching mode and switches on LED2 when its base reaches about 2V.

CMOS Monostables

P. Harding
Exeter

The circuits presented here are a further variation on the basic CMOS monostable design; the NOR type is reset by a positive pulse and, the NAND type by a negative pulse. Hence the reset pulse polarity matches that of the trigger pulse.

Circuit operation is simple. Taking the reset input of the NOR version high forces IC1 b's output low, removing the feedback to IC1 a. The original trigger signal must have been removed before the monostable can be reset. Operation of the NAND version is similar to that of the NOR type, but with reversed logic polarity.

With the values shown, the circuit has a period of about 6s, although component tolerances (in C1) will have a large effect on the actual period. Care must be taken when using high values of R2 with an electrolytic for C1; leakage currents may prevent the capacitor charging to the CMOS high threshold so that the monostable never times out.
**Micropower 5 Volt Regulator**

B. Hunter
Dundee

The voltage regulator shown here was designed to supply a CMOS microprocessor data logger which had to run for several days from NiCad cells without recharging. An ordinary low power voltage regulator such as a 78L05 consumes several milliamps and in a circuit with a very low quiescent current would contribute quite significantly to the battery drain. The regulator shown here requires a little over 100µA, giving a considerable saving in battery current. The common or garden low power regulator also requires an input voltage about 2 volts above the output voltage; the design given here will work with an input only 0.5 volts higher than the output voltage so fewer cells can be used to power the circuit.

The 9491 is a bandgap voltage reference which gives a very stable 1.22V and can operate from a current as low as 50µA. This reference voltage is fed to the inverting input of a CMOS op-amp where it is compared with a fraction of the output voltage. The output of the op-amp drives the base of the BC477 and this transistor increases the output current of the amplifier.

If the output voltage starts to decrease due to increased load, then the fraction of Vout on the non-inverting input of the op-amp decreases. This causes the output voltage of the op-amp to fall and thus turn the PNP transistor on to compensate for the increased load.

Pin 8 of the op-amp sets the quiescent current of the device to one of three values. If it is connected to v+ then the quiescent current is 10µA, if connected to v- the quiescent current is 1mA, and if connected to a voltage between v- and v+ 0.8V, then the quiescent current is 100µA. Thus connecting pin 8 to the reference voltage gives a quiescent current of 100µA. The capacitor across the output prevents any oscillation of the circuit.

Using the component values given, the circuit performs as follows.

For Vout = 5.06 volts:
Vin minimum = 5.27 volts with 10mA load
Vin minimum = 5.57 volts with 40mA load
No load current = 112µA

**Desoldering Tool Improvement**

S.S. Norman
Sunbury-on-Thames

The following idea is a method of making de-soldering tool nozzles last forever.

If a neoprene sleeve (RS Components Part No. 399-729) is fitted over the nozzle as shown, with the sleeve protruding about an eighth of an inch over the end, it can be seen that the nozzle will never get hot enough to melt and eventually wear out. The sleeve also improves the efficiency of the tool by forming a seal over the iron and joint to be desoldered, which results in more solder being removed in one operation.

When the end of the sleeve gets worn it can either be turned around or cut back, so a single sleeve can be used at least two or three times.

The price for one sleeve is about one hundredth of the cost of a new PTFE nozzle, so the use of the sleeves can produce quite a saving where these tools are used frequently and in large numbers.

If it proves difficult getting the sleeve on, a tiny amount of sleeving lubricant (RS Part No. 544-077) can be used to ease it on.

Note: RS Components will only supply trade and professional customers. If you are unable to use them because of this and can find no other source of neoprene sleeving, Crewe-Allan & Company of 57 Scrutton Street, London EC2 will order the RS parts you need for a small extra handling charge.

**Reducing Relay Power Consumption**

S.T. Jones
Solihull

Most relays need much more current to ‘pull-in’ than to stay closed. For example, a six-volt relay may need 80mA to pull-in but only 20mA to stay closed, so the extra 60mA is wasted current. In the circuit shown, current consumption is reduced by limiting the current drawn to 20mA with a suitable resistor. Normally this would prevent the relay closing at switch-on, but capacitor C1 charges to the supply voltage when the relay is off and discharges to provide a high current at switch-on. When the switching transistor turns on, this current pulse is sufficient to close the relay. D1 provides the usual back-EMF protection and can be almost any general-purpose type. C1 is electrolytic and should be of 200µF or more.

ETI DECEMBER 1984
ADSR For Electronic Organ

C.A. Van Latum
Rotterdam

While constructing an organ based on the SGS-Ates M108 organ chip, I found the normally used ADSR circuits far too expensive to construct.

The ADSR-unit described below incorporates all the normal ADSR functions and is very cheap and simple. The whole circuit is based on one op-amp wired as a comparator.

The trigger outputs of the M108 are first inverted and buffered (not included in the circuit diagram as one inverter-buffer circuit can be used to trigger all ADSR-blocks). As a key is pressed TDS will become high for about 9 ms. The output of the comparator IC1 will turn high and capacitor C1 will be charged at a rate determined by R4/RV2 (attack). When C1 has reached a voltage

\[ V = \frac{V_{\text{supply}}}{R1/(R1 + R3)} \]

the comparator output will turn low. C1 will then be discharged via R5/RV4 (decay) to a level determined by RV3 (sustain level).

All this assumes that the key is still pressed, so KPS is high. As the key is released KPS will turn low and C1 will discharge via R2/RV1 (release). As C1 must not be given the chance to discharge via the output op-amp a high input resistance device must be used, for example a TL081. Note that C1 must not be an open-drain output op-amp.

As quad op-amp ICs can be used, four independent ADSR units can be constructed with just two ICs. The connections to the control panel can be made very easily as only four wires are required per unit!

The necessary equations to calculate the component values are:

\[ V_{\text{max,off}} = \frac{V_{\text{supply}}}{R1/(R1 + R3)} \]

\[ V_{\text{max,off}} = \frac{x}{V_{\text{supply}}} \]

Attack time \( t_a = R.C.\ln(x) \)
Sustain level \( V_s = P.V_{\text{supply}}/20 \)
where \( P \) is fraction of RV3 (0—10)
Decay time \( t_d = 2.3.R.C. \) where \( R \)

\[ R = R5 + RV4 + R_p \text{ (volt. divider res.)} \]

Release time \( t_r = 2.3.R.C \)

Voltage divider resistance \( R_p = 100.P.(20-P)/20 \)

Remote Noise Alarm

S. Huckstepp
Colchester

This alarm allows a microphone to be placed at a great distance from the alarm and power supply circuitry yet includes a preamp at the microphone end to reduce noise pickup along the line and uses only two wires.

Q1 amplifies the voltage induced in the microphone while D1 provides a reference voltage 0.6 V less than the supply to overcome the transistor’s base-emitter voltage drop. When the level of the amplified signal tapped off by RV1 exceeds the thyristor’s base threshold, CSR1 conducts and increases the current consumed by this part of the circuit. C1 and R1 provide a delay to prevent CSR1 triggering at switch-on.

The voltage at the bottom end of R6/RV2 is usually less than 0.6 V below the supply voltage, but when CSR1 conducts this is pulled down and Q2 conducts. RV2 is adjusted to ensure that Q2 saturates.
TTL Clock Delay

Phil Walker

Some circuits require non-overlapping clocks for their operation, notably the 6500 series microprocessors and certain audio delay lines. It is not always easy to obtain this type of waveform without special chips so this circuit was devised using TTL gates as delay devices. The original circuit was intended to reconstruct the φ and φ from a 6502 based micro when only the φ signal was available at the connector interface.

As shown the circuit will give a period of about 50 to 80ns from the time one output goes to 0V until the other goes to the high level. Omitting IC1b and c will shorten the time while inserting the spare section of IC2 between IC1b and c will lengthen it. The operation of the circuit is not dependent on the input clock frequency but the rise and fall times should be better than 10ns if possible. If this is a problem, use the spare section of IC1 to sharpen the input signal (74LS14 preferred) and swap the designations of the outputs. This will add a gate delay to the reconstructed signals.

Automatic Car Alarm

G. Landry
Natal, S.A.

The problem with most car-burglar alarms is that one tends to forget to activate them. This little circuit does so automatically.

Upon switching the ignition off, Q1 turns off and C1 starts discharging through R2. This maintains the output level of the OR gate (D2, D3, R4) high. During this discharge period (set at two minutes by the values of R2 and C1) the driver can leave his car without setting the alarm off. However, after this period, the voltage across C2 is lower than the Schmitt NAND gate IC1a threshold. If an intruder opens a door, the OR gate goes low and the monostable around IC1a, IC1b is turned on. This in turn switches on Q2 which operates the relay for a period depending on C2 and R6 (set for 1 minute).

The only way to disable the alarm is to operate the external switch (a magnetic switch was used in the prototype). This causes the NAND latch around IC1c and IC1d to set, putting an earth on D4 which will reset the monostable. The car can now be entered without fear of setting the alarm off as the NAND latch will only reset when the ignition is turned on again. The circuit is protected against transients by D7, C3 and ZD1 and consumes about 20µA when on standby.
'A' Weighting Filter

B. Porter
Kings Lynn

The 'A' weighting is used to compensate for the unevenness in the average human hearing. Human beings, for the most part, much more sensitive to middle range frequencies than to either extremely low or extremely high frequencies.

This circuit will match the official 'A' weighting curve very closely indeed and can be used in conjunction with an audio millivolt meter to give an indication of the apparent loudness of human beings.

The resistor values given are for 1% types but if accuracy is not too important you can use 5% types and select the nearest available value. If you do use 1% types you may find it necessary to do a little substitution. A 15k and an 820R in series will prove an acceptable substitute for the 15k8, an 82k and a 1M2 in parallel can be used instead of the 76k8, and a 330k and a 4M7 in parallel can be substituted for the 309k, A 47p capacitor and a 4p7 in parallel will prove a sufficiently close approximation to the 51p specified.

Ultra Low Cost Light-Pen

G. Parker
London

This light-pen is intended for use with a ZX Spectrum and is the cheapest, simplest design you're ever likely to find: it does not even need an edge connector.

The unit (which can easily be housed inside an opaque biro case) is connected to the EAR socket and the +9V line. The latter can be obtained by either soldering a wire to the 9V socket inside the computer or adding an extra socket and plug to the power supply line.

The advantage of using the EAR socket is, aside from cutting out the expense of an edge connector, that no address decoding or data isolating is needed. You can put pulses on the EAR socket and unless the computer is performing that particular IN command it will ignore them with no damage to the circuitry.

To see what the pen is in, an IN84 command should be used.

Photo-transistor Q1 is a BC109, the top of which has been cut off with a pair of stout scissors. It has a high dark impedance and in the dark transistor switch Q2 will be off and when PB1 is pushed no current will flow. In the light, the transistor Q2 will switch on, allowing a positive voltage to flow through PB1. The amount of light required for switch-on can be adjusted by RV1 to suit different colours on the screen.

Casio fx-180P Resistor Decoder

R. Hutchison
West Kilbride

This program is designed to convert resistor colour codes to their correct numerical value. It works with both four and five band resistors, and, although designed for use with the fx-180P, should be easily adaptable to suit most other programmable calculators.

The program listing is as shown in Table 1. In order to make the best use of this system, part of the keyboard has to be colour coded. The easiest way to do this is to make a colour template to fit around the 0, 9, , and keys. This is really quite straightforward if drawn out on 1 mm squared paper. Once you have got the template to fit correctly, it is a good idea to sandwich it between two layers of clear Fablon. The colour coding for the template is given in Table 2. A 2mm wide coloured band around each key is very effective.

Use of the system as follows. Firstly load the program into the machine, then fit the template. Enter the colours of the first two (or three) bands; press RUN: enter the colours of the third (or fourth) band; press RUN. The calculator will now display the value of the resistor in engineering notation, i.e. 10 J (k); 10 (Ω); etc.

Examples:
- green-blue-red-yellow: display shows 5.629, i.e. 5.62 kΩ.
- yellow-violet-gold: display shows 4.79, i.e. 4.7 kΩ.

Note that it is necessary to press both gold or silver colour-coded keys when a gold or silver band is encountered.

Table 1. Program Listing

<table>
<thead>
<tr>
<th>Key</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Black</td>
</tr>
<tr>
<td>1</td>
<td>Brown/Gold</td>
</tr>
<tr>
<td>2</td>
<td>Red/Silver</td>
</tr>
<tr>
<td>3</td>
<td>Orange</td>
</tr>
<tr>
<td>4</td>
<td>Yellow</td>
</tr>
<tr>
<td>5</td>
<td>Green</td>
</tr>
<tr>
<td>6</td>
<td>Blue</td>
</tr>
<tr>
<td>7</td>
<td>Violet</td>
</tr>
<tr>
<td>8</td>
<td>Grey</td>
</tr>
<tr>
<td>9</td>
<td>White</td>
</tr>
<tr>
<td>+/−</td>
<td>Gold/Silver</td>
</tr>
</tbody>
</table>

Table 2. Template Colouring

<table>
<thead>
<tr>
<th>Colour</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETI</td>
<td></td>
</tr>
<tr>
<td>TECH TIPS</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Module</th>
<th>Power/Load</th>
<th>Price Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE608</td>
<td>60W/8R</td>
<td>£21.00</td>
</tr>
<tr>
<td>CE1004</td>
<td>100W/4R</td>
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<tr>
<td>CE1008</td>
<td>100W/8R</td>
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</tr>
<tr>
<td>CE1704</td>
<td>170W/4R</td>
<td>£25.00</td>
</tr>
<tr>
<td>CE1708</td>
<td>170W/8R</td>
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</tr>
<tr>
<td>FE908</td>
<td>120W/8R</td>
<td>£29.50</td>
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<tr>
<td>CE3004</td>
<td>300W/4R</td>
<td>£49.00</td>
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<tr>
<td>BO1</td>
<td>BRIDGER</td>
<td>£8.20</td>
</tr>
<tr>
<td>CPR2</td>
<td>PREAMP</td>
<td>£47.95</td>
</tr>
</tbody>
</table>
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MIND YOUR HEAD!

How many heads do you have? Are they laminated or solid? And how wide are the slits in them? Vivian Capel reveals all that you need to know about your tape heads (what else?)

While it is easy to understand the mechanical aspects of tape recording, and the electronic ones are quite straightforward, the operation of the heads and the various factors affecting them are generally less readily understood. In this article, we do not intend to go deeply into magnetic theory, but rather to explore some of the practical whys and wherefores, so that the recorder user will have at least a nodding acquaintance with the head and what it does.

Fig. 1 Magnetic recording head showing core, gap and coils.

Construction
The construction of a tape head is really quite simple, see Fig. 1. In essence it consists of a squared-off ring of magnetic material on which is wound one or two coils. One end of the ring is rounded and in the centre of this is a fine vertical slit or gap which is filled with a shim of non-magnetic material.

In the case of a stereo head there are two ring-cores and sets of coils, one stacked above the other, separated by a magnetic shield to reduce cross-talk between them.

When a current is passed through the coils a magnetic field is set up through the core and across the gap; the two sides of the gap form the poles of an electromagnet, one north and the other south, depending on the direction of the current through the coils.

Most of the magnetic field passes through the gap via the shortest path, that is from one gap face to the other, but not all. There is also an external field which forms a roughly hemi-cylindrical pattern around the outside of the gap. It is through this external field that the tape passes.

As the tape travels across the gap it is magnetized in sympathy with the signal currents through the coils, and thus a series of magnetic zones are created along the tape track. The height of these (which is the width of the track) is the same as the height of the gap and so is fixed, but the width along the tape depends on the frequency recorded: high frequencies produce narrow zones while low frequencies give rise to wide ones.

During playback, the magnetized zones passing back over the gap induce varying fluxes in the core which in turn generate corresponding EMFs in the coil windings; the recording process is the reverse, approximately.

Two Heads?
Obviously, the same head that made the recording can serve to play it back, and in the majority of recorders this is the practice. It would in fact seem that this was an ideal arrangement, as there thus can be no alignment or azimuth differences with the same head gap doing both jobs. Yet we find that in the more expensive machines two heads are provided (in addition to the erase head) one for record and the other for playback. Where space is limited as it is in the audio cassette recorder, the two heads may be mounted side-by-side in the same casing.

If one head seems to do the job well enough in most machines, why go to the trouble of having two? Suspicious-minded individuals may wonder if this is just a ploy to hike the price and sell the goods, rather like those early "10-transistor" radios that had three of them soldered to the printboard doing nothing.

In this case, there are several advantages in having separate record and playback heads. Firstly it makes AB monitoring possible, whereby you can switch from the source to the playback head whilst actually recording, and compare; any deficiencies in the recording can be immediately detected. However, some machines have separate heads but do not give the AB monitoring facility, so there must be other reasons.

To appreciate the playback head, we need to take a closer look at it, and in particular, its gap. We have already mentioned that high recorded frequencies are represented by narrow magnetic zones. To read them accurately, we need a narrow gap that is less than half-a-wavelength of the highest recorded frequency wide.

To see why this is so, imagine a complete cycle of a high frequency recorded on the tape; it has two sections, the positive half cycle and the negative, which are represented by corresponding north and south pole regions along the tape. If the playback gap is a whole wavelength wide, as in Fig. 2a, both sections appear across the gap at the same time and the flux cancels, giving no output. The gap width then, is one of the main limiting factors to the highest frequencies that can be replayed.

When the gap width equals half a wavelength, output is at maximum, Fig. 2b. We can then calculate the theoretical upper limit for a particular gap width, or alternatively specify a maximum width to obtain a given...
upper limit. The standard compact cassette tape speed is 1/2 inches per second, or 47,500 microns per second. Dividing that by any particular frequency will give its recorded wavelength in microns. So for 20 kHz, the wavelength on tape is 2.4 microns. Half of this is 1.2 microns which is therefore the maximum width for a gap which would be required to record up to 20 kHz.

Actually there are various losses which take place that affect the high frequencies more than the low. These cause a fall-off from around 4 kHz, but electronic equalization can boost the signal above that point so that a reasonably level response is achieved toward the theoretical maximum. Boosting beyond the limit set by the gap width is useless because cancellation occurs and boosting nothing produces nothing — except noise.

### A Wide Gap

One might, therefore, assume that a narrow gap in the region of 1.2 microns is necessary to obtain a good HF response from the record head too. Some surprise may be caused by the discovery that dedicated recordhead gaps are much wider, up to 10 microns in many cases. According to our above calculations, for a 10 micron gap the half-wavelength frequency is a mere 2.4 kHz. How does it manage to record wavelengths many times shorter than its width, and why is the gap made so wide?

Fig. 3a shows the goings on at the head, but an analogy might help us to see how it is done. Supposing a long strip of material is required to be painted in alternate inch-wide black-and-white stripes. It is moved past a machine which has two spray guns filled respectively with quick-dry black and white paint, at a speed of one inch in two seconds. The machine fires the spray guns through a mask with an inch-wide slot alternatively every two seconds. Thus one stripe is just beyond the mask as the next one is sprayed.

Could half-inch stripes be obtained? Yes, by simply operating the guns every second. The first stripe is an inch wide, but it has only travelled halfway across the mask before the next one is sprayed. So it overlaps the first, and in the same way the third overlaps the second. The result is a series of half-inch stripes. Even narrower ones could be obtained by firing the guns more frequently, yet with the same 1-inch mask.

In the recording head, for frequencies having a shorter wavelength than the gap, the flux partially erases what has gone before, leaving only that which has passed beyond the range of the gap; the trailing edge of the gap effectively 'writes' the recording.

Actually, the audio signal is superimposed on a steady high-frequency bias signal which carries it over the nonlinear low-level portions of the magnetizing curve. The bias signal magnetizes the tape but is almost completely self-erased by succeeding half-cycles, leaving the superimposed audio. The bias frequency ideally should be as high as possible to avoid intermodulation distort-

### Perpendicular Or Horizontal?

When recording medium to low frequencies, the recorded wavelength is long in comparison with the field depth and the resulting internal field produced in the tape-coating is mainly longitudinal, that is, it lies along
The smallest various the active magnetic particles and of each zone does recording magnetic ETI
The tape the future. considered feasible many wavelength of adjacent bar magnets system less side by side visible light as assembled end with similar poles adjacent.

To achieve a strong field in the longitudinal direction, the active magnetic particles in the coating are not of random shape like gravel chips, but acicular (needle-shaped). When the coating is applied during manufacture, it is paired through a powerful magnetic field before it dries to align all or most of the needles along the length of the tape.

At present, much research is being conducted in various fields to pack as much information as possible in the smallest space. Video and digital audio systems demand high information packing densities so stimulating the search. Attention has turned to making the recording field principally perpendicular, Fig. 4b. Just as you can get more people in a high-rise block of flats than in bungalows of the same ground area, more information could be stored by perpendicular fields.

This would mean orientating the needle particles so that they would all be standing on end. Though not impossible it would pose problems for the tape makers. The recording field would be applied by passing it through rather than across the tape, which would mean the tape travelling through the gap. One way of doing this would be to construct a head having a very fine magnetic pole-piece surrounded by non-magnetic material, with a permalloy plate behind the tape to complete the magnetic circuit.

The magnetic zones thus created would alternate NSNS and resemble a collection of bar magnets arrayed side by side with opposite poles adjacent. This is much less prone to self de-magnetization than the present system whereby the zones NSNNSN are equivalent to bar magnets assembled end-to-end with similar poles adjacent.

Information packing densities closer than the wavelength of visible light are possible, which makes feasible many applications that could not be seriously considered with the present technology. Linear video recordings may be possible, thus eliminating the mechanical complexity of rotating head-drums and helical scan.

Bias
So we may see radical changes in tape-head design in the future. But now back to the present, and in particular, tape bias. We have already alluded to HF bias, but why is it necessary and what exactly is its effect?

When any magnetizable material is magnetized, the process does not proceed at first in a linear manner; in fact the plot of magnetism against magnetizing force is quite curved. After this initial non-linearity though, the plot straightens and the characteristic becomes linear. The effect is similar to the operating curves of valves and transistors but with one exception, the magnetic curve has a negative component. The material can just as well be magnetized in the opposite direction, whereas of course you cannot reverse the current through a transistor.

A typical curve is shown as part of Fig. 5a; the negative section is identical but opposite to the positive section. One point to note is that this is the curve for an (initially) unmagnetized piece of tape; if the tape were magnetized, the magnetic field would, obviously, not be zero when the magnetizing force was zero, and we'd have a completely different curve; this sort of situation is dealt with in detail by text-books on electricity and magnetism.

If we applied a signal to the recording head in the form of sine wave, the resulting magnetization (and hence the resulting signal on replay) would be grossly distorted, due to the non-linear central portion of the characteristic, Fig. 5a. The simplest solution is to apply a DC bias current to the record head in addition to the AC signal, so that the AC signal sits entirely with the relatively linear section of the curve, as shown in Fig. 5b.

This works well enough in practice, but it is wasteful of the tape's recording potential. With the negative portion unused, the maximum recordable signal is less than

![FEATURE: Mind Your Head](image)

Fig. 4 Conventional recording heads produce longitudinal magnetic zones in the tape coating, with NS, SN, NS polarity, (a). Perpendicular recording in which the tape passes between the recording poles gives a greater packing density, and N, S, N, S adjacent pole polarity.

![FEATURE: Mind Your Head](image)

Fig. 5 Initial magnetizing characteristic of recording tape. (a) A sine wave signal recording over the curved lower portions of negative and positive characteristic, resulting in distortion and low volume. (b) DC bias lifts the operating point to the middle of upper straight portion giving linear output but limited amplitude. (c) AC high-frequency bias bridges the curve nonlinear portions so presenting the superimposed audio to both straight sections. The result is a linear, large amplitude recorded signal.
half what it could be if both portions were used and the signal-to-noise ratio is also less than half what it would be. For this reason, DC bias is used only on cheap cassette recorders.

AC bias is used in all the better and hi-fi recorders, and it does make use of the whole magnetisation curve. The audio signal is added to a high-frequency (several times the maximum audio frequency, and typically 30-100 kHz) sine wave, to give the effect shown in Fig. 5c (note that this is not amplitude modulation, and Fig. 6 shows the difference).

When this composite signal is applied to the tape, distortion occurs where the composite signal traverses the non-linear parts of the curve. But the distortion is only of the lower portions of the HF bias; the audio which is riding on the crest of the bias waves is unaffected. The upper and lower portions of the composite wave affect the positive and negative parts of the characteristic, producing complementary audio signals. These add to produce the final recorded audio signal of large amplitude.

What happens to the bias signal? It has been said that it is not recorded because the frequency is too high. Well, it is recorded on the tape, otherwise it could have no effect on the tape's magnetisation curve; the bias frequency is recorded by the 'paint stripe' effect already described for high-frequency audio.

However, it does not remain on the tape for more than a few microseconds. This is due to self-erasure. A magnetic field does not have hard and fast boundaries; it diminishes rapidly beyond the main field, but it does exist outside it. Hence the field from the gap extends along the tape for a very short distance; so even though the tape has passed it, it is still within a quickly diminishing field.

Now this has little or no effect on long wavelengths because most of the recorded half-cycle has passed well beyond the reach of the field before the next and opposite half cycle starts to build up. With very short wavelengths it is not so; the field from the gap at one half-cycle extends sufficiently to erase the preceding one, and as the tape proceeds away, the diminishing field zeroes out, until there is nothing left.

We end up with nothing on the tape except the audio signal. This effect accounts for another phenomenon. Self-erasure can also occur with high audio frequencies, although to a lesser extent than with the bias. At the high signal levels, the stray field is stronger and so erases further along the tape, affecting longer wavelengths than with low signals. Hence the high frequency response taken at 0 VU on the recording level meter is always poorer than when taken at a lower level.

Fig. 6 The difference between a superimposed signal (a) and a modulated one (b). With the superimposed signal, the amplitude of the high-frequency component remains unaffected, hence it is not modulated.

Fig. 7 Relationship between distortion and frequency response with a change of bias level. Optimum point for minimum distortion also produces a drop of 3 dB in the 10 kHz signal level (for one brand of C120; tapes vary in amount of distortion and HF loss).

Another associated effect is that too high a bias level curtails the audio high-frequency response. This is a rather unfortunate effect because there is an optimum bias level at which the distortion is at a minimum, and going either higher or lower will increase distortion. Unfortunately this optimum level for distortion is too high for maximum HF response, as self-erasure by the bias signal will have begun to make inroads into the higher audio frequencies.

So, bias can be set for either maximum HF response or minimum distortion, but the two settings do not coincide, see Fig. 7. Usually a compromise setting is chosen somewhere between the two. Each make of tape has its own bias requirements so a tape that performs well on one machine may not give its best on another which has a different bias setting. Understandably, makers tend to set the bias for best results on their own make of tapes, if they also manufacture tape. If desired, bias can be re-set using suitable test equipment, to optimise for a particular brand of tape.

Head Materials

Various head materials are currently being used by the manufacturers and are often specified in their brochures. What are the characteristics of these materials and which, if any, is the best?

The standard material used in the majority of ordinary cassette recorders and many hi-fi decks is Permalloy which is an alloy of about 78% nickel and iron with a small proportion of molybdenum. It accepts a high flux density without saturating which means that it will take high recording levels without distortion. It also has a high permeability, which gives a good flux at the tape.

Unfortunately, the permeability drops as frequency increases so that at 10 kHz it is between a fifth and a tenth of its value at 1 kHz. Hence, the head response falls with increasing frequency, with poor results at the upper end of the range. As self-erasure and other losses affect the high frequencies too, this characteristic is particularly unwelcome.

Another problem is caused by eddy currents. When an electrical conductor is situated in a changing
magnetic field, currents are induced in it. So the flux produced by the signal currents in the coil when recording, or by the tape during playback, produce currents within the core itself, because Permalloy is a good conductor. These eddy currents give rise to heat and therefore losses; furthermore, they increase as the frequency rises. So here is another factor that impairs the high-frequency response. In particular, such losses set a limit on the highest frequency that can be used for the bias. A high bias frequency reduces the possibility of intermodulation distortion, but this advantage cannot be realised with Permalloy heads.

To reduce eddy currents, Permalloy cores are assembled as a stack of laminates, similar to an iron-cored transformer. Unfortunately this brings another snag: it is almost impossible to assemble a stack of laminates so that the sides are perfectly in line; they may appear so to the naked eye, but through a microscope, they can be seen to be staggered to varying degrees. This matters little around the periphery of the core, but it does at the gap, where, owing to the small size of the gap itself, any staggering can increase the effective gap width (Fig. 8) which is especially detrimental in the case of the playback head where a narrow gap is essential.

A further drawback with Permalloy is its softness. It rates 130-140 on the Vickers hardness scale and wears rapidly compared to other materials, in the order of 120 microns per thousand hours, and 1,000-2,000 hours is about the average life before performance deterioration dictates a replacement. The non-magnetic shim which fills the head gap and thus prevents it becoming clogged with magnetic material shed from the tape, is chosen to have similar rate of wear as the core material. For Permalloy it usually is beryllium copper foil.

So as to avoid the various disadvantages of Permalloy, sintered-ferrite was developed as a head material. This is a combination of various oxides, mainly iron oxide, zinc oxide, manganese oxide, and nickel oxide, in fine grain form with a ceramic filler and binder.

At first glance the material seems inferior to Permalloy; it permits about half the maximum flux density, and has only around a tenth of its permeability. However, the permeability is less dependent on frequency, being three-quarters at 10 kHz of its 1 kHz value. It has a comparatively high electrical resistance which means minimal eddy currents, so the HF response is well maintained and the bias frequency can be high, reducing distortion levels. Absence of eddy currents means that the core can be solid instead of laminated, making it easier to make an accurate gap. Finally, a major advantage is the hardness, which at 400 on the Vickers scale, is three times harder than Permalloy.

There are, however, a number of disadvantages. As already noted, the permeability is much lower as is the maximum flux density. Also, the material is brittle and liable to chip. Tiny air bubbles can sometimes be found in it, which could result in cavities in the face when it is machined into shape. Residual magnetism tends to be higher, requiring a larger coercive force to overcome it which can result in a higher noise level.

These and other disadvantages have led to the search for a method of improving the characteristics of ferrite, and the development of HFPR (hot-pressed ferrite). As its name implies, this is produced by compressing ferrite at high temperature during manufacture, pressures of 7,000 lb per square inch at 1,400°C being typical.

The permeability of HFPR is not only better than ferrite but greater even than Permalloy, while the permeability consistency with frequency is as good as sintered-ferrite. Residual magnetism too is far better, being less than ferrite and Permalloy. Maximum flux density though is the same and Permalloy ferrite which is less than Permalloy.

As regards hardness, HFPR scores again being even harder than ferrite at 650-700 on the Vickers scale, making it five times harder than Permalloy. To give comparable hardness, the gap filler is usually made of hard glass. One manufacturer claims a wear factor of 0.4 micron per 1,000 hours which is very good indeed. HFPR heads are also used in video recorders, but they have a much shorter life there because of the high head-to-tape speed. A life of 1,000-2,000 hours is the normal expectation.

No bubbles can remain in HFPR heads so the possibility of unexpected cavities is eliminated. Unlike ordinary ferrite it can take a high polish and so ensure intimate tape/head contact with minimum drag.

It might seem that HFPR has nearly everything going for it but there is a major problem — metal tape. This needs a much higher flux density both to record and erase, and as we have seen ferrites are inferior to Permalloy in this one respect. So the search continues for the ideal tape-head material and various substances have been tried. One of these is Sendust, which has the sensitivity of Permalloy and the hardness of ferrite. The snag is low electrical resistance though, leading to eddy currents. This has been overcome by making it in ribbon form by blasting it through rollers when hot, then rapidly cooling.

Laminates are made from the ribbon, so we are back to laminated stacks and their problems of staggered gaps.

However, as the high permeability is most needed during recording on metal tape, and as recording-head gaps are wider than playback ones, gap accuracy is less of a problem. Laminated Sendust can be used for the record-head while a solid HFPR head can be used for playback.

![Fig. 8 Laminated stack with imperfect alignment. Effective gap width is increased. With widths of little more than one micron, small irregularities matter.](image)

### Table 1 Head materials and characteristics.

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Permalloy</th>
<th>Ferrite</th>
<th>HFPR</th>
</tr>
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<tbody>
<tr>
<td>Ni</td>
<td>Fe</td>
<td>Fe3O4</td>
<td>Fe3O4</td>
</tr>
<tr>
<td>Mo</td>
<td>MnO</td>
<td>ZrO2</td>
<td>NiO</td>
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<tr>
<td>Permeability: 1 kHz</td>
<td>18000 1200 20000</td>
<td>1500 900 10000</td>
<td>7000 4000 4000</td>
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<tr>
<td>10 kHz</td>
<td>1500 900 10000</td>
<td>7000 4000 4000</td>
<td>7000 4000 4000</td>
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<tr>
<td>Max Flux Density (gauss)</td>
<td>7000 4000 4000</td>
<td>7000 4000 4000</td>
<td>7000 4000 4000</td>
</tr>
<tr>
<td>Coercive Force (oersteds)</td>
<td>0.02 0.3 0.015</td>
<td>0.02 0.3 0.015</td>
<td>0.02 0.3 0.015</td>
</tr>
<tr>
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<td>5*105 &gt;100 &gt;100</td>
<td>5*105 &gt;100 &gt;100</td>
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<td>Vickers Hardness</td>
<td>135 400 700</td>
<td>135 400 700</td>
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</table>

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Azimuth

Correct positioning of the head or heads is essential. Firstly, the height must be such that the tape is in a perfectly straight line across the head assembly. If one head is out of line, the tape-guide on the side of the head will pull the tape up or down at that point, resulting in damage to the tape edge or a weaving motion producing erratic variations of signal level and HF response.

Next, the head must be vertical from front-to-back. A backward lean, for example, results in imperfect contact between the top half of the tape and the head, increasing the likelihood of drop-outs.

Finally, the azimuth or side-to-side angle must also be vertical. Theoretically, the azimuth doesn’t matter as long as the playback setting is the same as the recording. This is obviously the case with single-head machines when tapes recorded on the same machine are played back. However, problems occur when tapes recorded on other machines are played back on the faulty machine (or tapes recorded on the faulty machine are played on others) and also with pre-recorded tapes.

The reason is that a slanted record head produces corresponding slanted magnetic zones on the tape. A vertical playback azimuth will bridge across the narrow slanted zones, as a slanted head will bridge across vertical zones (see Fig. 9a). In both cases, the effect is that of increasing the head gap width. As it is only the narrow zones that are so affected, the result is a loss of short-wavelength high frequencies, the loss increasing with increasing azimuth angle.

This effect is quite well known, but there is another which is less commonly appreciated. When a stereo head is incorrectly set the two playback gaps are not exactly one above the other. The top one will be slightly in advance or behind the bottom as the tape runs past, hence one channel is delayed.

The delay is too small to be noticeable as such, but it will result in pitch differences in the high and higher mid frequencies, which will lead to poor stereo image. Also, switching to ‘mono’ and combining the two stereo channels into one can lead to a severely curtailed high-frequency response — this can happen even when the stereo doesn’t sound too bad! So, if recorder gives poor stereo image from pre-recorded tapes but a good image with tapes recorded on it, then the likely cause is the playback head azimuth setting.

![Fig. 9 When azimuth is not vertical, gap bridges across short wavelength zones, increasing its effective width and thus losing the high frequencies.](image)

To conclude, although the heads in your recorder are quite simple devices, there is rather more involved than you may think. We will undoubtedly see further developments as times goes on.

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260 ball full duplex
Full remote control
Standard 250 service interface
All standard 250 service interface
Standard test switching
Spare full data wire
Modular construction
Not the wires to comms line
Order now, while stocks last, Carnage and Lines £10.00.

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260 ball full duplex
Full remote control
Standard 250 service interface
All standard 250 service interface
Standard test switching
Spare full data wire
Modular construction
Not the wires to comms line
Order now, while stocks last, Carnage and Lines £10.00.

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ELECTRONIC COMPONENTS Equipment

ELECTRONIC COMPONENTS Equipment

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ELECTRONIC COMPON...
SPECTRUM CENTRONICS INTERFACE

It may seem boring to keep publishing Centronics Interfaces (although we assume that the users of the relevant computers will be quite interested); however, they all use different methods — this one uses a PIO. Design by Mark Purcell.

One of the main reasons for buying a printer is to complete a word-processing system so that decent hard copies of files or letters may be made. Printers are available with two types of interface: RS232 (serial) and Centronics (parallel), each of which have their advantages and disadvantages. For the hobbyist, it doesn’t really matter which interface is used as long as the price is low. RS232 printers tend to be anything from £20 to £40 more expensive, and less available, than their Centronics equivalents, because of the added circuitry needed for serial communication, and it would therefore seem logical to go for a Centronics printer when on a low budget.

One of the most popular word processing packages available for the Spectrum is the excellent Tasword Two from Tasman Software. This package has Centronics printer-driving software written-in. The rest of this article describes the design and construction of a simple, cheap, Tasword Two compatible Centronics interface for the 48K Spectrum.

Using this interface with your own home-spun software should not be difficult, although the exact details will be left up to you. The data to the Centronics printer is straight ASCII, although sometimes with the top one, two, or even three bits lopped off (particularly with daisy-wheel printers that are not capable of graphics). As the Spectrum uses ASCII to represent characters, this makes life very easy. Also the hand-shaking with Centronics interface is very simple: the STROBE line is taken low when data to be printed...

Table 1 Selecting an operating mode; only Port A may be used for mode 2 operation.

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
<th>M1</th>
<th>M0</th>
<th>MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0 (OUTPUT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
<td>1 (INPUT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2 (BIDIRECTIONAL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>3 (CONTROL)</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unused Bit</td>
</tr>
</tbody>
</table>

**HOW IT WORKS**

Most of the work of the interface is done by the PIO, so, without going into the intricacies of the workings of the PIO itself, and how it ties into the Z80 CPU, there is not a great deal we can say! There are plenty of books around on the Z80, and one we would suggest if only on the grounds of price is called ‘A Z-80 Workshop Manual’ by E A Parr, published by Bernard Babani (publishing) Ltd, at £2.75 (ISBN 0 85934 087 2).

Fig. 1a (above) Main circuit diagram; b (below) clock reshaping circuit.
is stable, and the printer takes the BUSY line high when it has read the data.

**Design Details**

The final design is based on the Z80A parallel input/output chip. Only two other chips, ICI and 2, are used in the interface, making it cheap and easy to construct.

The PIO has two data ports, A and B, and two control registers (one for each port). Each port can be set to either input or output (or a combination of I/O) by programming its control register (see Table 1). It was decided to make port A input, so that the BUSY signal from the printer could be monitored (bit PA0), and port B output so data could be sent to the printer. The PIO generates its own data valid, or STROBE, signal.

**Address Decoding**

Table 2 gives the port addresses used by Tasword Two, and if you are designing your own software, you will have to use these addresses in your software. It can be seen that there are three outputs and one input. Since we are using a Z80A PIO, the STROBE signal is automatically generated so the data output to port 59 can be ignored. Similarly, the control words for a Z80A PIO will be different from any other interface so the data output to port 127 should also be ignored.

The DATA should obviously be directed to port B on the PIO and the BUSY input from port A. The only bits of the address that vary between port addresses are A2 and A6; hence by directing all unwanted output data to port A (which is configured in input mode) the data will be ignored. This is achieved with IC2b and IC2c. We also wish to be able to program the PIO initially, so A7 is used as a control/data select. Note that A2 is used by Tasword Two so the ZX printer should be disconnected when using the interface.

Figure 1(a) gives the full circuit diagram of the interface. With Interface 1 connected, the clock output from the Spectrum is inadequate to drive the PIO directly and requires some reshaping. Figure 1(b) gives a simple waveform-shaping circuit that can be used with Interface 1.

**Construction**

A PCB has been designed to accommodate the interface, and this is shown in Fig. 2. This has been designed so as to be fairly small, so some care will be

---

**Fig. 2 PCB overlay and Spectrum edge connector details for masochists who want to design their own circuit. We haven't given full details of the printer connector, as these seem to vary; however, we hope that just about any socket will fit the board.**

---

**Required when soldering! Another point to watch is that many of the links pass beneath IC1, and whether you use a socket or not, you will have to remember to insert these links before anything is soldered in the IC1 position. Components R1, 2, and Q2 may be used, or the link used instead, as required.**

**Using the Interface**

Before the interface can be used it is necessary to program the port control registers of the PIO. Port A's control register is selected when all eight address lines are high — this corresponds to port 255. From Table 1 the 'input' mode word is 4Fh or 79 decimal, hence OUT 255,79 will put port A into input mode. Similarly port B's control register is selected when all address lines except A2 are high, or port 251. From Table 1 the 'output' mode word is 0Fh or 15 decimal, hence OUT 251,15 will put port B into output mode.

The easiest way to make sure that the ports are initialised before attempting to dump a file is to incorporate the control register programming into the Tasword Two BASIC; that way it will auto-

---

<table>
<thead>
<tr>
<th>PARTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEMICONDUCTORS</td>
</tr>
<tr>
<td>ICl 74LS12</td>
</tr>
<tr>
<td>ICl 74LS74</td>
</tr>
<tr>
<td>ICl 74LS10</td>
</tr>
<tr>
<td>MISCHELLEOUS</td>
</tr>
<tr>
<td>PCB: Spectrum edge connector; connectors for Centronics printer.</td>
</tr>
<tr>
<td>ADDITIONAL PARTS FOR USE WITH INTERFACE 1</td>
</tr>
<tr>
<td>R1 2k2 1/4W 5%</td>
</tr>
<tr>
<td>Q1 470R 1/4W 5%</td>
</tr>
<tr>
<td>IC1 8BC108C or BC182</td>
</tr>
</tbody>
</table>

---

**run on loading and perform the necessary initialisation: first load Tasword Two and enter BASIC by pressing STOP, b and ENTER, EDIT line 10 and add OUT 255,79; OUT 251,15: to the beginning of the line, then RUN, STOP, t and ENTER to save the modified program. Any text file can now be printed out by loading the file into Tasword (if it is not already there) and using the 'print text file' option in the menu.**

**BUYLINES**

There shouldn't be much to cause you any problems here; the PCB is available through our PCB service, and everything else is fairly easy to get hold of.

---

<table>
<thead>
<tr>
<th>Table 2 Ports used by Tasword Two software.</th>
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<tbody>
<tr>
<td><strong>STROBE</strong></td>
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<tr>
<td>A7</td>
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<td>A6</td>
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<td>A5</td>
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<td>A4</td>
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<td>A3</td>
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<td>A2</td>
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<tr>
<td>A1</td>
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<tr>
<td>A0</td>
</tr>
<tr>
<td>PORT NO</td>
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<tr>
<td><strong>DATA</strong></td>
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<tr>
<td>11</td>
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<tr>
<td>10</td>
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<td>9</td>
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<td>2</td>
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<tr>
<td>1</td>
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<tr>
<td><strong>CONTROL</strong></td>
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<tr>
<td>11</td>
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<td>10</td>
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<td>1</td>
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<tr>
<td><strong>PORT NO</strong></td>
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</table>
NEW PACKS:
K324 OPTO PACK - a variety of single point and seven segment LEDs (incl. dual types for contrasts of various colors and sizes), opto-\-lators, numitrons, multig digital gas display changes, photo transistors, infra red emitting diodes, etc. (VAT added)

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ESTABLISHED FAVOURITES
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K314 100 SILVER MICA CAPS - from 5pF to 10uf in 4 steps £1.50
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W 4700 PUSH BUTTON BANKS - an assortment of latching and independent switches on banks from 2 to 7 way, DPGA or DPCO. A total of at least 4 switches for £2.85; 100 £38.50. 250 £77.00

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177 114mm PCB with one massive Vara Decal 5.7 x 50mm rated 2V 1000MAH and another smaller Decal 3.5 x 30mm rated 6.5V 400MA. The price of these Ni-cad stacks is now over £25. Also on the panel is a mains input charger transformer with two separate secondaries wired via bridge rectifiers, smoothing capacitors and a relay to the output tags. The panel weighs 14kg. All this for just £6.75.

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These units are in use in a computerized tank, and offer the experimenter in robotics the opportunity to buy the electro-mechanical parts required in building remote controlled vehicles. The unit has 2 x 3 motors, linked to a magnetic clutch, enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive gear to approx 50rpm. Data supplied with the unit showing various options and driving the motors etc. £29.95. Suitable wheels also available 7.9mm. Diagonal with blue wire, drifted to push-fit on spindle. 2 for £1.30 (limited qty). 3.5 dia aluminium discs 3mm thick, drifted to push-fit on spindle. 2 for £8.95

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2030 Panel 247 x 39mm with 5 x 2 TDA 1004 6W audio amp I.C's, not soldered in so they can be changed to suit requirements. Also 1 10 x 2, 470pF choke, ceramic discs, Rs, also chokes. (All easily removed). Stereo Amp? Only £3.00 (IC's cost £4.50).
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DIGITAL FRAMESTORE

This project definitely rates the tag ‘experimental’; and with the necessary ADC at around £100, and 48 64K DRAMs included, it isn’t going to be cheap either! However, we think that our readers will be interested in the techniques involved. Design by Daniel Ogilvie.

A framestore is a device that can capture an entire image from a TV screen and freeze it electronically. The captured image can then be manipulated or combined with or compared to others.

Using a framestore, one TV camera could be used to fade between two images; one would be captured on the framestore, then the TV camera pointed at the second. A video mixer would be used to fade from one image to the other. More complex effects could be achieved by using the same image for both, with minor changes or manipulations between the two images.

Storage of the image can be synchronised with one-off events; for example, it could be synchronised with a flash gun going off; the flash is synchronised to occur during the field blanking (fly-back) time and the resultant image is read into the store on the next frame scan.

A technique known as target integration can be used; here the electron beam in the camera is shut off and a feint image is built up over a period of time on the target, then the beam is turned back on again to read it into the framestore. This is similar to long exposure photography — and uses of this include astronomy.

In the design described here, the image is stored in digital form, which makes it possible to analyse or manipulate the picture using a home computer; this will be discussed at length in a future article.

Camera tubes are available which can see in the infrared or the ultra violet, which enables us to extend our view of the world beyond conventional visible optics. For example, finger prints can be viewed under UV light, stored in the framestore, enhanced by computer and then compared with a library of finger prints for a match. Also, inks can be made to be luminous in the infrared making it possible to check for cheques or passport forgeries.

Some Television Fundamentals

Most readers will be familiar with the conventional television system used in this country which is faster scanned. The information on the brightness of the camera lens’s field of view is encoded in a serial form and superimposed on synchronizing pulses which enable it to be easily recovered. Looking at your television screen, the trace starts at the top left hand corner and moves across horizontally until it reaches top right where it resets back to the left, a little bit down, and scans across again.

The time taken for the horizontal line scan is 64us and this is known as the line period. The line scan is performed 312½ times, until the trace reaches the bottom of the screen when it returns to the middle top of the screen. The trace performs a further 312½ line scans, filling in the gaps between the first 312½ line scans, see Fig. 1.

Each set of 312½ line scans is called a field and requires 312½x
Q1 forms a 25.625 MHz oscillator; this is rather more complicated than usual because the crystal has to work in the third overtone mode and so the signal has to be filtered to ensure that oscillation occurs at the correct frequency. The signal is buffered by Q2 and amplified to TTL levels by Q3. (For 1024 pixels to be stored, the crystal has to be 41.8 MHz.) The 25.625 MHz clock is divided by two by IC1, to generate (CLK) and (CLK) (brackets here denoting that these are unbuffered and prompt); IC2a and b buffer and invert these to generate CLK and CLK, both at 12.8125 MHz (nominal 13 MHz). The 25.625 MHz clock is also fed to the clock input of the octal flip-flop, IC3; either five or eight latches may be strung in series, and, with the inverter, this produces a division of either ten (640 pixels) or sixteen (for 1024 pixels and 41.0 MHz clock). The divided-down clock frequency is fed to IC5, (a special-purpose device) which generates the MIXED BLANK, MIXED SYNC, LINE and FIELD outputs; the latter two are inverted and buffered by Q6/7 and Q4/5 respectively, to give 75 ohm FIELD and LINE signals for the video camera. IC5 also generates the even field, EF, signal. The (CLK) line is used to drive a divide-by-eight counter, IC6, and the bottom three binary outputs from this are used to select which one of decoder IC7's outputs is to be pulled low. IC6 is synchronously reset by
LINE to ensure that it starts in the same position every time. The Y0 output is used as the timing reference, T0, for the first of the eight memory access cycles, while Y6 provides the transfer pulse, TF, for the memory buffer section.

The binary outputs of IC6 are also used to drive four data selectors, IC11-14, which generate the WR, LD, RAS and CAS memory control lines.

The switch inputs are de-bounced by IC8a and b and IC4b and C, and gated with the load inputs of IC9a. Latches IC10a and IC10b prevent the load signal reaching IC11 until EF and T0 have both gone high; as IC11 generates the W line, this means that a write cannot commence in the middle of a frame.

The LINE pulse resets counter IC15 which then proceeds to count six T0 pulses, to generate the left-hand margin (78ns x 8 x 6 = 3.74 us), which then allows the sixteen-bit counter, IC24-27, to count the T0 pulses via IC1b. Every sixteen T0 pulses, all the outputs from IC24 will go high; this is gated by IC9b. When this has occurred five times (when 640 is selected) or eight times (when 1024 is selected) the count will be stopped, because the right-hand margin has been reached. The number of pixels stored per line is therefore 8 x 16 x 5 = 640 (or 8 x 16 x 8 = 1024 for 1024 selected).

The top and bottom margins are generated by IC5 20 and 21, which count the LINE pulses; when 32 line pulses have occurred, the flip-flop IC17b is cleared via IC18c; this takes its Q output high, allowing IC18a output to go low, so that T0 pulses can pass through IC16b and be counted; so the address counters can only increment while IC17b remains cleared. Decoders IC 26 and 27 monitor the top four address lines to provide a line counter. When the counters reach 4x4906x8/640 counts = 256 lines the Y4 output of IC26 clocks IC17b via IC1d which sets this latch and halts the count until the 32 lines of the second field have elapsed when IC27 performs similarly (9x6096x8/512 counts = 512 lines). The counters are reset by the EF (even field) pulse which indicates the start of the new frame.
64us = 20ms to be completed. The two fields are related in that the information in the second field augments the information in the first. The two fields together are called a frame and this requires 2x20ms = 40ms to be completed. The two fields are said to be interleaved. The reason for this interface is to provide a fast enough screen refresh rate without just resorting to sending the information faster which would result in the need for a higher bandwidth.

The Video Waveforms

As I have already mentioned, the information broadcast is superimposed on synchronizing pulses, which indicate where the top and left of the screen are. A typical video waveform is shown in Fig. 2, which shows line synchronizing pulses. Each pulse initiates a flyback of the trace across the screen from right to left ready for the next line of information. The field pulses caused the trace to reset to the top left of the screen and initiated the slower vertical scan downwards which ensures each line appears below the previous one.

The video waveform superimposed on the sync pulse represents the brightness of the scene. The higher the voltage at any particular point in the waveform, the whiter the corresponding point on the screen. The set-up voltage is defined as black and is about 45mv above the 'back porch' of the line wave-form (see Fig. 2). The sync pulses are, therefore, notionally darker than black and this ensures that the flyback is not visible on the screen. We derive a pulse during the period of the back porch to clamp the incoming video to black to ensure we obtain a stable grey scale to our stored picture.

There are a number of other features regarding the video waveform that will concern us, but we will deal with these as we need to.

We are concerned with the storage of one frame of this information. The method we shall use is to convert the TV screen into little packets of information and store them into a digital memory as values representing the brightness of the scene.

Memory Needs

With 625 lines to store, if we stored only one byte representing the average brightness across each line, we would require 625 bytes of memory. Obviously this is not very representative of the scene we may be looking at.

Well, let's store 625 values across the line and see what that requires, assuming that each value stored will be in the form of an eight-bit byte. We now need enough memory to store 625 lines of 625 elements. The elements are called pixels; this requires 625^2 bytes, i.e. 390,625 bytes: rather a lot!

There is an additional consideration. The line duration is 64us, and we want to break this up into 625 pixels which means we have only 64us/625 = 120ns to convert the video into a digital word and store it.

Looking at the sync waveforms again we can see that there is a left and right, top and bottom margin to the screen. Storing the video waveform from these parts of the screen is a waste because there is very little useful information there. It is at the extremes of linearity of the camera scans, the lense and the television screen. We would lose little by storing only the 512 central lines.

Similarly the line scans contain little of use at the edges, so we need only store the central section of the lines. The screen is wider than it is deep (it has a 4:3 aspect ratio), so to maintain a similar horizontal resolution to the vertical resolution, we will need to store more than the 512, say around the 625 pixels first envisaged. Actually, the generation of the clock signals is eased considerably by prudent choice of numbers (you'll have probably already noticed the 512 lines), and in practice it was found that 640 pixels stored across a nominal total line length of 820 pixels (much of the residue being taken up with sync and fly-back) worked out reasonably neatly. Putting these numbers together, we arrive at a memory store requirement of 640 x 512 = 327,680 bytes.

The memory requirement has been reduced to some extent, but we have increased the speed requirement of the A-to-D converter and of the memory. This is unfortunate because speed is costly, in both these areas. It also makes the design of the timing and control logic more critical. The conversion and storage of each pixel will have to take place in 64us/820 = 78 ns.

It's Been Framed!

A block diagram of the whole system is shown in Fig. 3. The crystal clock generates the pixel clock rate — which is our highest frequency. We require 820 pixels across a line which gives us a crystal frequency of 1/64us x 820 or 12.81225MHz. We generate twice this, (25.625MHz) to ensure an even square wave master clock waveform. This is sent through the lower address counters which divide the 12.8125MHz by 820 and generate a binary address for the memory. The output from this counter will be at line frequency; the left and right margins are also generated by these counters.

The line frequency is fed to the upper address counters which divide the line frequency by 625 to provide the upper address lines to the memory, and also generate the top and bottom margins. At the
end of a frame the address counters are reset by the sync pulse generator and the process continues again.

Most of the time, we will be using the framestore to read out of memory; while this is happening, data is being sent from the memory to the DAC for conversion back to analogue and, after mixing with synchronising pulses, display on the monitor.

To store video, from, for example, a video camera, the write line on the memory is held down for the duration of one frame, while the input signal is converted by the ADC. As already mentioned, the ADC will be converting at a rate of 12.8125MHz.

To be completed next month.

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Standing Physics On Its Head

Dear Sir,

It is a well-known mathematical paradox that a perfect low-pass filter must begin to react to a pulse on its input before that pulse is applied. However, this piece of mathematics has eluded physical realisation — until now. Look at the oscillogram you display in your review of the Bridge scalers in the September ETI. The bottom trace clearly shows the SB121 overshoot here before every edge of the square wave input.

There would be many applications for a circuit which detects pulses before they happen. Clicks could be removed from audio recordings without using a delay-line buffer. Delicate equipment could be protected from mains surges. Digital circuit designers need no longer worry about clock skew — just insert a few endo-chronous filters into the longer signal paths. But the most obvious use is in oscilloscopes themselves: a predictive trigger to capture those intermittent events which conventional trigger circuits cannot handle. The absence of such a documented feature from the scopes under review suggests that it is an accidental phenomenon which has gone unnoticed by the manufacturers. Perhaps one of their component suppliers is making his capacitors out of resublimed thiotimolines?

Yours faithfully,
Richard Kennaway
Norwich

Fascinating as the possibilities outlined by Mr. Kennaway are, we have succeeded in tracking down the source of this phenomenon and found the problem to be a surprisingly simple one — our photographer was holding his camera upside down!

The One That Got Away

Dear Sirs,

I refer to your article in ETI of June 1984 in the Digest section, concerning a new battery developed by Matsushita and marketed by Panasonic UK Limited. This is the BR211 Lithium battery.

As an angler, not an electronics follower, this item interested me very much from the point of view of illuminating fish-rod tips, with which I have been experimenting for several years now. Also, as press officer of the Bournemouth based BAC Angling Club, my experiments are of interest to a good number of local anglers.

With this in mind, I wrote to Panasonic UK Ltd enclosing details, drawings and observations, regarding my struggles with batteries and LEDs etc., and enquiring whether I may track down a supplier of their advertised battery. This letter was sent at the end of May this year.

Since we are now well into August, I feel it is fair to assume that I am not likely to receive a reply or even acknowledgement from Panasonic UK Ltd. I wonder if you could help. I am no longer concerned whether they are interested in my dabblings or not, but I would like to know where to buy 'The World’s Smallest Battery' as it was described. Perhaps it is so small that nobody can find it?

Yours faithfully,
Martin Hursthouse
Bournemouth

We telephoned Panasonic UK but no-one there seemed to know much about the BR211. They passed us on to Panasonic Industrial, who told us that the information we published must have come directly from the Japanese arm of the company. There are plans to distribute the BR211 in this country but no agents have yet been appointed and it is unlikely to be available before the beginning of next year at the earliest. In addition, because they are concerned only with industrial electronics, Panasonic Industrial were unable to assure us that the agents appointed would include a company prepared to sell directly to the public in small quantities. We can only suggest that you drum up as much support in the angling world (and elsewhere) as you can and keep lobbying Panasonic — if it becomes clear to them that there really is a demand for the BR211 in the domestic market they may feel encouraged to appoint a suitable distributor as quickly as possible.

Beating The Common Code

Dear Sir,

I have recently purchased and installed a home security system that you reviewed in the July 1984 issue of ETI. The article was entitled 'Housewatch 2000 Burglar Alarm' (page 50) and featured the Coloroll Ltd / Munford & White Control Panel.

I have therefore been in a position to practice button pushing on the control panel and have found a serious fault in the ULA that comprises the system security. It is possible, with the panel in the Day condition where it can be operated by any person or villain, to find out the 4 digit control code within 2 minutes and without tampering with the unit in any way. The average time to crack the code is only 1 minute.

I have written the method on a separate sheet which is in a form that I present to visitors to play at code-cracking when they visit the house.

Yours sincerely,
M. Brandligt
Oxford

Whilst we agree that it is quite easy to find the code of the alarm when it is in the 'day' state, this doesn't actually affect the security of the alarm. Let's look at the arithmetic.

With the alarm in the 'day' state, there are nine possible first digits in the code and eight possible second digits making a total of $9 \times 8 = 72$ combinations, only one of which will put the alarm into its test state.

To get the alarm out of the test state there are seven possible first digits (the third digit of the full code) and six possible second digits, making a total of $7 \times 6 = 42$ possible combinations.

It is relatively easy to find this code provided:

1) you know how the alarm operates in the first place — a clever, professional thief will have done his or her homework, but aren't the majority of domestic break-ins the work of opportunistic amateurs?

2) you are allowed to play with the alarm in the 'day' state.

It is on this second point that your argument falls down. If the alarm is armed, the thief will have to find the full four-digit code in one go. There are $9 \times 8 \times 7 \times 6 = 3024$ possible combinations, far more than a thief could hope to try in the twenty-five seconds allowed after arriving through the entry-zone, and if a thief gets in by some other route the alarm will go off immediately anyway. We think your home is secure — unless any of your
invited visitors return later, uninvited!

Of course, if you do suffer a break-in at a time when the alarm is un-armed, it would be sensible to change the code as well as changing all the locks. However, changing the code is very straightforward.

Disc-usted

Dear Sir,

I have been reading the articles on audio amplifiers for many years and good as his latest design is I don’t think I will be making it. He seems not to have heard of the Compact Disc.

Yours Truly,
B.A. Thacker
Crew

Although this was not brought out in the series of articles, the design was produced with Compact Disc very much in mind. This is one of the reasons why the volume and balance controls have been placed in the power amplifier rather than the pre-amplifier and why that unit has been provided with an unusually sensitive and high-impedance input. Signals from Compact Disc units can thus be fed directly into the power amplifier without having to pass through unnecessary connectors, switching, and signal handling stages in the pre-amplifier. This being so, the Audio Design amp-amp is probably better suited for use with Compact Disc players than almost any other amplifier around.

Tip Of The Iceberg

Dear Sir,

I hope you have a few minutes to spare, because I am about to relate the Saga of the Missing Tech-Tip.

Once upon a time (14/1/84) an intrepid ETI reader (me) sent what he thought was a rather elegant piece of software to the Mighty ETI Tech-Tips Feature. His idea was a program to read resistor colour codes using the Casio fx-180P calculator. The reader waited, with bated breath (he had run out of Polo mints) for a reply from ETI. He waited for three months, and then wrote to ETI again, along the lines of “Oi, mush, wot’s happened to me software?” or words to that effect.

Still no reply having plopped on his doormat (it wasn’t house-trained) by the middle of June ’84, he was prompted to write again. Which is why he is now writing to Heap Big Boss Man of ETI.

I think it’s safe to assume that my design has gone astray. Encountered a time warp or been half-inched by the Vogons (remember them)? If you could write and reassure me that two-way communication via letter is still possible, I would be much obliged. I would also be pleased to re-submit the design, assuming that it doesn’t turn up in the ETI offices.

I look forward to hearing from you (please).

Yours Faithfully,
Ronald Hutchison
(State Registered ETI Reader)
West Kilbride

Sadly, Mr. Hutchison is not the only reader to have experienced this upsetting phenomenon of Tech Tips apparently vanishing into the fourth dimension (otherwise known as the ETI filing system).

We hope that he and the others affected will accept our apologies and the following explanation.

The problems with the Tech Tips feature arose partly because of its success. We have had so many sent to us that we now have two bulging files full and contributions are still arriving at the rate of a dozen or so a month. This flood of items has coincided with a period during which we have frequently not had enough space to put all the things we wanted to in the magazine, and Tech Tips has often been left out to make room for other articles. Not having the staff to cope with the filing necessary to keep such a large number of contributions in order, the whole system has become rather disorganised and letters querying the whereabouts of particular Tech Tips have all too often vanished themselves!

Rather belatedly we have got around to doing something about this. The Tech Tips special in this issue marks our first assault on the ever-growing file and we intend to include the feature on a far more regular basis from now on.

Mr. Hutchison may also like to note that his program is amongst the items featured.

We will also be looking closely at the conditions under which Tech Tips are accepted to see if they can be tightened-up slightly. It would obviously be better to reject a few more items in the first place than to have them on-file for months, being considered and then rejected.

In the meantime, why not consider if your Tech Tip could actually be a project. We do quite often ask readers to re-vamp their ideas because they are substantial enough to be full-blown projects, and we and our sister magazines, Electronics Monthly and Digital and Micro Electronics, are always looking for good projects.
The MC6804 P2
Remember our article on Motorola's MC68020, the world's first true 32-bit micro (depending on what definition of a 'true' 32-bit micro you adopt)? Well, Motorola have been busy at the other end of the scale, with a four-bit micro too. A sequel to the story of its bigger brother, we'll be taking a little look at the world of the Micro-microprocessor — and its one device that could well find itself used quite heavily by hobbyists in the none-too-distant future.

Active Bass Speaker
Just in case you might have got the impression that all the next issue will be features, here's a project for you. Mind you, your neighbours may well sink to bribing your newspaper deliverer to hang onto your copy of ETI, because this sub-resonant speaker should certainly rattle a few walls and floor-boards!

Readers' Survey
The time to seek your opinions has rolled around once again, with the added bonus of the possibility of winning a year's subscription.

Distortion Meter
Well, this item got squeezed out of this issue, for which we apologise, there just wasn't room to get in everything we wanted to get in. However, we promise, cross our pulse generators and hope to die, that it will be in the next issue.

IS ELECTRONICS RELIABLE?
There are a number of question marks over the performance and reliability of electronics, not a few of which have turned up in ETI projects! The space shuttle fails to get off the ground. An IC will not work within its specifications, and duplicates also fail to work. The Nimrod 'eye in the sky' radar system won't work as it was designed to do and is sent nearly all the way back to the drawing board. A leading semiconductor company admits that many of its ICs have not been properly tested, and initiates a hastily assembled crash testing programme. Anyone who reads the electronics trade press will have seen these stories; next month's ETI will attempt to get them in perspective.

ALL THIS AND MORE IN THE NEXT ISSUE OF ETI. RESERVE YOUR COPY OF THE JANUARY ISSUE NOW!

All the articles listed above are at a late stage of decay in the Editor's in tray. However, the availability of space and other factors beyond our control (like the Assistant Editor being strangled by an innocent passer-by after one of his appalling puns) may limit our ability to bring them to you.
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VARIO UPDATE

Lindsay Ruddock's vertical speed indicator project in our April and May issues aroused considerable interest. Here the author replies to some of the suggestions made by readers regarding the design.

One modification which has been suggested is the addition of "total energy" compensation (see Read/Write, August '84 ETI, page 62). It is the author's intention to develop such a system at some stage, but it would require such extensive modifications that it might be better to think in terms of designing a new vario from scratch. There seems to be little demand for total energy compensation from hang glider pilots, probably because of the extra complication introduced by the need to plumb in a source of pitot pressure and because hang glider pilots are more aware of their airspeed than are sailplane pilots. There is, in any case, at least one variometer on the market with total energy compensation, and interested readers might like to contact the manufacturers at the address given at the end of this article.

That having been said, there may still be a few readers who really are interested in total energy compensation and who are prepared to do a little experimenting in order to achieve it. The following notes may be of some help to them.

The ETI design senses only static pressure, which it feeds directly to the differentiator. To provide total energy compensation, the input to the differentiator should be modified to:

\[ P - \frac{1}{2} pv^2 \]

where \( P = \) static pressure
\( \rho = \) air density
\( v = \) velocity of glider

The quantities "\( p \)" and "\( v \)" are not directly available so more manipulation is necessary:

\[ p - \frac{1}{2} = 2p - \frac{1}{2} pv^2 \]

\[ = 2p - (p + \frac{1}{2}pv^2) \]

\[ = 2x(\text{STATIC PRESSURE}) - \text{PITOT PRESSURE} \]

This expression is realizable, since the quantity \((p + \frac{1}{2}pv^2)\) is, in fact, the pitot pressure which can be sensed by a second pressure transducer plumbed into a pitot source.

Pitot pressure is the extra pressure that arises in a tube when the mouth of the tube faces into a stream of air. It appears in books on aerodynamics and fluid flow, and is well-known to amateur flyers and aerodynamicists - but not to ETI's assistant editor, who carefully amended 'pitot' to 'pilot', all the way through the original script, then wondered why the author had so consistently made the same rather curious typing error - t and l being well-removed from each other on a conventional QWERTY keyboard. We're ashamed to add that the editor, despite his background in physics, had little more idea as to what pitot pressure was!

What is required, therefore, is to modify the input to the differentiator by subtracting the right amount of pitot pressure in accordance with expression (3). One possibility is to place a summing amplifier between the static pressure transducer buffer and the differentiator, as shown in Fig. 1.

It should be emphasised that this is only a suggestion aimed at those willing and able to develop their own circuitry. The author has not tried the system and cannot offer any further practical information. Readers who are particularly interested in total energy compensation should obtain a copy of the September 1975 issue of "Soaring" magazine in which the subject is fairly well-covered.

Temperature Compensation

In an effort to present as straightforward a circuit as possible in the ETI vario design, temperature compensation of the transducer was kept simple.

Better temperature compensation of the Sensym LX0503A can be easily achieved by 'tuning' the regulated voltage to the device. Since the vario circuit is not sensitive to supply voltage, it is convenient to make the regulated voltage to the complete circuit adjustable. This is implemented by replacing the 7B05 regulator chip with an adjustable op-amp regulator based on the LM10.

The original PCB was designed so as to leave space for a satellite board carrying the LM10 regulator circuit just above the transducer and to the left of the existing 7B05A regulator. There is also some space available on the underside of the transducer PCB and this can be used if there is insufficient space above, as might be the case if one of the larger transducer types has been used.

A suitable vero board layout for the new regulator circuit is shown.

Fig. 1 Suggested modification to the original vario circuit to give total energy compensation.

ETI DECEMBER 1984
The circuitry. Note that the previously optional 100μF decoupling capacitor, C4, should now be fitted.

The resistor R, sets the regulated voltage. eg R, = 1k, V = 5V, R, = 13k, V = 6.25V

\[ V = 4.9 \times \frac{R_1 + 47k}{47k} \]

A good starting voltage is 5.5V, R, = 5.6k.

R, is adjusted downwards if the vario reads sink as it cools (use the fridge to find out) and vice versa. A large percentage of LX0503A devices end up with satisfactory temperature compensation with supply voltages of between 5 and 5.5 volts, which explains why the LX0503A is shown wired across 5V in the original design.

Further benefits of using the LM10 are that battery life is tripled to a hundred hours from an alkaline battery and ordinary zinc carbon types may also now be used, giving about 50 hours. This is because not only is battery drain halved (the 78105A draws 3mA standing current), but the battery endpoint voltage is lowered — the LM10 regulator requires only 0.2 volts input to output differential compared to 2.5V for the 78150A. Other adjustable regulators can be used, but have not been checked out.

Note that while tuning the supply voltage is recommended as a method of temperature compensation for the LX0503A, the alternative transducer, the MPX100A, can only be compensated by the single series resistor/constant supply excitation voltage method as outlined in the original article.

Some people have acquired Foxboro transducers. For these, and Druck-Keller types, constant current excitation is best. The precise current affects sensitivity but for compensation purposes the absolute value does not matter. A suitable circuit is shown in Fig. 4.

All the compensation methods mentioned compensate explicitly only for span. Since the operating pressure range is not too great, it is not worth considering offset errors separately.

A word of explanation for all these compensation methods is probably in order. The major temperature dependent parameters of a piezoresistive pressure transducer are:

1. temperature coefficient of bridge resistance (approx. +2000ppm/C).
2. temperature coefficient of gauge factor or pressure sensitivity (approx. -2000ppm/C.).

Note the opposite signs of these coefficients.

In the best transducers, eg Foxboro, Druck-Keller, these coefficients are equal as well as opposite, which explains why constant current excitation provides automatic compensation.

In the case of the MPX100A, constant current excitation causes over compensation as the magnitude of the temperature coefficient of bridge resistance is greater than the temperature coefficient of gauge factor. Something in between has to be used, which is why a compensating resistor in series with a constant voltage is recommended. Adjustment is easy and the method gives very satisfactory compensation, even for use as an altimeter.

In the case of the LX0503A, the least consistent of all the low-cost transducers on the market, the gauge factor temperature coefficient is much greater than the bridge resistance temperature coefficient. Compensation must be by some other method such as using the internal Vbe multiplier.

The total energy compensated variometer mentioned in this article is manufactured by Thunderbird Electronics Ltd, 20 Buttgarden Street, Bideford, Devon, tel 02372-5133.
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<td>Music Over Unit</td>
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ADVERTISERS INDEX

B. Bamber ........................................... 70
B. K. Electronics ................................... 6
B.N.R. & E.S. ....................................... 73
Circuit ............................................... 22/23
Cricklewood Electronics .............................. 10
Crimson Elektrik ..................................... 47
Cybernetic Applications ............................... 12
Dateline ............................................. 27
Display Electronics .................................. 56
Electrovalue .......................................... 60
Greenbank ............................................ 47
Greenweld ............................................ 59
Henry's Audio Electronics ............................ 54/55
House of Instruments ................................. 70
Hy-Tek Electronics ................................... 38
ICS ..................................................... 47
ILP Electronics ....................................... 65
Kelan Engineering .................................... 37
Kemplant .............................................. 82
Maplin ............................................... OBC
Microprocessor Engineering ....................... 60
Microwave Electronics ................................ 66
Midwich .............................................. 28/29
MJL Systems Ltd ...................................... 70
Newrad ............................................... 59
Powertran ............................................. IFC/IBC
Rapid Electronics ..................................... 8
Riscomp .............................................. 21
R.T.V.C. .............................................. 60
R.V.M. Audiotronics .................................. 66
Ship Co. Ltd ........................................... 66
Skywave Software .................................... 59
SME ..................................................... 82
Steward of Reading .................................... 73
Systems Electronique .................................. 82
Techomatic ............................................ 14/15
TK Electronics ........................................ 48
Watford Electronics .................................... 4/5

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