THE FINAL LINK

PLUS
RS232 I/O For The ZX81/Spectrum
Telephone Call Meter
Electronics For Peace?
The Secrets Of Telecine
LEARNING TOOLS

P101Mk2
The P101 Mk 2 Hydraulic Robot Arm offers unrivalled value for money in the field of educational robots. Either as a self-contained system or linked to an external micro, the P101 Mk 2 gives a realistic simulation of industrial robots. The P101 Mk 2's robust construction makes it an excellent base for experimentation and general robotics research.

Six-axis Robot System kit £1200 + VAT

P102Mk2
The two-speed Hydraulic Robot Arm is designed to provide "hands-on" experience in practical robotics courses. The Genesis P102 Mk 2 has most of the features of large industrial robots costing from 10 times the price.

The P102 Mk 2 is supplied with its own micro-processor control system and remote control box. Alternatively an external microcomputer can be used to control the robot via its RS232C interface or parallel port. Complete Six-axis Robot System kit £1625 + VAT

MICROGRASP
A real programmable robot for the price of a printer!

MicroGrasp has four servo-controlled axes and an independent gripper. The robot can be connected to most popular computers via special Powertran adaptors.

Robot kit with power supply £215 + VAT
Universal interface board kit £57 + VAT

POWERTRAN PLOTTER
Three-colour precision plotting on an A3 plane. This plotter is one of the most versatile peripherals that can be bought.

Exchange the pen carriage for a router or a scriber for computer-controlled etching or machining. Available for BBC "B" or RML 380Z.

£270 + VAT

HEBOT II
With independent control of its two wheels, two-tone hooter, flashing "eyes", retractable pen and four-way collision detectors, Hebot provides an ideal introduction to computer control. Connects to most popular micros.

Complete kit £95 + VAT
Universal computer interface board kit £11 + VAT

Access/Visa cardholders - save time - order by phone: 0264 64455.

Please send me the following kits

I enclose Cheque/Postal Order value £
(Don't forget to add V A T.)

Name
Address

To Powertran Cybernetics Limited, Portway Industrial Estate, Andover, Hampshire SP10 3ET

Please allow 21 days for delivery. Offers subject to availability. Prices apply to UK only, are exclusive of V A T and correct at time of going to press. Overseas customers - please contact our Export Department.
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### Tantalum Bead Capacitors

<table>
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<tr>
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**MINIATURE TOOLS**

**PRECISION JEWELLERS' TOOLS**

Restored Temped Handles and Black Chrome. Chrome Plated handles. Sawfly Hacks for use on Precise work.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>ST1 SCREWDRIVER SET</td>
<td>Precise screwdrivers in hinged plastic case. Sizes: 0.5 x 2.5, 2.5 and 3.5mm</td>
<td>£1.75</td>
</tr>
<tr>
<td>ST3 NUT DRIVER SET</td>
<td>Precise nut drivers in hinged plastic case. With safety cut off. Sizes: 2.5 x 4, 4.5 and 5.5mm</td>
<td>£1.75</td>
</tr>
<tr>
<td>ST4 TOOL SET</td>
<td>Precise pliers in hinged plastic case. Contains a Miniature Round Nose Plier, 0.5 x 5.5 x 6.5mm.</td>
<td>£1.75</td>
</tr>
<tr>
<td>ST5 WRENCH SET</td>
<td>Precision wrenches in hinged plastic case. Sizes: 4.5 x 5, 5.5 and 6.5mm.</td>
<td>£1.75</td>
</tr>
</tbody>
</table>

**TOOLTRONICS**

**JEWELLERS' TOOLS**

1. **Miniature Round Nose Pliers**
2. **Miniature Long Nose Pliers**
3. **Miniature Flat Nose Pliers**
4. **Miniature 90° Angled Pliers**
5. **Miniature Pin Vice**
6. **Miniature Combination Pliers**

**TOOL KIT AND CASE**

13 Piece tool kit and case. Wrist strap. £1.65 each. Order No. TK102.

**LOW COST CUTTERS/PLIERS**

- **Miniature Round Nose Pliers**
  - Insulated handles 4.5 x 6.5 mm
  - Order No. BK102
- **Miniature Long Nose Pliers**
  - Insulated handles 6.5 x 10 mm
  - Order No. BK104
- **Miniature Flat Nose Pliers**
  - Insulated handles 5.5 x 75 mm
  - Order No. BK106

**SIGNAL INJECTOR**

Simple push button operation. Oscillators at 500 Hz with hysteresis to 5 kHz. 1 kHz probed. Ideal for checking with shooping equipment. One 75p battery supplied. Order No. VPI02 £2.50

**LOGIC PROBE**

Automatic telling. White LED indication. Maximum width of input 300 mV. Maximum input frequency 100 kHz. Power supply 5V AC or DC. Order No. VP104. £4.50

**ANTEX SOLDERING IRONS**

- **BI-PAK SOLDERING KIT**
  - Order No. VP80 £7.00
- **ANTEX SOLDERING IRON**
  - 240v mains Ind Direct Heaters
  - Iron 240v mains Ind
  - Lightweight Soldering Iron 240v mains Ind
  - 50p each (minimum 100)
  - Order No. VP119 £1.75

**TESTER**


**CIRCUIT TESTER**

D.C. continuity tester for circuit checking on all low voltage equipment and components. D.C. checking also possible. Takes two AA batteries. 90 cm lead has one coil clip. Bottom 16cm. Order No. VP100.

**MINIATURE VICE**

Miniature vice and metal vice with setting action base. Ideal dports. Single action to secure or release socket. Various sizes with rubber pads. 20mm wide, open end to 60mm. Orders 85p. 60mm £1.50

**METRIC & BRITISH MEASURES**

Steel tapes in sturdy aluminium plastic case. Silk mesh strip. These are coated cotton tapes, have inch and millimeter graduations. Automatic push button return. 2.5m metric and 6.5mm. 1000mm £1.75

**AUTOMATIC WIRE STRIPPER**

Will clamp 5 different sizes of wire and by turning the handle the insulation is removed. Perfect for use in home and industrial use. Order No. VP112 £3.75

**BI-PAK SOLDER-DESOLDER KIT**

1. 50p each (minimum 100)
2. Order No. VP119 £1.75

**BATTERY TESTER**

Tests all types of batteries including standard NAA/SA (All) Transistor, all standards and varieties. Includes Battery tester, and travels in a 3.5 litre moulded plastic case. £4.75

**RATCHET SCREWDRIVER KIT**

Comprises 4 standard screwdriver blades & 1 Phillips blade. 2 1/2 inch and 3 inch. Order No. 256B £1.45 each.

**BRAND NEW LCD DISPLAY MULTITESTER**

- **LCD 10 MEGOHM INPUT IMPEDANCE**
- **3.5 digit**
- **200mV to 1000V DC & AC**
- **0.01 to 10000 Ohms**
- **Auto range, auto polarity, Two range output.**
- **Over range indication.**
- **Resistance**
- **12.5mm x 17.5mm large LCD readout.**
- **Double shock.**
- **Fuse circuit protection.**
- **High performance and low cost instruments.**

**RANGE**

- **DC voltage 0-200mV**
- **AC voltage 0-2000V**
- **AC current 0-20mA**
- **Resistance 0-200k Ohms**
- **Temperature range**
- **Sample time**
- **50p each (minimum 100)**

**ORDER No. 1222 OUR PRICE £6.80 EACH**

**HT320 MULTITESTER**

- **Universal Tester**
- **Mini battery**
- **AC voltages 0-150V & 0-1000V**
- **DC voltages 0-15V & 0-1000V**
- **Watt meter**
- **Resistance 0-200k Ohms**
- **Temperature range**
- **Sample time**

**ORDER No. 1323 OUR PRICE £16.40 EACH**

**BI-PAK PCB ETCHING AND DRILL KIT**

- **BI-PAK PCB ETCHANT**
- **5 collets**
- **16 ranges pph**
- **12 holes, pack FERRIC CHLORIDE**
- **11,000mm Drill 10 pph, 100mm**
- **11,000mm Drill 15 pph, 100mm**
- **11,000mm Drill 7 pph, 100mm**
- **3 holes, pack FERRIC CHLORIDE**

- **12 holes, pack FERRIC CHLORIDE**

**ORDER No. 1015 OUR PRICE £8.95 EACH**

**RATCHET SCREWDRIVER KIT**

Comprises 2 standard screwdriver blades & 1 Phillips blade. 2 1/2 inch and 3 inch. Order No. 256B £1.45 each.

**THANK YOU**

**SHIPPING**

Free Order Delivery 10 pence per item.

**FOR YOUR ORDER INVOICE, AND PAYMENT**

1. Please use your credit card. Ring for details.
2. Send your orders to Dept EE2. Bi-Pak PD Box 6 WARE, HERTS.
3. Orders over £50.00 (e.g. WARE) TERMS CASH WITH ORDER SAME DAY DESPATCH.

**FOR YOUR INFORMATION**

1. Bi-Pak PS Box 6 WARE, HERTS.
2. Invoices normally sent 2nd Class Mail.
3. If you require goods urgently, call your order in to us on 1% p.m. to your local supermarket.

**ETI APRIL 1985**
ETI APRIL 1985

DIGEST

Eurocard Rack Cases

O K Industries have added eight new 3-unit high card cases to their Black range. The cases accept both sizes of Eurocards and all other sub-assemblies designed for use with 19" sub-rack systems but offer a choice of four widths instead of the standard rack width which is usually available.

The new cases are made from aluminium and are supplied in kit form. They are suitable for all sub-assemblies manufactured to DIN 41494, part 5 and accept both 100 x 160mm and 100 x 220mm Eurocards. The top of the enclosure is secured only by the rear fixing screws which allows it to be removed easily for internal access. The four widths available are 101, 203, 304 and 426mm and each can be ordered in depths to suit either 160 or 220mm Eurocards. Price range from £30.96 to £52.63.

OK plan to extend the range still further in the near future with a series of 4, 5 and 6-unit high card cases in widths of 203, 304 and 426mm. Further details and a full catalogue are available from OK Industries UK Ltd, Dutton Lane, Eastleigh, Hampshire SO5 4AA, tel 0293-619841.

LED Along An Optical Guide

AEG-Telefunken have produced a printed circuit mounting LED which has a built-in flexible optical guide which will transmit light for distances of up to 2.0 metres. The device allows front panel indication to be achieved using a board-mounted LED, thus removing the need for off-board wiring, or it could be used with a photo-sensitive detector to form an opto-coupler with very high voltage isolation.

Advance Buys House Of Instruments

A dvance Power Supplies Ltd, the UK power-supply manufacturer formed in April 1984 as a result of a management buy-out of the former Gould Power Conversion Division, has purchased instrument distributor House of Instruments.

Advance sees the move as a major step forward in its expansion and diversification plans, and is moving the existing House of Instruments operation from Saffron Walden to its Bishop's Stortford headquarters. Advance say they are committed to providing continuity for existing House of Instruments customers, and the sales staff are remaining with the company.

For the future, Advance intends to invest considerably in House of Instruments, both in terms of higher stocking levels to ensure speedier service and in completely new product lines and services. Advance Power Supplies Limited, Raynham Road, Bishop's Stortford, Herts, CM23 5PF, tel 0279 55 55.

Bradley Marshall Resurgent

W hen Bradley Marshall's Edgware Road component shop was severely damaged by a gas explosion next door, it was almost like an old friend dying.

Happily, the company has risen, phoenix-like, in a new shop opposite its old premises. And it's bigger and better, with more space, more components, more staff and a new computer centre.

London's Edgware Road will be even more welcoming to electronics enthusiasts now. Bradley Marshall, 382-386 Edgware Road, London W2 1BN, tel 01-723 4242.

LED Along An Optical Guide

AEG-Telefunken have produced a printed circuit mounting LED which has a built-in flexible optical guide which will transmit light for distances of up to 2.0 metres. The device allows front panel indication to be achieved using a board-mounted LED, thus removing the need for off-board wiring, or it could be used with a photo-sensitive detector to form an opto-coupler with very high voltage isolation.

Come And Go At The Same Time

I t seems an obvious idea, really, but so far as we know, Norbain are the first to actually produce bidirectional opto couplers. Needless to say, this will probably provoke a mailbag or two of readers' letters along the lines of "When I was knee-high to an EF80, there was a company on the Edgware Road that sold two ORP12s glued to two 12V light bulbs — mind you, you could only go at 2 baud with this set up...".

There are two new opto-couplers, both using gallium arsenide LEDs with NPN silicon phototransistors for the outputs and designated the OP1 2500 and the OP1 2501. Both devices have an input to output isolation voltage of 1500V with guaranteed minimum current transfer ratios of 12.5% for the OP1 2500 and 20% for the OP1 2501.

Additionally the OP1 2501 has a CTR symmetry of 0.5 minimum and 2 maximum. In terms of a bidirectional opto-coupler, CTR symmetry means that the output radiant power from the LED will not be identical with the same forward current. This will be reflected in the output waveform which will develop alternate peaks at two different amplitudes.

The power dissipation of the input diode is 100mW derating linearly at 1.33mW/°C above 25°C. The power dissipation of the output transistor on the OP1 2500 is 150mW and 300mW on the OP1 2501, derating linearly at 2mW/°C and 4mW/°C at 25°C respectively. The output rise and fall time of the devices is typically 2μs within an operational temperature range of -55°C to +100°C. Norbain House, Boulton Road, Reading, Berkshire RG2 0LT, tel (0734) 864411.

Monolithic Memories have produced an A2 sized wallchart which lists and compares bipolar PROMs from all of the leading manufacturers. The chart is available upon request from Monolithic Memories Ltd, Monolithic House, 1 Queens Road, Farnborough, Hampshire GU14 6DJ, tel 0252-517431.

LED Along An Optical Guide

The optical guide will be available in standard lengths of 0.5, 1.0, 1.5 and 2.0 metres but may be cut and polished at an intermediate length to suit the application. The current transfer ratio of the guide is 50% and the LED colours available include red, yellow and green.

AEG-Telefunken (UK) Ltd, 217 Bath Road, Slough, Berkshire SL1 4AW, tel 0753-872120.

LED Along An Optical Guide

The optical guide will be available in standard lengths of 0.5, 1.0, 1.5 and 2.0 metres but may be cut and polished at an intermediate length to suit the application. The current transfer ratio of the guide is 50% and the LED colours available include red, yellow and green.

AEG-Telefunken (UK) Ltd, 217 Bath Road, Slough, Berkshire SL1 4AW, tel 0753-872120.
**BURLGAR ALARM**

Better to be 'Alarmed' then bombed.

**Thangar's Famous Minder Burglar Alarm System**

(4-digit Microcontroller principle. Fully guaranteed.

- Combo Unit: houses microphone/radar receiver, range up to 15 metres adjustable by sensitivity control. Three-position, key controlled. Frequency - test armed 30 second exit and delay.
- Alarm 10000v, 250mV output. Housed in a tamper-proof heavy duty metal case. The control unit and outdoor alarm contains rechargeable batteries which provide enough function remaining power to operate the alarm and/or functioning siren for at least 1/2 year.

Price £148.00

40p delivery per pair.

**STEREO CASSETTE DECK**

50% saving on our usual price - use to hiss through to beautiful music signal supplied.

- Metal top black finish.
- Normal Chrome tape
- Quality Hi-Fi stereo.
- Full control.

Price £35.99 - £30.00 P&P ea.

**SPECIAL OFFER**

- **BOXLOR**
  - £32.99
  - £29.99 - £25.00 P&P
  - £29.99

**STereo Cassette Deck**

- **NEW**
  - £75.00
  - £65.00

**PEZO ELECTRIC TWEETERS**

- **MOTOROLA**
  - £32.99

**Hobby KITs**

- **PROVEN DESIGNS**
  - £15.00

**FM SIDEBAND TRANSMITTER (SLOT-IN TYPE)**

- **NEW**
  - £22.99

**STEREO DISCO MIXER**

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  - £50.00

**GOODS FOR WORKSHOPS, FACTORIES, OFFICES, ETC.**

- **SUN GAS**
  - £95.00

**STereo Money Incase**

- **NEW**
  - £14.00

**AMPLIFIER MODELS**

- **POWER AMPLIFIER MODELS**
  - £50.00
  - £45.00

**STEREO CASSETTE DECK**

- **NEW**
  - £32.99

**SUN GAS**

- **NEW**
  - £95.00

**MOTOROLA**

- **NEW**
  - £32.99

**Hobby KITs**

- **NEW**
  - £15.00

**FM SIDEBAND TRANSMITTER (SLOT-IN TYPE)**

- **NEW**
  - £22.99

**STEREO DISCO MIXER**

- **NEW**
  - £50.00

**GOODS FOR WORKSHOPS, FACTORIES, OFFICEs, ETC.**

- **SUN GAS**
  - £95.00

**STereo Money Incase**

- **NEW**
  - £14.00
First Digital Recording Console

The first ever digital multi-track sound mixing console is now in full operation. Manufactured by Neve electronics, the digital console was installed at CTS recording studios in West London in just 24 hours with final adjustments taking place between Christmas and the New Year.

Neve claim to have spent some five years researching and developing this new digital console. In addition to collaboration with the BBC, much of the recent work on multi-track facilities was done in conjunction with CTS engineers. Neve says that it has received numerous enquiries about its DSP console from studios and broadcast companies throughout the world and that it anticipates that over the next decade the digital business will expand to form a major addition to its already growing and developing analogue activity. Further DSP consoles are already in production.

Neve Electronics International Ltd, Melbourne, Royston, Hertfordshire SG8 6AU, tel 0763-60776.

Computer Wars

The battle to the death continues and small black objects continue to hurtle down — in price. In the same week that Acorn suspended dealings in their shares because of financial problems, Sinclair announced a sharp reduction in the price of the Spectrum Plus computer.

The Spectrum Plus will now cost £129.95 including VAT instead of £179.95. At the same time the company announced that they will stop selling the original ZX Spectrum 48K in the UK in order to concentrate on the Spectrum Plus. Owners of the 48K ZX Spectrum may have their machine upgraded to a Spectrum Plus for £30.00 or can purchase a kit and do the job themselves for £20.00. The introductory software six-pack which was previously included in the price of £179.95 will now be available separately at normal prices or at a special price of £14.95 to purchasers of the Spectrum Plus.

Sinclair says that they hope the price reductions will enable them to increase their 44% share in the UK market. The price of the QL remains unchanged at £399.00 including VAT. For Spectrum upgrade kits contact Sinclair Research Ltd, Stanhope Road, Camberley, Surrey GU15 3PS, tel 0276-686100.

Snail Update

Readers who saw the February News Digest may remember an item describing a microcomputer peripheral called Slomo, a device which slows down a micro so that complex games, etc can be learnt more easily. The address given at the end of the article was that of Cambridge Computing Research Ltd but we have since been told that CCR are in receivership and that no further orders should be sent to them. Slomo is still available from Nidd Valley Micro Products who originally designed it and the price is unchanged at £14.95 inclusive. They can be reached at Stepping Stones House, Thistle Hill, Knaresborough, North Yorkshire HG5 8JW, tel 0423-864488.

Special Features

Electronic Brokers have published a 20-page, two-colour catalogue which describes their range of test and computer equipment. It has sections on oscilloscopes and logic analysers, multimeters, generators, counters and timers powers supplies, line conditioners and EPROM programmers and also describes a range of DEC Tektronix computer equipment. Copies of the catalogue are available from Electronic Brokers Ltd, 140-146 Camden Street, London NW1 9PB, tel 01-267 7070.

Global Specialities Corporation have produced a 12 page catalogue which describes their range of design and test instruments. The catalogue includes power supplies, capacitance meters, function generators, multipliers and mixers and is available from GSC, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ, tel 0799-21682.
**Rapid Electronics**

**MIN D CONNECTORS**

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**CONNECTORS**

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**ACCESS AND BARCLAYCARD WELCOME**

**MAIL ORDERS:**

Unit 1, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD.
Tel. Orders: Colchester (0206) 36412.
Telex: 987756.

**O R D E R I N F O:**

All components brand new and to full spec. All prices exclude VAT.

Please add to total order. Please add VAT for all orders over £5. Send cheque/P.O. or Access/Visa number with order. Our new 50 page catalogue is given free with all orders over £5. Please note orders welcome with Access or Visa. Official orders accepted from colleges, schools etc.

**The Rapid Guarantee**

* Same day despatch  * Competitive prices  * Top quality components  * In-depth stocks  

**OLDCO CONNECTORS**

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**NEW PRODUCTS CATALOGUE**

Our new fully illustrated catalogue is now available-free to all interested parties. Contact us for a copy. It includes the most competitive prices in the market today.

**RESISTORS**

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**COMPUTER CONNECTORS**

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**ACCESS AND BARCLAYCARD WELCOME**

**MAIL ORDERS:**

Unit 1, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD.
Tel. Orders: Colchester (0206) 36412.
Telex: 987756.

**ACCESS AND BARCLAYCARD WELCOME**

**MAIL ORDERS:**

Unit 1, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD.
Tel. Orders: Colchester (0206) 36412.
Telex: 987756.
Single-Action Wire Stripper

B & R Electrical Products have introduced a self-adjusting wire stripper and cutter which will prepare the ends of insulated cables in one movement. The tool accepts most types of solid and stranded wires and the manufacturers claim that it costs only about a third of the price of comparable tools currently on the market.

The TC1017 is robustly constructed and self-adjusting during operation to enable fast and accurate stripping of insulation from most types of solid or stranded insulated wire with outside diameters from 0.5 to 5mm. For particularly hard or soft insulation materials a manual adjustment is provided to alter the force of the blades, but such adjustment is not normally necessary.

The tool operates in one continuous action by gripping the insulated material in its metal jaws, simultaneously cutting through it and removing the insulation by the sliding action of the blades. Moulded into the jaws of the tool are graduations in millimeters and inches to assist measurement of the length of insulation to be stripped. The tool also incorporates a pair of tempered steel cutting blades to enable the wire to be cut and trimmed to length before stripping.

Low-Cost Touch Screen

Microvitec have produced a touch sensitive clear screen which fits over their computer monitors and which can be used by the young, the disabled and others who have difficulty with keyboards to enable them to communicate with computers. The screen uses infra-red beams to detect the presence of a finger or a stylus, is inherently safe, and the manufacturers claim that it costs only a fraction of the price of currently available touch screens.

The Touchtech 501 consists of a stand into which metal-cased Microvitec monitors are secured and a screen bezel. The bezel contains a number of infra-red transmitters and sensors which project a network of beams across the screen area. The beams cannot, of course, be seen, but interrupting any of them with a finger or stylus will immediately be detected by the appropriate sensor and the co-ordinates fed to the computer. The information can then be interpreted by the software as required, for example, as a yes or no decision or as a choice between other alternatives.

The Touchtech 501 comes complete with a user's handbook and a diskette containing nine demonstration programs developed by the Government-backed Microelectronics Programme. The complete package is expected to sell for £210.00 plus VAT.

Microvitec PLC, Futures Way, Bolling Road, Bradford, West Yorkshire BD4 7TU, tel 0274-390011.
Low Cost Logic Analyser

Thurlby Electronics have introduced a portable, sixteen channel logic analyser which is claimed to offer high performance but will sell for under £400 excluding VAT in its basic form. Features include a 2000 word memory, comprehensive trigger facilities and an RS423 interface, and Thurlby hope that the low price will encourage organisations to equip each of their engineers with one rather than expecting a number of engineers to share one machine as at present.

The LA-160A has a maximum clock rate of 10MHz and the LA-160B has a maximum clock rate of 20MHz. Both have sixteen data channels but can be enlarged to 32 channels using a clip-on extender module, whereupon the maximum clock rates become 5MHz and 10MHz respectively. The acquisition memory holds 1999 sixteen bit words and stores 999 before the triggering event and 999 after it. The memory size becomes 1000 32-bit words when the extender module is added. A built-in state domain display shows the data in either binary, octal, decimal or hex form or in a mixed display of binary and hex, and by connecting the unit to a conventional oscilloscope a full, multi-channel timing display can be obtained.

The trigger facilities include 20 bit trigger width, the ability to set the trigger word in any display format, selectable trigger hold-off and a trigger arm input with selectable data. Data can be captured synchronously or asynchronously using either the clock of the circuit under test or the internal clock which has sixteen selectable frequencies from 1KHz to 10MHz or 20MHz. Two clock qualifiers enable data to be captured selectively, for example on the Read cycle of the microprocessor bus.

The LA-160 is microprocessor controlled via an interactive keyboard with all the set-up information being stored in permanent memory. A non-volatile reference memory is also included. This can be loaded from the acquisition memory or the keyboard and allows reference data to be stored for comparison purposes. The software facilities include word search, block memory compare, word by word memory compare and stop on equality or non-equality acquisition modes. A built-in RS423 interface enables the contents of the acquisition memory to be dumped to a computer. The inputs are fired at TTL level but optional high impedance variable threshold data pods are available. Other options include an IEEE-488 bus analysis connector and a printer interface for hard copy.

The LA-160 weighs less than 1.8kg (4lbs) and is compact enough to fit into a toolkit or briefcase. The 10MHz version (LA-160A) costs £395.00 and the 20MHz version (LA-160B) costs £495.00 the optional extras range in price from £7.50 for a logic grabber set up to £125.00 for the 32 channel extension module, and all prices exclude VAT. For further details and a list of distributors contact Thurlby Electronics Ltd, New Road. St. Ives, Cambridge PE17 4GB, tel 0480-63570.

High Sensitivity Relay

ITT Switches (UK) Ltd claim to have produced the most sensitive single-coil bistable relay available. It only requires a 40mW pulse for 10ms to change it from state to state.

The RZ2T relay has a two-pole changeover configuration and uses bifurcated contacts. Being a bistable type, it will remain in its operated state until a pulse of reverse polarity is applied to move into the other state. The contact bounce time is less than 0.5ms which ITT claim is ten times better than the average performance of similar electromechanical relays. It is housed in a standard DIL PC-mounting case and will withstand most normal PCB cleaning processes except ultrasonic cleaning.

ITT Switches (UK) Ltd, 8 Roberts Way, Wickford, Essex SS11 8DD, tel 03744-66111.
DISC DRIVES

These are fully casced and wired drives with slim line mechanisms of high quality, Shugart A400 standard interface. Drives supplied with cables manuals and formatting disc suitable for the BBC computer. TEAC 80 track drives are supplied with 40/80 track switching as standard. All drives can operate in single or dual density format.

1 x 100K 40 T S TOSSA...
1 x 200K 40 T B1SS11500...
1 x 400K 40 T BIS50...
1 x 100K 80 T S TOSSA...
1 x 200K 80 T B1SS11500...
1 x 400K 80 T BIS50...

3M 5 1/4" 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.

40 ST DD £15 (c)
80 ST DD £22 (c)
40 DS DD £18 (c)
80 DS DD £24 (c)

DRIVE ACCESSORIES

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

Single Disc Cleaner £6 (d)
10 Disc Library £3.50 (c)
30 Disc Case £11.30 (d)
70/80 Disc Lockable Box £19 (c)

MONITORS

Machines available in plastic or metal cases, please specify your requirement.

KAGA Super Hi Res Vision III RGB £340 (a)
Hi Res Vision II £235 (a)

MONOCHROME MONITORS 12":
Kaga Green KX1201 G Hi Res...
Kaga Amter VX1201 A Hi Res...
Sanyo Green DM812CX Hi Res...
Swivel Stand for Kaga Monochrome £21 (c)

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

ATTENTION

All prices in this double page advertisement are subject to change without notice.

SPECIAL OFFER

2764-25 £4.90
27128-25 £16
26624-15 £26
26622L-15 £31
26614-12 £35

CONNECTOR SYSTEMS

EDGE CONNECTORS

DIN 41822
36 way plug Centronics (gold) 500/50C 475Gp...
seven way plug J35Gp...
10 way plug J55Gp...
20 way plug J75Gp...
Flexible cable 50/m 75/p

GENDER CHANGERS

20 way plug 64 way...
3 way plug 72 way...
Flexible cable 50/m 75/p

RIBBON CABLE

10 way 4 pin plug 3 way plug...
16 way 4 pin plug 3 way plug...
20 way 4 pin plug 3 way plug...
Flexible cable 50/m 75/p

TELEPHONE CONNECTORS

4 way plug 110p...
6 way plug 110p...
10 way Flexible 110p...

DIL HEADERS

Male to Female 10p...
Female to Female 10p...
Male to Male 50p...
Flexible cable 50/m 75/p

DIL SWITCHES

4 way plug 80 pin Header...
8 way plug 100 pin Header...
21 pin Header 200 pin Header...
8 pin Solder Connector 200 pin Header...

MISC CONNS.

4 way plug 80 pin Header...
8 way plug 100 pin Header...
21 pin Solder Connector 200 pin Head...
8 pin Solder Connector 200 pin Header...

TECHNOMATIC LTD 01-208 1177

ETI APRIL 1985
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The loudspeakers are obviously the final link in the hi-fi chain, some would say. Not, others would contradict, the room modifies the sound so must be counted. They're both wrong, as Vivian Capel will demonstrate.

The human ear makes all the other links in the hi-fi chain seem crude in construction and design. An understanding of these fascinating instruments with which we have been endowed can help us identify the important characteristics of the sounds that we hear. This in turn can shed light on the art of sound reproduction and hi-fi. The ear is divided into three sections, the outer, middle and inner ear; each section has its own specific function.

The Outer
The outer ear consists of the appendage known as the pinna, and the ear canal terminating in a diaphragm stretched across it, known as the ear-drum. The pinna is provided not merely for decoration or even to protect the ear from the intrusion of foreign bodies, though it does both to a certain extent. Its convolutions produce reflections which follow the direct sound into the canal with minute delays, hence with phase differences. The reflections differ according to the angle of incidence of the sound, so the resulting phase differences serve as a code to identify direction. The auditory section of the brain decodes this information instantly to locate the position of a sound source.

It is commonly believed that source location is due entirely to volume and phase differences existing between the two ears. If this were so, our sound location would be limited to the front horizontal plane, as it is with conventional stereo systems. However, as we have the facility of all-round location with vertical identification as well, there is evidently more involved. This can be demonstrated by plugging one ear and trying to identify the direction of a sound source. It is still possible, though the sense of direction is reduced.

The amount of phase difference generated by there being a path difference between direct and reflected sound depends on two things: the path difference itself and the wavelength of the sound concerned. The first of these will depend on the dimensions of the pinna convolutions, and if these are small in comparison to the wavelength, the phases difference will be quite small and probably undetectable. So, logically, we will get best sense of sound location with higher frequencies where the wavelength is comparable to the pinna convolutions.

At mid-to-low frequencies, the wavelength of the sound becomes comparable to the head’s size, so comparison of phase between the two ears may help location here. At lower frequencies, it would take pinnas (or possibly heads) of literally elephantine proportions to give good directional sense, and the practical problems in carrying around that lot must outweigh any advantages for everyone except the elephants themselves. However, this is not a major problem, as the majority of low-frequency natural sounds do have higher frequency components that we can locate satisfactorily.

The Middle Ear
The directional-encoded sound travels down the ear canal to the ear-drum, or timpanum as it is also called, which vibrates in response. The next section, the middle

Fig. 1 Our hearing system showing the three main sections: the outer, middle and inner ear.
The ear, has the function of impedance matching and dynamic range compression. The well-known rule which applies in electronics as well as mechanics is that to transmit the maximum amount of energy from one unit to another, impedances must be similar. Electrical impedances are matched between amplifier output stages and loudspeakers by transformers, and the mechanical impedance offered by the road wheels of a car is matched to the engine torque by the gearbox.

In the case of the ear, minute air pressure variations acting on the ear-drum make this a low impedance member, whereas the fluid-filled inner ear which converts the vibrations to neural signals is of a higher impedance. Matching is accomplished by three interjoined bones termed the hammer, anvil and stirrup. The first two of these are a pair of pivoted levers that produce a leverage ratio of nominally 3:1, and the stirrup, or stapes as it is also called, communicates the motion of the second lever to the window of the inner ear.

The three bones are held in position by tiny muscles. These can cause the pivot position to change and they can also stiffen to cause a decrease in the amount of movement. Hence these can reduce the sensitivity of the whole ear progressively as the input sound level increases. This enables the ear to handle an enormous range of sound levels, the loudest being $10^{12}$ times larger than the faintest. We can accommodate all the natural sounds we are likely to ever encounter — from the rustling of leaves to a nearby thunderclap — but we can have problems with man-made sounds such as the explosions, jet engines and machine tools, to name but a few.

If the middle ear were a completely sealed cavity, differences of atmospheric pressure would cause the ear-drum to be stretched inward or outward depending on the atmospheric pressure. This would displace the three connecting bones and upset the sound compression. The eustachian tube connects the middle ear to the back of the throat, and so maintains atmospheric pressure on the inner surface of the ear-drum.

**Inner Ear**

The final bone of the trio, the stirrup, transmits the sound vibrations to the window of the inner ear. This is shaped like a snail's shell hence its name, the [cochlea](https://en.wikipedia.org/wiki/Cochlea). It is really a long tube rolled up in a spiral. To understand what it does we will imagine that it is unrolled — but we can have problems with man-made sounds such as the explosions, jet engines and machine tools, to name but a few.

If the middle ear were a completely sealed cavity, differences of atmospheric pressure would cause the ear-drum to be stretched inward or outward depending on the atmospheric pressure. This would displace the three connecting bones and upset the sound compression. The eustachian tube connects the middle ear to the back of the throat, and so maintains atmospheric pressure on the inner surface of the ear-drum.

**Fig. 2** Diagram of basic components with cochlea straightened out to show various features.

The whole tube is filled with fluid and is sealed at the far end so that a complete path is formed along one half, through the helicotrema and back along the other half. The top half or scala vestibuli has at its entrance a diaphragm termed the [oval window](https://en.wikipedia.org/wiki/Oval_window), while the bottom one, the scala tympani, is termed at another diaphragm, the [round window](https://en.wikipedia.org/wiki/Round_window).

When pressure variations are communicated to the upper oval window by the stirrup, they travel along through the fluid to the far end, down through the helicotrema gap and back along the lower chamber to the round window. As fluid is incompressible, the round window serves to absorb the pressure variations and dissipate them to the air in the middle ear.

Now as those vibrations travel along the upper chamber they pass through thousands of very sensitive hair cells on the upper surface of the dividing membrane. These are linked to the nerve fibres that are connected to the auditory part of the brain, and their movements produce the neural signals along the fibres.

**Fig. 3** Equal loudness contours. These show the amount of sound pressure required to produce sensations of equal loudness at various frequencies and volume levels. They are therefore the inverse of a frequency response curve.
The most sensitive region at all sound levels is around 4 kHz, with lifts in response at around 400 Hz (for higher the 18 to 25 age range; these curves are now the overall sound more 'natural' (or so the manufacturers say...). This explains why some amplifiers have loudness compensation to bass and treble is comparatively much lower than at the higher levels, in particular on the bass end. This explains why some amplifiers have loudness controls to lift the bass response at low sound levels, to make the overall sound more 'natural' (or so the manufacturers say).

As with most other abilities, there is a decline in the sensitivity of our hearing with age. Over the age of 30, the high frequency response falls off at an increasing rate (Augh! - Ed.), and at 60 the response is some 15 dB down at 3 kHz as compared to the age of 20. At 6kHz, the response is even lower, at around 25 dB down. This progressive loss of sensitivity is known as presbycusis.

Warning Quo Fans!

Permanent damage can be inflicted on your ears by over-exposure to loud sounds. Short periods of over-indulgence produces a temporary loss of sensitivity, after which your hearing will recover. However, if you listen to such a sound for long enough, permanent damage will occur, and the 'safe' time depends on the level of the sound. There are maximum permitted times for which workers in the UK can be exposed to industrial noise, and these could be used as a guide; the starting point is at sound level of 90 dB, which is permitted for up to 8 hours. From this, the maximum permitted time halves for each additional 3 dB; so for 93 dB, 4 hrs max is allowed; 96 dB, 2 hrs; 99 dB, 1 hr; 102 dB, 6 hrs; 105 dB, 4 hr; 108 dB, 7 mins; 111 dB, 3 mins.

Damage can be greater if the noise contains impulsive components caused by percussive sources. However, irrespective of the frequency or nature of the noise which produced the damage, the effect is always the same, a reduction in sensitivity centred around 4 kHz, ie. the frequency region for speech. Lower and higher frequencies are less affected if at all. As the damage increases with further exposure, the band of affected frequencies broadens until damage increases with further exposure, the band of affected frequencies broadens until the frequency of the note which may be harmonically unrelated to the note being played. All these harmonics and overtones produce a characteristic pattern or formant which is different for each instrument and gives it its special tone.

Identifying Sounds

How is it then that we can identify sounds, especially musical instruments that are playing the same note? The standard explanation is that we do it by means of harmonics and overtones. When a string or column of air in an instrument vibrates, it is in addition to the fundamental vibration, there are harmonics at twice, three times, four times and so on the fundamental frequency. As well as these various parts of the instrument body vibrate at resonant frequencies which may be harmonically unrelated to the note being played. All these harmonics and overtones produce a characteristic pattern or formant which is different for each instrument and gives it its special tone.

Decibels

We've been using the term 'decibel' or 'dB' for some time in the article, so it's about time we said what it is. It expressed a logarithmic ratio between two quantities. In the case of sound pressure levels, it is between the one being expressed and a reference which is the accepted threshold of hearing, 20 µPascals, or 200 µdynes/cm². Being logarithmic, it more closely expresses the perceived sound levels, because of the ear's sound level compression. A difference of 1 dB is the absolute minimum that can be detected, but usually it needs some 3 dB difference before a change of level is perceived. Doubling the sound pressure level produces a 6 dB increase in the logarithmic scale, so a subjective doubling of the sound level requires an increase of some 10 dB which is three times the actual level.

Listening Levels

What volume level then, should orchestral music be reproduced? If too quiet it lacks colour and interest, while if too loud, as is more often the case, it is unnatural. One reason for this, even if the amplifier can handle the peaks without stress, is those aural response curves. The frequency balance is distorted at very high levels just as much as at low ones. For optimum fidelity, the sound pressure level at the ears should be about what it would be in the concert hall.

What sort of levels could we expect there? A lot depends on the acoustics, the size hall and the position of the listener. Taking Bristol's Colston Hall as an example, from a centre position in the 11th row, considered among the best, peaks of 86 dB were measured during an orchestral concert. On another occasion, in the 9th row and with a different orchestra, 90 dB was clocked. From a similar position, during a large scale orchestral and choral work, a peak of 94 dB was recorded. Those peaks were rare and momentary. The quietest passages were pianissimo strings which measured 45 dB and were just audible. Woodwind solos were in the 60 dB range, while most of the orchestral playing was in the 60-80 dB region. Thus, a dynamic range of some 45 dB from quietest to loudest is called for which is well within the range of hi-fi producers, in fact many exceed this unnecessarily.

If you are keen on getting the level right, a sound level meter should be used. Not all are expensive, some are available without the sophistication of professional instruments, quite reasonably. However, if you feel indisposed to shell out for even one of these, a few common sound pressure levels might help to get things in perspective. Soft whisper at 1 metre, 45 dB; normal conversation at 1 metre, 65 dB; vacuum cleaner at 1 metre, 75 dB; cruising motor coach inside, 70 dB; whistling kettle at 1 metre, 85 dB; pneumatic drill at 1 metre, 110 dB.

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Harmonic analysis reveals that the pattern changes considerably with some instruments between their lower, middle and upper registers. The flute for example has few if any harmonics in its upper register, being perhaps one of the purest toned of instruments, yet in its lower range it can have up to ten. The bassoon has an upper register that is fairly conventional, with strong fundamental and a series of harmonics of diminishing amplitude, but its middle compass has a weak fundamental with the second harmonic actually stronger, and the following ones irregular in strength. The low register is different again with a very weak fundamental and harmonics increasing in amplitude as high as the fifth.

Also, many instruments have a quite different harmonic pattern when played softly to when played loudly; the piano is an example. Yet, with all this we can
Fig. 4 Formant of glockenspiel: a pure tone with low harmonic content; very difficult to identify without starting transients.

Fig. 5 Piano played pp: mainly second harmonic with fundamental as seen from broader negative half-cycles.

Fig. 6 Piano played mf: stronger second harmonic with others, mainly even.

Fig. 7 Trumpet: stronger harmonic content when piano note but not dissimilar, when starting and finishing sections removed. Harder sound than piano.

Fig. 8 French horn: mellower tone then trumpet, but similarity in waveform can be seen.

Fig. 9 Clarinet: distinctive pattern consisting of strong fundamental with strong odd harmonics in large number.

Fig. 10 Violin: large number of harmonics both odd and even gives rounder, less incisive tone than clarinet. Yet without starting and finishing portions, it is difficult to distinguish them (even the violinist had it wrong).

still recognise the instruments whatever their register and level.

Clearly something else must be responsible for giving the characteristic sound in addition to harmonic content. Another factor which has been suggested is the ‘shape’ of the sound, that is the way it starts, decays, and finishes. Percussive instruments produce very steep starting transients, but quickly decay to inaudibility. The attack of the bow on stringed instruments is quite different and the notes can be sustained or even increased in volume at the will of the player, and the cessation is abrupt as the bow is lifted. Wind instruments also have a characteristic start and can be sustained or increased. Further complications are vibrato, in the case of strings, whereby the performer makes small rapid changes of pitch to give expression, and tremolo with some wind instruments such as the flute, which is mainly amplitude variations.

**Experiment**

To test the validity of this theory, I set up an experiment with the cooperation of a small amateur orchestra. Six instruments were chosen that were unlike in tone: trumpet, French horn, B-flat clarinet, glockenspiel, violin, and piano. Each instrument played in turn an ascending scale of C-major starting at middle C. Each note was played deliberately and slowly, with no vibrato or tremolo and duly recorded on a reel-to-reel tape-recorder.

Next, each note was ‘topped-and-tailed’; that is the start and finish were edited out leaving only the middle portion, and the order of the instruments re-arranged.

Finally, members of the orchestra, members of a choir that frequently performed with it, and some hi-fi enthusiasts were asked to try and identify the instruments from the doctored recording. Each participant had an answer sheet and was asked to put the name of each instrument down as it was heard. They were asked not to guess, but put down only if they thought they knew the identity of the instrument, and also not to put the final one or two by process of elimination. If they were not sure they were asked to leave the space blank. All we told which instruments were being played but not their order. Some participants were the original players.

In view of this knowledge and familiarity with the sound of the instrument, one would expect a high score. In fact only 25% got all the answers right, and no instrument was correctly identified by all participants. A breakdown of the correct answers was: trumpet 65%, horn 85%, clarinet 85%, glockenspiel 85%, violin 45%, piano 70%.

The trumpet was not too difficult, but it sounded strange and fooled 35%; the horn was, to my ears, unmistakable — even so, 15% got it wrong. The clarinet was much more difficult, but was given away by a slight breathiness on a couple of notes; without this, fewer would have got it right.

In spite of its high score, the glockenspiel was very difficult. It was given away by a slight tinkle on one note due to insufficient chopping of the starting transient when editing. The effect was of a pure clear tone very much like the flute. The violin was also difficult, many confusing it with the clarinet and vice-versa. It was even mistaken for the trumpet and piano in some answers.

A most peculiar effect was given by the piano, and 30% failed to get it right. The sound was more like a mellow brass instrument! All participants said that the test was difficult, and many, though giving the right
Listening Fatigue

A strange effect this, and often unsuspected. After a spell of listening to recorded music, various symptoms may arise. These can range from a mild feeling of having heard enough, to feelings of unease and actual irritation. It may not be actually associated with the sound heard, but these nevertheless are the cause.

So what causes listening fatigue? Distortion is certainly one of them. Even harmonics generated by the reproducing equipment, although related as harmonic distortion are harmonious with the fundamentals and can be tolerated in quite large doses. Odd harmonics are dissonant, and small amounts can be unpleasant. Crossover distortion, inherent with simple class-B output stages, consists mostly of third harmonics. Although reduced to very low levels by sophisticated design, it can still have an effect, even if to a lesser extent.

Another cause is intermodulation distortion. Here, harmonically unrelated spurious frequencies are generated by the interaction of two signal frequencies. Complex waveforms consisting of many frequencies can generate an abundance of spurious ones, and nearly all discordant. This too can result in fatigue.

A further cause is excessive high-frequency response. Peaks in the treble can over-emphasize the natural harmonics of the musical instruments. The effect may be an apparent brilliance which is not unpleasant, but even stimulating to start with, yet can soon produce fatigue symptoms.

Holophony

A couple of years ago (in July 1983) we published an article on Holophony, and for fuller information you should look there. However, since that article was published, the editor has had a chance to discuss the holophony with the inventor, Hugo Zucarrelli. The basis of his theory is that the ear actually emits a sound of its own, which interferes with the incoming sound. This interference pattern is decoded by the cochlea, which, with sound travelling in opposite structure as a sonic interferometer.

As readers will guess, reactions to this sort of theory have ranged from polite disinterest to noisy dismissal. This hasn’t been helped by the somewhat disappointing results on the holophony demonstration record, or Hugo Zucarrelli’s rather secretive attitude towards his invention. However, he certainly convinced the editor that the standard explanation for how we locate sound sources is inadequate.

Over-efficient loudspeaker tweeters, spurious oscillation in cross-over networks, and tweeters that beam sound directly at the listener can all be responsible. Boomy bass can be annoying, though this is less heard nowadays than it used to be.

Some interesting experiments were conducted at Kings College, Cambridge, by Dr G Cross in the early part of the last decade, on listening fatigue. It was found that valve amplifiers produced less fatigue than transistor ones. At that time crossover distortion was more pronounced with the then current transistor designs, whereas many valve amplifiers operated in class-A. However, another possible contributing factor is the extended HF response of transistor amplifiers compared to that of valves. Transient distortion is another amplifier defect that could have an aural effect. It is caused by delay in the negative feedback signal reaching an earlier controlled stage, so that it is too late to reduce sudden transient signals. The result is an overloaded stage and severe distortion. However, because it passes quickly it may not be consciously noticed.

Dr Cross also found that fatigue was produced when the reproducing system was upgraded. This was explained by a frame of reference being established by the inferior equipment. If used for a period, this is taken as ‘normal’. This difference in performance of the new system, say an improved HF response, violates the established frame of reference. In time, the new system itself becomes accepted as the norm, but during the adjustment period, fatigue symptoms can be encountered.

Yet another effect could be described as the ‘new equipment anxiety syndrome’. This is possibly more likely with hi-fi enthusiasts than with listeners who buy equipment just to listen and enjoy the music. Enthusiasts tend to be very critical, so having spent much time and effort evaluating different products, then finally taking the plunge and acquiring a particular outfit, there is anxiety, conscious or unconscious, as different favourite records are played, lest the new purchase be found wanting in some respect.

This could explain why those folk who are constantly changing their equipment never seem to get any real enjoyment from it, and so make yet another change — they are in a constant state of anxiety!

Listening fatigue though is not brought on only by reproduced sounds. Dr Cross’s research was initially stimulated by the fact that some lecturers at the college were holding students’ attention while other parts of the same material and teaching techniques were not. It was found that the voices of the unsuccessful ones were in fact producing listening fatigue which affected attention and also retentivity of students.

One interesting fact that came to light was that female voices were less likely to produce fatigue than male. Apart from the possibility of the students being predominantly male, hence more likely to be attentive to a female speaker, a possible explanation for this is the harmonic content of the female voice. Although the female voice is pitched higher than the male, it has fewer harmonics, hence a purer tone. The male voice, though deeper, has more harmonics and therefore extends higher in the overall frequency spectrum. As we have previously seen, an excess of high frequencies, or prominent harmonics can result in fatigue.

We do not know all the mechanisms and psychological effects that are involved between the outer ear and the sensations of sound produced in the brain, but the outline here presented should help us appreciate the equipment with which we have been endowed and how it relates to reproduced sound in our homes.
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ETI APRIL 1985
RS232 I/O FOR
ZX81 OR
SPECTRUM

Designed for use with either the ZX81 or the spectrum, this project is for those who would like to be able to communicate with printers and other computers. Design and development by Peter Moore in conjunction with Newtech (Micro) Developments Ltd.

This RS232 interface provides a wide range of software programmable baud rates and a true positive/negative voltage swing at its output. The facility is provided for a 'ready' signal from external equipment to be read by the computer and the interface provides its own 'ready' signal for external equipment. The interface plugs into the rear edge connector of your ZX81 or Spectrum and a rear edge connector is provided so that further peripherals can be plugged in behind.

Construction
All the components used in this project are mounted on a single sided fibreglass PCB. There are fifteen links to be made on the PCB not counting the pads marked A, B and C. These pads are used to select either an active high (logic 1) or active low (logic 0) ready signal from the RS232 interface: if you link A to C the ready out signal will be active high; linking A to B will select an active low signal. Decide which you require and solder a link accordingly.

Solder the remaining fifteen links in position; note that three of these are located beneath ICs 1, 2

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<td>'Ready' line output</td>
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<td>0V/GND</td>
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<td>Serial output (TX)</td>
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<td>5</td>
<td>Serial input (RX)</td>
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Table 1 Connections to SK2

Fig. 1 Overlay diagram of the interface board

PARTS LIST

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</tr>
<tr>
<td>IC6 74LS00</td>
</tr>
<tr>
<td>IC7 7660</td>
</tr>
<tr>
<td>IC8 1488</td>
</tr>
<tr>
<td>IC9 7005</td>
</tr>
<tr>
<td>D1,2 1N4148</td>
</tr>
<tr>
<td>AC1,2 8ZY88C4V7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MISCELLANEOUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1 2.4576 crystal</td>
</tr>
<tr>
<td>SK1 23 + 23 way ZX81</td>
</tr>
<tr>
<td>Spectrum edge connector</td>
</tr>
<tr>
<td>SK2 5 way 0.1&quot; PC plug and in-line socket</td>
</tr>
</tbody>
</table>

PCB: rear edge connector strip, IC sockets: 1 off 40 pin, 1 off 16 pin, 5 off 14 pin, 1 off 8 pin; wire, solder, etc.
and 3; you may wish to solder these on the copper side of the board, in which case use insulated wire.

Next insert and solder the two diodes D1 and D2 and Zener diodes ZD1 and ZD2, making sure they are the right way round. Solder resistors R1 (10MΩ) and 2 and 3 (1kΩ).

Now insert and solder the IC sockets one at a time taking care to ensure that all pins are soldered and that there are no solder bridges across any of the PCB tracks.

Solder IC9 in position taking care to mount it with the flat, metal side facing the nearest edge of the PCB. Insert and solder metal side facing the nearest edge to ensure that all pins are soldered together so that they touch their corresponding tracks on the PCB surface.

Before inserting the ICs, make a final check of all your soldered joints and make sure there are no solder bridges across any of the PCB tracks. Carefully insert the ICs making sure that they are the right way round, in the right sockets (!) and that no IC pins become bent under their respective ICs.

You can check that your RS232 interface is working correctly by temporarily connecting SO and SI directly together; data sent to the RS232 board to be transmitted should appear at the RS232 input port.

### Programming

The RS232 interface provides software control over the transmission/reception baud rate, the number of data bits per character and the number of stop bits appended. Programming is accomplished by means of a data byte written to the interface board's status port (see Table 2). A logic 1 in bit D7 (TSB) will select two stop bits while logic 0 will select 1 stop bit.

<table>
<thead>
<tr>
<th>NB2</th>
<th>NB1</th>
<th>Bits/char</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3 NB1 and NB2 programming. Note that the Bits/char figure excludes start and stop bits. A combination of two stop bits and five bits per character will result in 1½ stop bits.

NB1 and NB2 select the number of data bits per character (see Table 3). Where the number of data bits per character is five and the number of stop bits selected is two, 1½ stop bits will be appended. To select (for example) two stop bits, eight bits per character at 1200 baud: 1111 1011₂ = FB₁₆ = 251₀ (D4 is unused and can be either 0 or 1).

Three bits read from the RS232 interface's status port indicate the current state of the UART and the equipment it is communicating with (by means of the ready line) DAV is the UART data available flag; this will be logic 1 when data (which has not yet been read by the computer) has been received by the UART. DAV connects to D3.

IC3 is an AY-3-1015 UART (Universal Asynchronous Receiver/Transmitter). One of the most successful devices ever produced, it is designed to interface serial to parallel and parallel to serial data channels.

The AY-3-1015 consists of two main sections: a transmitter, which converts parallel data latched into the IC into serial form, adds start and stop bits and transmits the data from its serial output, and a receiver which converts serial data to parallel form at the serial input to parallel data.

The UART requires a clock signal sixteen times the required baud rate; IC2 is a programmable baud rate generator which, in conjunction with crystal X1, R2, C1 and C2, supplies a range of software programmable baud rates.

UART Flag TBMT (Transmitter Buffer Empty) is at logic 1 when the UART can receive further data to be transmitted in serial form. The state of TBMT and the ready input line RDY (for transmitting data) and DAV (Data Available) for receiving data are read into the computer by a read from the status port (A₆=0).

When such a status read operation is made, the output of IC4d is taken to logic 0; this line is taken to IC5c whose output is connected in open collector fashion to D6, IC5c then communicates the current state of the ready input to the computer data bus. IC4d's output is also connected to the SWE (Status Word Enable) input of the UART; when SWE is taken to logic 0, DAV and TBMB (which are tri-state outputs) are enabled and pass the current UART status to data bus line D0 and D7 respectively.

Data to be transmitted in serial form is latched into IC3 by DS being strobed to logic 0. When IORQ, A7 and WR are at logic 0, DS will be taken low latching the data on the data bus into the UART. The UART converts this data into serial form adding start and stop bits (no parity - NP is connected to Vcc) and outputs it to the UART serial out (SO) line.

IC8 is an RS232 line driver IC which inverts the serial data providing approx +9 volts for a logic 0 input — 9 volts for logic 1. IC8 is powered from the +9 volt line from the computer; it also requires a negative supply of similar magnitude to the +9 volt line.

### Table 2 Significance of bits used to program the interface.

<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>
</tr>
</thead>
<tbody>
<tr>
<td>TSB</td>
<td>NB2</td>
<td>NB1</td>
<td>not used</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Baud rate selected.

<table>
<thead>
<tr>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
<th>Baud rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9600</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4800</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2400</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1200</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>134.5</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2400</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4800</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>9600</td>
</tr>
</tbody>
</table>

Table 4 Baud rate selection.
HOW IT WORKS

The ready line (RDY IN) indicates the state of the devices with which the RS232 board is communicating; depending on this piece of equipment, RDY will be either 0 or 1 when further data can be transmitted. RDY connects to D6 during status read operations.

Spectrum Programming

Two IN/OUT port addresses are used by the RS232 Board:
- OUT 65471 is the (status out) program port.
- IN 65471 is the status input port; OUT 65407 is the data output port;
  IN 65407 is the data input port.

Before being used to transmit and receive data, the UART should be read (to reset DAV if necessary and also the ready output line) and the required baud rate, number of data bits per character and number of stop bits required should be written to the status port, e.g.:

0 PAUSE 1: LET A=IN 65407
20 OUT 65471, x

where x is the UART programming data.

The subroutines listed in Fig. 4 could be used for data input/output operations. An alternative

---

Fig. 3 Circuit diagram.
PROJECT: RS232

1000 REM Spectrum subroutines - input data
1010 PAUSE 1: LET a=IN 65471: IF a/2=INT (a/2) THEN GO TO 1010:
REM loop if DAV=0
1020 PAUSE 1: LET a=IN 65471: RETURN
1030 REM Outputting data
1040 PAUSE 1: LET a=IN 65471: IF a<192 THEN GO TO 1040: REM loop
if RDY or TBMT =C
1050 OUT 65437,n: RETURN

1075 REM Alternative line 1040
1040 PAUSE 1: LET a=IN 65471: IF a(120 OR a)=191 THEN GO TO 1040

Fig. 4 Spectrum subroutines.

1 REM Program to output at string of data to a printer
180 INPUT 10: LET i=10+CHR$(15): REM 10 ends with carriage return
110 FOR f=1 TO LEN i: LET n=CODE i(f)
120 FOR f=1 TO LEN if: LET n=CODE if(f)
130 IF a/Z=INT (a/2) THEN GO TO 1010:
140 IF a<128 OR a>191 THEN GO TO 1040:
150 LET A=USR 16514
160 LET A=USR 16528
170 LET A=USR 16540
180 LET A=USR 16544
190 LET A=USR 16550

Fig. 5 Spectrum program to output a string of data to a printer.

ZX81 Programming

Since the ZX81 has no IN and OUT commands, three short machine code routines are used (see Fig. 6). Before being used to transmit and receive data, the UART should be read (to reset DAV if necessary and also the ready output line) and the required baud rate, number of data bits per character and number of stop bits required should be written to the status port, eg: 10 POKE 16545, x 15 RAND USR 16544 where x is the UART program data.

To read data in from the RS232 port use:
LET A=USR 16514
The subroutine checks the state of DAV and, if DAV =1, inputs the data and returns it in variable A. Since it is highly undesirable (from the user's point of view) for the computer to enter a machine code loop (if DAV is 0), the subroutine returns whether or not new data has been received; if it has, A will return holding a number greater than 255, otherwise A will of course be less than 256.

As before, the subroutine does not cause the computer to enter a loop if TBMT and/or RDY is inactive. The number returned in A will be less than 256 if the data has been output, otherwise A will be greater than 255.

Fig. 7 gives a short BASIC subroutine that could be used to output data.

Poke 16540, x LET A=USR 16528 where x is the data to be output.

As before, the subroutine does not cause the computer to enter a loop if TBMT and/or RDY is inactive. The number returned in A will be less than 256 if the data has been output, otherwise A will be greater than 255.

Fig. 7 also gives a short BASIC subroutine that could be used to output data.

Fig. 6 ZX81 BASIC machine code subroutine, with a program to get it into the memory. If RDY is active low, data for 16536 should be 191.

Fig. 7 ZX81 machine subroutine.

BUYLINES

All components used in this project with the exception of the PCB are readily available from electronic component suppliers. The PCB is available from Newtech (Micro) Developments Ltd. for £5.80. Newtech also supply a full kit of parts for the project at £28.95 and will also supply the RS232 interface built and tested and mounted in a case for £33.95. These prices are all inclusive. You can find Newtech at 1 Courtaulds Road, Newton Abbot, Devon TQ12 2JA.
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As a preamble to a discussion on the nasties of transistors, John Linsley Hood reveals that the carbon diode (more accurately, the coke diode) pre-dated germanium and silicon types.

When I was about nine years old, my grandfather gave me an old crystal radio to play with. This was one which he had made for himself, and used during the 1920s. My own reaction was that if it had worked once, it should work again, so I took it all to pieces, and cleaned it most carefully and put it back together, and indeed it did work again, though the 'crystal' was a bit decrepit and it needed a lot of patience to find a workable spot for the 'cats whisker'.

This set me to experimenting to see if I could find any useful substitute for the now rather eroded lump of lead sulphide, and I found in due course that a piece of domestic coke would work quite well. The reason why a crystal and 'cats whisker' works at all is shown in Fig. 1, and, surprisingly this forms the foundations for the whole of present day semiconductor electronics.

At a junction between a conductor (the copper or silver wire 'cats whisker') and a semiconductor (the occasional small areas on a crystal of lead sulphide, or, in my case coke), a 'depletion zone' will arise in which electrons from the semiconductor will be absorbed by the conductor, leaving a region empty of electrons surrounding the point of contact. Current can now pass from the conductor into the semiconducting region, but not conversely, unless a fairly high potential is applied; the junction acts as a rectifier.

In the case of a metal/semiconductor junction, the current vs. voltage characteristics of such a junction are as shown in Fig. 2 with the bit of the graph just around the origin expanded. This kind of characteristic is helpful if it is to be used as a detector in a crystal radio, since the voltages available at the rectifier are extremely small, virtually just what comes out of the aerial wire multiplied by the Q of the aerial tuned circuit; so any kind of 'dead space' around the zero voltage point on the graph would cause the signal to be lost.

This type of crystal/cats whisker diode was employed during the war years when very high frequency rectifier diodes were needed for use as detectors (i.e. rectifiers) at the input of centimetric radar receivers. Since it was not possible at that time to amplify the RF signals at those frequencies, all that could be done was to demodulate the RF input from the aerial, and then amplify the resultant relatively low frequency pulse signals.

The type of construction employed is shown in Fig. 3, and the semiconductor employed was a tiny chip of nearly as possible single-crystal silicon. If the surface was carefully cleaned and etched, almost any point on it would work, and the 'whisker' could be kept in place with a filling of some hard wax, provided that this didn't seep between the metal whisker and the crystal surface.

So far as I was concerned, my experiments with crystal radios were a dead end, and as soon as pocket money and circumstances allowed, I moved up to thermionic...
valves — nice shiny things, whose glass envelopes could be polished, and which always worked if their filaments were intact. These were much more predictable than crystals and cats whiskers, and they could be used to amplify signals which crystals could not.

However, in the USA, Shockley and his colleagues at the Bell Telephone Labs. had not forgotten the crystal diode, and were actively considering the ways in which this could be made to amplify. Their approach was that shown in Fig. 4. 

![Fig. 4 Early point-contact transistor.](image)

**Point Contact Transistors**

This type of device operated on the principle that a region of semiconducting material — by which I mean things which are neither metallic (and therefore good conductors) nor insulating (materials like germanium, silicon, and some forms of carbon, are examples) — depleted of electrons by its contact with a conductor, would allow an input of electrons, but would now allow an outflow.

However, Shockley and his colleagues, Bardeen and Brattain, reasoned that if two-point contact diode 'whiskers' were very close together, then current injected into the semiconductor by one metal point, and which would only need a low potential to achieve this forward conduction, might be swept up by the, other, reverse-biased diode and cause a current to flow in this where previously there had been none. The advantage of this would be that a relatively high voltage, several volts perhaps, could be applied to the emitter whereas only a fraction of a volt would be required at the emitter — as the forward-biased point was named.

Happily, the idea worked, and because the main characteristic of such a point contact device was that the resistance of the input electrode was low, whereas that of the output, reversed-bias electrode was high, the device was known as a transfer resistor (it transferred the current from a low resistance circuit to a high resistance one) or transistor for short.

The proportion of current which was actually transferred from one electrode to the other was known as alpha (α), and this was a measure of the skill in getting the points close together. Ideally it would be unity, which would imply that all the electrons emitted would be collected. Curiously, though, it could sometimes be higher than this if the interaction of the injected electrons with the base material caused new electrons to be generated.

For this type of transistor to work, the base material would have to be one having a deficiency of free electrons in its structure. Nowadays we would refer to this as P-type material.

**Junction Transistors**

Understandably, the kind of transistor which Shockley and his colleagues first developed would have been very tiresome to try to manufacture on any sort of commercial scale, so the scheme shown in Fig. 5 was used instead, in which a slice of germanium was etched away from both sides by jets of hydrofluoric acid until the two cavities almost met. Point contact wires could then be applied from either side and would be separated by a region which was as narrow as the thickness of the residual base material.

![Fig. 5 (left) Commercial point-contact transistors.](image)

This was better, but still a bit awkward to make and not very shock proof. The answer to this was to replace the wire point contacts with deposited blobs of metal, as shown in Fig. 6. If these were made of Indium, this would diffuse into the P-type base, causing an N-type region which would work just as well as a metallic whisker contact. The final development of this system came with the structure shown in Fig. 7, where the base was just a thin layer of mono-crystalline germanium 10 to 20 thous. thick, with indium blobs applied to either side, and then heated to cause it to diffuse inward.

![Fig. 6 (right) Improved point-contact transistors offering greater immunity to mechanical shock.](image)

![Fig. 7 First true junction transistor.](image)

The closer the two diffusion layers got together the higher the current gain would be, so it was a matter of some skill in the making of such devices to stop just in time. If the two inward diffusing regions met in the middle — like Aunt Emily's shingles — the result would be a defunct device. As an extension of this, if the user allowed the device to get hot, the diffusion would continue, and the transistor's current gain would get higher and higher, until finally it would short-circuit.

Silicon would be a better material to use from the point of view of its thermal stability, but it had not been favoured in the earlier transistor types because of the difficulty of obtaining high current gains. Speaking from the point of view of a traditional two-sided diffused junction transistor, current gains in the common emitter mode (β) of 50-100 could be obtained with germanium, but only in the range 15-25 with silicon.

This difficulty was resolved when the planar form of transistor construction was invented by the Fairchild Instrument Corporation. This is shown in Fig. 8.
Planar Transistors
These employ a thin wafer of very high purity monocrystalline silicon as the substrate, doped with a suitable trace quantity of some impurity. For example, boron will give a P-type result, and arsenic will make an N-type material. These impurities can be diffused into the crystalline slice from one side only (where the term planar is supposed to imply this), and if a normally N-type substrate is diffused with sufficient P-type impurity, through some sort of vapour-resistant diffusion mask, the result will be a P-type area, as shown in Fig. 8. If the wafer is then masked again to give a smaller area, an N-type impurity could be diffused into the middle of this region, to give a transistor of the kind shown in Fig. 9.

Because the effective base region, the P-type sandwich filling between the two N-layers can be made very thin by careful control of the diffusion process, current gains of 400-500 are feasible. Moreover, if the device becomes hot, both regions will diffuse — if they do at all — in the same direction, so the problem of them meeting head-on is lessened.

However, the main advantage of this kind of construction is that it is possible to make many hundreds of transistors at a time on a single thin wafer of silicon. Nowadays these can be 5 or 6 inches in diameter, so, with a transistor occupying a chip probably only 0.1" square, the possible output per wafer can be visualized. This has brought the cost of such devices down dramatically, so that to a manufacturer who buys in bulk, small signal transistors will not cost much more than 1p each.

Epitaxial Planar Transistors
These are a development of the basic planar construction of Fairchild, with the difference that a thin layer of monocrystalline material is grown onto the surface of the wafer, as in Fig. 10, before the selective diffusion processes are begun, to arrive at the cross-sectional structure shown in Fig. 11. This has the advantage that the base region is now formed in the epitaxially grown layer, and this will have just one impurity element, not two.

This is advantageous because the breakdown voltage of a transistor is determined by the base region, and a singly-doped layer will have better characteristics than a doubly-doped one. Also, the emitter-base junction will have better characteristics because the emitter will now have only two diffused-added impurities instead of three.

Most modern small-signal transistors are of the epitaxial base type, because they are easier to make in good yields, and are as good or better in performance. There is also a small advantage in the noise characteristics of epi-base devices, in comparison with straight double-diffused planar ones, which is an added bonus.

Junction Transistors — How Do They Work?
The method of operation of the common base (ie, base connected to the common or OV line, and the input signal applied to its emitter) point-contact transistor,
sketched above in Fig. 4, is fairly easy to grasp; however, the way in which a common emitter junction transistor works is very much more difficult to visualise, or explain in any manner which would both be simple and also would reconcile the several physical concepts now accepted by the solid-state physicists. However, it is possible to offer a model which doesn't take too many liberties with the accepted theories, and yet is fairly easy to follow. This is as follows.

Consider the semiconductor sandwich which I have sketched in Fig. 12, made from two layers of N-type semiconductor material, on either side of a thin slice of P-type. Now if a good connection is made to the P-type material (and for good transistor performance this is very necessary) and this is connected to the battery at the same point as the lower N-type slice, then the N-type region at the bottom of the diagram and the P-type region in the middle of the sandwich will be at the same potential. There is therefore no incentive for electronic current to flow from the (electron rich) N-type zone into the P-type (electron deficient) middle layer, so this remains short of mobile electrons, and when switch SW1 is closed, no current flows through the load resistor (R1) or the meter.

Fig. 12 Semiconductor sandwich (see text).

However, if the voltage on the P-type layer is gradually increased by a potentiometer, as shown in Fig. 13, eventually the forward bias on the middle layer will become high enough for electrons to be attracted from the lower — let us call it the emitter — N-type region into the middle P-type slice. If this layer is thin then most of these will be drawn across this region into the top N-type zone — which I propose to call the collector — and current will flow in the load resistor and meter.

Fig. 13 Semiconductor sandwich with voltage applied to the P-type layer.

The amount of current which will flow in the P-type region, which I propose to call the base, will be the difference between the number of electrons leaving the emitter region, and the number which is promptly swept up by the positively charged collector region. If all of them were to be lost to the collector, there would be no current flow in the base at all. I am not sure what would happen then!

The way in which the current flow in the collector circuit varies, as the voltage applied to the P-type base region in the middle of the sandwich is increased from 0V upwards, is shown in Fig. 14. and I have shown the base current flow in the same diagram. Conventionally, the ratio of total current to base current (I/Ib) is known as the current gain or beta (b).

Several important conclusions can be drawn from this model. The first of these is that the thinner the base region, the higher the current gain will be. Also, since the only thing which stops current flow from the emitter to the collector is the thin base region, the thinner this is, the lower the collector-emitter breakdown voltage will be, though this also depends on the doping levels and extent of unwanted impurities in the three regions. Nevertheless, a transistor with a high current gain is likely to have a lower c-e breakdown voltage than a transistor with a low beta.

Another point which can be inferred from Fig. 12 is that if the base region is open circuited, leakage currents from the base region into the collector will cause the base to have a positive voltage, and will consequently cause an amplified emitter-collector leakage flow. So, make sure that the base circuit return path resistance is not too high. Also, since leakage currents get worse with temperature, if the device is going to get hot, it will need a lower base circuit resistance for a given overall collector leakage current level. Because transistors with high current gains require less base current for a given collector output current, and for a given base voltage, the input impedance, as seen at the base of the transistor, increases directly as the current gain is increased, and this makes such high-beta transistors useful in high impedance, low signal level circuitry.

The kind of device I have sketched, in crude form, in Figs. 12 and 13 is an NPN device (though in practice it would be made in the forms shown in Figs 8/9 or 11). The same sorts of argument are appropriate if one credits holes ( Places where electrons should be but aren't) with the same qualities and ability to move as positive electrons. For all practical purposes this is true, but the 'holes' move much more slowly, and they can become trapped or detained in unwanted impurities or crystal lattice defects, leading to delayed responses in operation — particularly noticeable in pulse propagation systems.

Because PNP transistors have an N-type base region, where all the movement of charge is by electrons, PNP transistors usually have a lower noise level than NPN ones, and would usually be preferred for low signal level audio input circuits.

I will talk about some of the less common aspects of transistor operation later in this series, and also show how circuit calculations are done with the Y, Z and H parameters. However, next month I propose to take a closer look at small signal and power transistors, and their uses and limitations.
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!!Brainstem Issue 2 out soon!!
BUZBY METER

Here’s a project for all our readers who have contributed to that great national charity — British Telecom. Design and development by Nick Payne.

You stare blankly at a telephone bill which baldly declares “4077 units — £205.30” and you wonder how it all happened. You use a neighbour’s phone and are uncertain whether to leave 10p or £5 or something in between. You may be a hesitant speaker on the phone worrying about how much it must be costing, which might, in fact, be surprisingly little or maybe, for business purposes, you would like to charge the cost of a call to a certain account.

From all these situations the Telephone Call Meter, sometimes known as the “Buzby Meter” described below can rescue you.

Overview

This device is an aid to checking the cost of telephone calls. Before a call is made, an amount equal to the cost of a small time interval (7.5 seconds) of the call is entered on the keyboard and the cumulative cost of the call is shown on the display, incrementing every 7.5 secs. For convenience a list of the most used rates is attached to the device.

The device uses the auto-constant feature available on most calculators. It consists of an electronic calculator plus timing circuit, which operates on the auto-constant key of the calculator. As an example, a call to a certain town might cost 2.6p every 7.5 secs. Before the call is made 2.6 + \(=\) is entered on the keyboard. When the called party answers, the timer is started and 2.6 is added to the display every 7.5 secs, giving the true cost of the call as it progresses. The “+” key actuates the auto-constant in the add mode.

The circuit of Fig. 1 shows the timer circuit operating a CMOS analogue switch is in parallel with the “equals” key which causes the constant to be added.

Furthermore, the timer circuit automatically takes account of the
HOW IT WORKS

Referring to Fig. 1, IC1 is a 4060 CMOS oscillator ripple counter. The frequency of operation is controlled by C1, R1, R3 and RV1. It is trimmed to 68.27/512Hz or once every 7.5 secs. With the switch SW3 set at Dial, this waveform is fed into the monostable formed by IC4b, R5 and C2. Negative edges on the Q9 waveform are converted into negative-going pulses of 50ms duration. For the timer to run, SW2 is open, putting a low level on the reset input of IC1 and high level on the output of IC4a. This turns on CMOS analogue switch IC3c.

The positive going pulses are therefore switched through to IC3d. IC3d is wired in parallel with the "equals" key on the calculator keyboard, so that when it is pressed on, the calculator chip responds by incrementing the displayed value.

When the telephone call is finished, the user resets the counter to prevent further incrementing of the display by closing SW2. Reset will force all counter outputs low. If Q9 is high before reset, resetting will present a negative going edge causing it to output a pulse. This pulse is prevented from reaching the calculator by the output of IC4a going low, turning off switch IC3c. R6 pulls the output of IC3c low when it is off. The feature for calculating the 3 minute minimum charge imposed on some operator calls is performed by the two latches formed by IC2a with IC2b and IC2c with IC2d and analogue switches IC3a and IC3b. The user sets SW3 to "OPR". Refer to Fig. 2 for detailed timing of waveforms.

During reset, latch IC2a/b is set so that IC4b output is high and latch IC2c/d is set so that IC4d output is low. Therefore, switch IC3a is on and IC3b is off. R4 pulls the output of the switches low when they are both off.

When the reset is removed and the counter starts, 2 cycles of 2.13 Hz from Q5 passes through IC3a to the monostable, thus pulsing IC3d twice, causing the calculator to add the initial displayed quantity to itself twice, effectively multiplying it by 3. This now represents the 3 minute minimum charge.

Q7 goes high after approximately one second resetting latch IC2a/b and turning off switch IC3a. This prevents any further pulses from Q5 reaching the monostable. After 2 minutes Q14 goes high resetting latch IC2c/d closing switch IC3b. This allows Q12, which next goes low after 3 minutes, to be fed through to the monostable, incrementing the displayed quantity at the end of 3 minutes and thereafter every minute.

The circuit will run off any voltage between 3 and 18 and would normally run off the same voltage as the calculator. However, the RC oscillator clocking IC1 is less stable when the supply voltage is less than 4V. Substituting a 74HC4060 and 74HC4016 for IC1 and IC3 would improve performance with a 3 and 4V supply. A solar powered calculator may work here if the solar cells have enough excess power in normal light. At 4 to 5V a 4066 is better than a 4016 for IC3. The supply rails to the calculator chip must lie inside the rails to the timing circuit for proper operation of switch IC3d. Supply current is approximately 70µA at 6V. The device will normally be 1% accurate at room temperature, which is the accuracy the clock can be trimmed to.

Connecting The Calculator

To find if your calculator is suitable for this conversion, first it must have an auto-constant. This typically works as follows:- pressing "1" causes the display to go 1,2,3, etc each time the = key is pressed. In this case = is the auto-constant key with 1 being the constant. Your calculator may work slightly differently, but if you cannot get it to work in this fashion at all, it is not suitable. Otherwise make a note of which is your auto-constant key. This is the one which the timing circuit is connected to.

With the calculator switched off, open the back and find the leads that go from the keyboard to the chip. Keep the auto-constant key depressed, find with an ohmmeter which two of the leads are connected, and which are not connected when the key is released. On some calculators any impedance below 50k is considered a connection. Do not use a X10k range on the ohmmeter or the chip may be damaged.

If you have an LCD or a modern LED calculator that is all that is needed, these two leads can be connected either way round to the output of the timing circuit. However, older LED and all fluorescent display calculators have a negative bias rail of typically 30V generated by a DC-DC converter (see Fig. 4). In this case, with the calculator switched on, check which of the two keyboard leads selected above has the most negative voltage. This is the "D" lead. Better still with a
'scope, the "D" lead will be seen to have negative going pulses on it, while the other lead, the "K" lead, will be floating. In this case add the extra circuit shown inside the dotted box in Fig. 1. (X2, X3, R7-R9, Q1).

Mounting And Power Supply

With a larger calculator, there is probably room for the timing circuit somewhere inside the case and room for the switches on the front panel. For the smaller slimline calculator it is better to mount everything in a flip-top box, e.g. Vero 75 - 3018C. Fig. 5 shows this method of mounting.

In the author's version, and APF M1920 calculator was used. the two button cells are removed and two lengths of wire approximately 30 SWG, 8" long are connected to the + and - pads. Two more pieces are connected with great care (the pc pads are small) across the = key. A piece of masking tape can provide temporary strain relief for the four wires. The soldered joints should be kept low and smooth to avoid shorting to the back of the case.

Drill a small hole in the back of the calculator to allow passage for the four wires, and carefully remove all burrs. A matching hole should be drilled in the front panel of the flip-top box, along with holes for switches SW1-3, and any holes necessary to give access to the screws which hold the calculator body together. Glue the calculator case back to the panel of the flip-top box (or bolt it to the panel, if there's room inside the calculator case for the screw heads). Do make sure all the holes line up before the glue sets!

Feed the four wires from the calculator through the appropriate hole, then screw the calculator body onto its case back; make sure you pull the four wires through as the calculator body comes together.

The power supply is wired as Fig. 3 because 3V is not enough to run the circuit board; this is got around by soldering a 3V tap onto the battery holder. On the circuit board connect the two keyboard leads from the calculator to points A and B. Leave out links X2, X3 and R9 and Q1 but put in link X1.

Fluorescent Display Calculators

For an older LED display or a fluorescent (green) display calculator all components on the printed circuit board except X1 must be mounted. In this example a National Semiconductor 200 type calculator was used (for information on this chip MM5795 and calculators in general, refer to National Semiconductor MOS/LSI Databook 1977 Edition). The 'D' input which is the most negative key line is connected to R7 and the 'K' output, the floating input to the chip is connected to Q1 collector. See Fig. 4 for power connections; in general the +V line to the circuit board should go to the most positive point found in the calculator, while the 0V should go to a point not more than 15V negative of this point. With luck you can use the calculator on-off switch to switch the circuit board as well.

Hand-held calculators of this type are too thick to mount on top of the front panel of a flip-top box, but can be clamped underneath with a cut-out for the keyboard and display. Also take the opportunity to mount bigger batteries then those that fit inside the calculator.

Trouble-Shooting

If nothing seems to work, first check that all components are correctly inserted and there are no dry joints or solder bridging of tracks. Then check the power is supplied to the board. Check the oscillator IC1, C1, R2, R3 and RV1 with a 'scope, signal tracer or audio amplifier. Then check the countdown chain Q4-Q14 (the outputs change slowly enough to be seen with a voltmeter). Check the rest of the circuitry with SW3 in the 'DIAL' position, referring to Fig. 2. C2 and R5 set the pulse length to the keyboard. If your calculator is slow it may not see this pulse. Try increasing C2 or R5.

<table>
<thead>
<tr>
<th>Peak (9-1, M-F)</th>
<th>Standard ((6-9, 1-6, M1-F)</th>
<th>Cheap (all other times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L 0.45</td>
<td>0.34</td>
<td>0.08+</td>
</tr>
<tr>
<td>a 1.35</td>
<td>0.90</td>
<td>0.34+</td>
</tr>
<tr>
<td>b1 2.25</td>
<td>1.69</td>
<td>0.67+</td>
</tr>
<tr>
<td>b 2.70</td>
<td>2.03</td>
<td>0.84+</td>
</tr>
</tbody>
</table>

Table 1 Figures to enter to get the costs.
Using The Telephone Call Meter

If the meter is mounted in a fliptop box, you have a convenient place (in the lid) to glue the call charges. The machine works by adding on the charge for 7 1/2 seconds of the call. Although telephone charges are reckoned by 4.7p message units, the length of which vary by the distance being called and the time of day, reckoning the call in 7 1/2 second chunks does not lead to any great inaccuracy. For a b-rate trunk call (over 35 miles) at peak rate you get 15 secs for 4.7p. Therefore 7 1/2 seconds costs 4.7 x 7.5/15 = 2.35p = 2.70p (inc 15% VAT)

To use the machine for such a call, set the OPR/DIAL switch to DIAL, key in 2.70p +, dial the call and when the called party answers set the STOP/GO switch to GO. The display will show 2.70 and every 7.5 seconds it will increment 5.4, 8.1, 10.8 etc. When the call ends, switch to STOP and the display will stop incrementing and there will only be a one or two pence error in the displayed quantity.

A partial list of call charges appears on Table 1. They are worked out by dividing 40.54 (the number of seconds for one unit (40.54 = 4.7 x 7.5 secs + 15% VAT). The final thing to do is to adjust RV1 until the calculated increments exactly once every 7.5 secs.

If the 3 minute minimum charge feature is not required leave out R4, IC2 and SW3, but ground pins 6 and 12 of IC3.

### Parts List

<table>
<thead>
<tr>
<th>Resistors (W 5%)</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R6, R7, R8</td>
<td>1M0</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>1M5</td>
<td></td>
</tr>
<tr>
<td>R3, R4</td>
<td>470k</td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td>47k</td>
<td></td>
</tr>
<tr>
<td>R9</td>
<td>200k</td>
<td>(or 220k) submin preset</td>
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</table>

### Capacitors

<table>
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<tr>
<td>C1</td>
<td>4n7</td>
</tr>
<tr>
<td>C2</td>
<td>100n</td>
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### Semiconductors

<table>
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<tr>
<td>IC1</td>
<td>4060</td>
</tr>
<tr>
<td>IC2</td>
<td>4001</td>
</tr>
<tr>
<td>IC3</td>
<td>4016</td>
</tr>
<tr>
<td>IC4</td>
<td>4069</td>
</tr>
<tr>
<td>Q1</td>
<td>2N2907</td>
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</table>

### Miscellaneous

<table>
<thead>
<tr>
<th>Value</th>
<th>Remarks</th>
</tr>
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<tr>
<td>SW1</td>
<td>SPST (or DPST, see text) slide or toggle</td>
</tr>
<tr>
<td>SW2</td>
<td>SPST slide or toggle</td>
</tr>
<tr>
<td>SW3</td>
<td>SPDT slide or toggle</td>
</tr>
</tbody>
</table>

Box (Vero 75-3018C or 75-3019) or similar); calculator; battery holder; wire, PCB, etc.

*May not be needed — see text.*

---

**Fig. 6 Overlay diagram.**

---

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---

**Etiquettes**

- **ETI April 1985**
- **Henderson's Audio**

---

**Footnotes**

- Nothing here should cause any problems.
- The PCB is as ever available through our PCB service.
UNIVERSAL EPROM PROGRAMMER Mk II

When the Universal EPROM programmer was published in August 1983, it was capable of programming all the EPROMs commonly available on the amateur electronics/small business market, and a few more besides. Since then, technology hasn't stood still, and nor have we! We present the Mk II version, which will be capable of programming the newer EPROMs now in circulation. Readers who have built the earlier version need not despair, because an upgrade for this will also be described.

DIGIVISION

The TV signal is sent in an analogue fashion — so what's the point of using digital signal processing in a TV? Vivian Capel investigates ITT's Digivision D1000, which has been seven years and £20 million in the making.

STEREO SIMULATOR

Finally, just in case you thought we'd gone completely digital, here's an audio project. It's a natty little device which can give you pseudo-stereo from a mono source, and it can also give spatial stereo as well. And it's small enough to be used as an internal add-on in a variety of audio gear.

DIGITAL SCOREBOARD

So you really would like your name up in lights? Sorry, but we can't help just yet — but here is a project that will your score up in lights. The modular approach of this design makes it quite flexible, and it can be controlled either by thumb-wheel switches or from a computer I/O port.

6802 EVALUATION BOARD

Here's a project that's been designed for people who would like to break into the world of machine code and microprocessors. It's based on the 6802 which is a version of the 6800 with one or two extra bits (no pun intended) added.

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Almost everyone watches feature films on television from time to time. These are the films which you might have seen at the cinema a year or two ago, and they were probably produced on 35mm colour film. Some pre-recorded video cassettes are also made from feature films, and in both cases the film is then viewed in a way not intended by the person who made it. Whether the dramatic material is as well suited to presentation on a small screen as on a large screen is often open to debate, but the technical quality of the programme is usually as good as we would expect it to be had the film been made specifically for television.

Colour Television

Before making any further reference to films, let’s refresh our memories on the subject of colour television.

The television picture is built up by means of an interlaced raster scan, illustrated in Fig. 1. In Britain a 625 line frame is used, built up from two 312.5 line fields. Fifty fields per second are transmitted, forming twenty-five complete frames. This method gives a reasonable compromise between vertical resolution and flicker, within the limits of the transmission bandwidth used.

As with the black and white system, colour television relies on the persistence of vision of the eye to prevent the viewer observing the scanning process which builds up the picture — it all happens too fast. The colour perception of the eye is also fooled into seeing that which is not there. The eye seems to assess the colour of the light it receives by evaluating the proportional stimulation of cells which respond to red, green, and blue light. The frequency response is sufficiently broad for there to be an overlap of response between red and green, and green and blue.

If, for example, a spectrally pure yellow light (a sodium street lamp is a good approximation) is shone into the eye, the green and red cells are both stimulated. The shade of yellow is determined by the proportional stimulation of the two types of cell. So far as the eye is concerned, the same colour is present if a mixture of red and green light in the right proportions is used instead of a single yellow light. This is how colour television achieves the effect of colour.

There is always a problem because not everyone’s eyes work in exactly the same way. Different people need slightly different proportions of primary colours (red, green, or blue lights) in order to produce the illusion of a certain spectral colour. The proportions are also affected by the precise wavelengths of the primary colours which are used. For this reason the choice of coloured dyes for film or light emitting phosphors for television is of great importance.

System Difference

The frame rate used for film is different from that used by any major television system in the world. Most film is taken at 24 fps (frames per second) but the television system in Britain works on 25 frames per second. This is close to the right speed, but American television gives worse problems with a rate of 30 fps.

Even if one were to run the film through a projector at the appropriate frame rate and televise the image directly, there would still be one major problem. The frame blanking period of the television system is much shorter than the time required to pull the next frame of film into view in the projector.

The sequence of operation in a projector is, approximately: 1) a shutter cuts off the light; 2) a claw, engaged with sprocket holes in the film, pulls the next frame into view; 3) the shutter uncovers the light source, so that the frame is visible. While the film frame is displayed it must be completely stationary or else it will appear blurred. Therefore a mechanical settling time is needed.

The result is that this means of televising a film, using a projector, screen, and television camera, would give black areas at the top and bottom of the picture. This occurs quite simply because the television camera is scanning while there is no image on the screen. If the phase of the projector and the television camera were to drift, there would be a black band settling in the picture. This would give wo-see problems with a rate of 30 fps.

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the periphery of vision than in the central area.

There are other points of incompatibility between film and television, and these generally show up the inadequacies of television. First, the contrast range which can be reproduced on film is very much greater than available from a television set. This is particularly true in a well lit room where a mid-grey area may appear to be black: anything dimmer than mid grey will be indistinguishable.

Film desaturation is in the primary colours used. Different film stocks use different sets of primary colours, but none of them are the same as the ones used in colour television. This causes both mild desaturation (alteration of the colour towards a neutral grey of the same brightness) and a change of hue (colour).

The aspect ratio (the ratio between the height and width) also differs between film and television. This applies most seriously to cinemascope films. The frame of a cinemascope film is the same shape and sized as that of an ordinary film, and in fact there is no mechanical difference. The difference is in the anamorphic camera lens used, which compresses the image horizontally. In this way, the breadth of the scene filmed is greater compared with its height than the width of the film frame compared with its height.

**Telecine Systems**

The above incompatibilities demand a special piece of equipment to convert from film to television. One intractable difference, which no conversion equipment can alter, is that the ordinary television system in this country cannot approach the clarity and detail of even a fairly ordinary quality film. Small details, clear on the film, simply show up as blurs on a domestic television. With this reservation, a good telecine machine can provide television pictures which go a long way towards doing justice to the film.

A number of different methods of film to television transfer have been used, but many of them are variations on a theme. There are three main methods.

The first, and least useful method, is to use a projector, screen, and television camera. In order to avoid the problem of black bands across the picture, very long persistence camera tubes are used so that the image persists during the time that the screen is blanked to move to the next frame. This delay causes streaks to be invisible behind moving objects. Due to the differences between three coloured channels, the streaks are normally multicoloured. This effect is present to some extent in all the home video cameras I have seen.

The long persistence camera technique has been (and may still be) used at some small TV stations in the USA, and is employed in the telecine adaptors available for home video use. It is not widely used.

**Flying Spot Scanner**

Many variations of this idea have been used, and for a long time it has been the major basic technique. The method is to display a television raster on a small cathode ray tube, and focus the image of the raster on to the film. The light passes through the film and then through red, green, and blue dichroic colour splitters and into photomultipliers, which give an electrical output proportional to the light of each colour. The digital signal generated is stored in a frame store and then read out at the normal television rate. This means, of course, that the scanning for storage is carried out at a faster rate than normal television scanning, and in a non-interlaced manner.

**Charge Coupled Devices**

This led logically to the third major technique of televising film, which uses CCD (charge coupled device) line arrays to digitise the film line by line as it passes by. The digital signal generated is stored in a frame store and then read out at the normal television rate.

This technique has recently become very widespread. Two of the major telecine manufacturers, Marconi and Bosch, make only CCD based machines, while another major producer, Rank Cintel, makes both flying spot and CCD type telecine machines.

**Flying Spot Variations**

A flying spot scanner without a frame store must track the film movement with the image of the raster. This has not always been accomplished electronically. One idea which was tried was the hologon, a multi-faceted prism made to spin so as to present a new face to each film frame. Its angles are such that the image of the raster is deflected to follow the film movement. Several machines of this type have been used at the BBC for many years.

A difficulty in the use of this system is that movement of a heavy, spinning, block of glass must be matched to the television synchronisation signals so that the optical changeover from one facet to the next occurs during the frame blanking period. Because high quality pictures are required, this is more difficult than the control of the heads in a video cassette machine.

The film, of course, also has to be synchronised in a similar manner, so there are two sources of mechanical error which must not add up to a noticeable picture disturbance.

---

**Fig. 2** The light passing through a colour film is directed through a series of dichroic filters to select the colours fed to the photomultipliers.
Hopping Patch

In many ways, it is easier to move an image on a CRT than to move it optically. Hopping patch is so called because the patch on the CRT hops between two locations, which correspond to the positions of the film frame the first and second time it is scanned.

The movement of the film is in the opposite direction to the direction of scanning, so the resultant raster is half the size that would be required to scan a stationary frame. Figure 3 illustrates this.

![Diagram of the hopping patch system](image)

This system still requires the film to be in the correct place at the correct time, but this is easier than synchronising a prism as well. It also has its own special problems. Because of the interlaced method of producing a television picture, alternate lines on the picture are scanned by the two rasters. If the positioning of each raster relative to the other is not very accurate, the picture details will not match between the two halves and a very visible jitter will result.

This applies to every part of each raster, so a deviation of more than half a television line width from the correct rectangular shape will cause an effect on the picture that would make some viewers seasick.

Film Tracking

Instead of forcing the film to be in the right place to be scanned at the right time, an electronic film tracking system can be used. This determines which of the film frames passing nearby is best placed to be scanned for the next field, and scans it. The position of the film is sensed by optical sprocket hole detectors or by the use of shaft encoders on sprocket wheels. This means that any small disturbances in the control of the film position will not contribute to jitter on the picture. The attendant disadvantage is that the rasters do not always occur at exactly the same place on the CRT, so the job of keeping the shape and positioning accurate is more difficult.

The film tracking method does have an attractive spin-off, which is that the precise film speed no longer matters so far as providing a good picture is concerned. This would allow a film to be played at 24 fps instead of 25 fps, on a British television system. A film can be stretched or compressed by a few percent to fit the standard programme times. In order not to upset those with perfect pitch, or even just good hearing, audio pitch correctors are available. These devices use memory to treat the sound rather in the way a frame store treats the video. This can result in some parts of the sound waveform being cut out, or played twice, but this is not normally noticeable.

Some Current Machines

Almost all of the telecine machines sold for professional uses nowadays incorporate framestores. The only exception to this is a new machine, shown for the first time at the IBC Exhibition in Brighton this year, by Independent Cine Equipment. This particular machine uses a film tracking technique to avoid the cost of a framestore, and to provide superior performance in those situations where a framestore is a liability rather than an asset. An illustrative example of a film tracking system is shown in Fig. 4.

The performance of this particular machine is probably comparable with that of some of the better known and more highly priced machines, but it does not offer computer controlled special functions. It is likely that, given the decreasing cost of memory, the extra cost of a frame store in an 'all singing, all dancing' machine would not be very significant.

Digiscan

The most widely sold flying spot telecine is the Rank Cintel Mk III C. This is available in a version using a hopping patch and a version using a frame store and a single patch position. The hopping patch option offers
operation only at standard film speeds, but it does offer a higher resolution than the frame store version which is limited by the number of memory locations used. An ordinary domestic television set would not show any difference but broadcasters seem to prefer hopping patch machines.

The frame store version (named Digiscan) offers variable speed operation, because regardless of film speed, there is always an up to date picture stored in the frame store. There is also a digital picture enhancement system which, though it cannot produce resolution that is not there in the first place, can greatly improve the appearance of a picture. One method of doing this is illustrated in Fig. 5, were a video edge is artificially sharpened to make the outline of an object appear crisper.

The enhancement shown is carried out on a single video line, and would only sharpen vertical lines on the picture. A frame store allows the comparison of a picture line with the one before or after it, so that differences can be emphasised, thus sharpening horizontal lines.

There is another great advantage with the Digiscan system. Because the film frame is scanned from top to bottom rather than in an interlaced manner, there is no chance that the position of the two interlaced fields finally displayed will not match up correctly even if the geometry of the scanning is imperfect.

**Colour Correction**

Any system of transferring film to video must take account of the higher contrast available on film, and the differences in the primary colours used. The effect of the higher contrast on the film is that, without any form of correction, large picture areas would appear on the television as completely black or completely white. The signal range must be compressed (referred to as gamma correction) in order to provide a better representation of the film picture. The gamma law is

\[ \text{Antilog}(\text{Gamma} \times \log(\text{signal})) \]

and may result in a gain in the dark areas several hundred times the gain in the light areas.

The gamma law must be correct for each colour, or else the hue will be affected by the brightness. The hue of near black and near white must also be adjusted to compensate for differences in film stock, and even for different scenes. Typically this correction is controlled by three joysticks, with three overall level controls. Thus, the operator may turn the stem of the joystick to adjust the amount of gamma correction used, and adjust the position to determine how this is shared between the red, green, and blue signals.

In addition to requiring the correct gamma for each colour individually, the gamma of each colour may need to be modified by the signals from the other two colours to compensate for the mismatch between the coloured dyes used in the film and the colours used for colour TV. On some types of film stock it can be impossible to achieve natural colours unless this process (referred to as masking) is carried out. Most machines have several preset masking matrices for different film types.

This vigorous correction has several consequences. The first is that there is too little dynamic range in an ordinary frame store to permit the correction to be carried out after storage. If this were tried, then areas which had to be amplified substantially would have the size of the minimum digital step of brightness similarly increased. Distinct stepped brightness levels would be clearly visible.

For this reason, the correction in the Digiscan system is carried out before the signal is digitised. The only problem here is that the digital store is not updated while the film is stationary, so in order to colour correct a scene the operator has to keep running the film back and trying again.

A computer control system is available to take account of the different colour correction needed for different scenes. This stores the correction settings for each scene, and applies them at the appropriate frame number.

Many other facilities are available, including an XY zoom system which will allow the operator to zoom in on any part of the film frame. A subset of this system allows the machine to televise cinemascope films. A portion of the picture width is enlarged to fill the whole screen, and the operator can pan the displayed portion across the frame. The degree of horizontal enlargement is chosen to alter the tall thin images to realistic proportions.

If the panning has not been done quite carefully enough, the viewer may begin to feel like a spectator at a tennis match. You may occasionally notice the picture panning across to the person speaking just when he finishes what he was saying and someone on the other side of the picture speaks.

A cinemascope film may, instead, be shown with a blank above and below it on the television screen, to reduce the height to a realistic level, but this is not so common.

**CCD Machines**

There are several manufacturers of CCD type machines. They provide different facilities and are suitable for different applications.

One of the generic differences between flying spot and CCD telecines is that the CRTs used for flying spot scanners have the highest output in the green region, and well down in the blue and red regions. Because of this, the signal to noise ratio of the red and blue channels of a CRT based machine is normally unimpressive. On the other hand, the high output and better spectral response of the projector lamps used on CCD machines gives a good signal to noise ratio on all channels.

A major selling point of Rank Cintel's ADS1 is the facility to detect dirt and scratches on the film. This is possible because the light from the filament lamps used to illuminate the film, unlike the light from a CRT, contains a lot of infra-red. The dyes used on films are transparent to infra-red light, so only the dirt and

---

Fig. 5 Edges may be made to appear sharper than they are on the video signal by adding overshoot and speeding the transition. No more detail is generated, but it fools the eye into perceiving a very crisp image.
scratches show up under this wavelength. A special channel is used to detect such blemishes, as illustrated in Fig. 6. Note the extra long optical path length and the special stop for the infra-red, because the focal length of the lenses is very different at this wavelength.

Once the scratch has been detected, it must be concealed. To do this, the video signal must be delayed to allow the concealment circuitry to work. The concealment circuitry is digital and generates a ramp from just before the scratch until just after it, neatly joining up the video waveform. This is illustrated in Fig. 7.

The ADS1 telecine carries out its colour correction by means of analogue circuitry before the frame store. It is very similar to the Digiscan machine in this respect.

The Marconi telecine machine does not offer dirt concealment. One of its special features is that it carries out the colour correction digitally. The block diagram of Fig. 8 illustrates this.

A normal frame store has too few bits to permit the extreme 'black stretch' which is often needed to gamma correct a film. Such is the case with this machine as well, but the DAC digitises the signal to an accuracy of 11 bits. The processing carried out to this accuracy makes good use of look-up tables — a more pedestrian method of processing would not be fast enough.

In the logarithmic conversion, and again in the multiplication, an extra bit is added in the processing to avoid rounding errors. The signal is truncated from 13 bits to 8 bits in the antilog lookup table, and the resultant signal is stored in luminance and colour difference stores.

A German company, Bosch, make a CCD based telecine called the FDL 60. One of its major features is that, in televising cinemascope films, the entire width of the picture may be displayed on a monitor, with border lines superimposed to show which part of the picture is to be broadcast to fill the TV screen. This...
FEATURE: Telecine

makes it easier for the operator to pan appropriately. The panning information is stored in a control computer, and used to control the machine 'live'.

The FDL 60 also features a grain reducer which does a very good job of hiding film grain, so a 16mm film can look almost as good as 35mm film. The grain reduction relies on the fact that the grain produces very rapid changes in picture content, which can safely be ignored in a slowly changing scene. If too much correction is used, the grain corrector will try to correct for movement in the scene. The picture would then resemble that obtained from a TV camera using a slow response tube.

Applications

There are two main applications for telecine machines in broadcasting. The obvious use is on-air transmission of films. The films used tend to be made specially for television, so the quality is uniform.

The somewhat limited dynamic range available from CCD machines is quite suitable for this type of film. The reliability and freedom from the need for constant readjustment of CCD machines thus make them desirable for on-air usage.

Films which are not specifically made for television do not often have such an ideal characteristic, and are often processed and transferred to tape before broadcast. A flying spot scanner is preferred for this post production work. The ability to zoom, by altering the raster size, with no loss of resolution, and the higher contrast range which can be accommodated, all contribute to its popularity.

The Future

It would appear that the use of film in television is increasing, despite the use of, for example, electronic news gathering equipment. One might imagine that, as video tape based systems become more compact and convenient, film will finally decline as a medium for television.

This may not happen so soon as some people think, for two reasons. First, improvements in film still continue, so that smaller gauge films can be used to give the required quality. Second, when high definition television is introduced, film will be able to meet the picture standards while videotape systems may have a struggle at first.

The next question is — what type of telecine? Although CCD machines are improving, the resolution is limited by the number of elements in the line array, and further improvements are desirable even for present TV standards. It is very likely that the flying spot telecine will enjoy a renaissance if high definition is introduced in the foreseeable future.

One might go further, and suggest that a telecine with a frame store is unlikely, at first, to meet with approval from broadcasters, and that a hopping patch system will be used. In this case, it might well be that the limitations of the basic system will mean that some kind of "film tracking system" will be used on machines for this purpose. Thus events have almost gone full circle, because the technical literature on film tracking for flying spot systems goes back for at least twenty years.

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I

In this section I hope to explain one further method of image enhancement that can be performed on any computer and can produce some very useful results such as edge detection or noise filtering.

Let us for example consider how we might perform a high-pass filter function on our stored image. The simplest way to filter the picture would be an LCR network on the front end before we stored it. This is simple in theory, but variable filters at 6MHz are difficult to design. If we wished to extend the filtering to include low-pass or band-pass filters more switchable elements would have to be added and the design would become increasingly difficult and complex.

Another approach some readers may have encountered would be to take the Fourier transform of the picture, and then to choose just the required coefficients before applying the inverse transform to restore the filtered version of the image. ‘Taking a Fourier transform’ is just the mathematical equivalent of splitting the signal into its constituent frequencies, the ‘coefficients’ referred to being the sizes of the different frequency components. Once a signal is split into its component parts this way, we can perform any filtering function we like, no matter how complex. It does not matter that the function we might choose does not have an ‘analogue’ (LCR) counterpart. Two examples will illustrate how powerful this method can be.

The transmission of television pictures entails a high bandwidth because of the amount of information that has to be sent. This applies also to the storage of information where the large amount of memory (in this case about 393K bytes for one image) means optical discs offer the Hobson’s choice.

Any technique to reduce the amount of memory required to represent an image is worthwhile. Some simple methods can be used effective on documents or similar (one bit data) or on some images with little detail. But for any image with detail these techniques are of little use. However by examining the Fourier coefficients and running complex selection routines to select only those necessary to retain picture detail we can reduce the memory requirements dramatically. There are stores of a complex 24 bit colour (8 bits of red, green and blue) being reduced to one bit with little observed degradation of the image! Further reductions are possible if a degree of degradation is considered acceptable.

One further example is the removal of motion blur from a picture — for example, a photograph of a race horse passing by, taken with a stationary camera. Simplistically, if we could examine the Fourier coefficients we should be able to identify the coefficients associated with the race horse’s velocity and remove it from the spectrum, leaving the image without the blur.

Fourier analysis certainly offers

BUYLINES

No particular problems should be experienced with any of the components in the framestore. As was stated, the DRAMs used were Motorola MCM6664L20. In view of the number used it is well worthwhile shopping around for the best price. STC should offer a competitive price and accept Access and Barclaycard (tel. 0279 26777).

The ADC/DAC are obtainable from MCP Electronics Ltd, Alperton, Wembley, Middlesex HA0 4PE, tel. 01-902 3941. The full type numbers are ADC-TDC 101407 and DAC TDC 101615C8. They have a minimum order of £25, which will not be a problem in this case.

The crystal is a special and was obtained from IQD Ltd, North Street, Crewkerne, Somerset TA18 7AR, tel. 0460 74433.

The TTL is standard. The 74F devices can be obtained from Hi-Tech Components, Gilray Road, Diss, Norfolk (tel. 0379 4131), or STC amongst others.

The PCBs will be available from the ETI PCB Service; six memory and one each of the control and ADC/DAC card are required.

The TA6993W used in the external sync circuit will have to be shopped around for. It is an RCA device. Try Macro Marketing (06286 4422) or STC.
us a lot in terms of the range of picture enhancements, but unless you have indeterminate patience or a PDP11 to hand, I do not think these techniques can be applied; I would certainly be interested in hearing from anyone who is attempting it.

Let us look at a technique that can be performed on images and is within the scope of our home micro.

The techniques discussed above would be performed in the frequency domain, i.e., we would be manipulating coefficients of terms that represented all the frequencies present in the image. We could however manipulate the image in the spatial domain. In other words, by looking at the adjacent pixels to the one we are operating on and only changing it dependent on its own and the local pixel value we can perform a number of techniques similar to those we saw at first in the frequency domain.

The technique itself is called convolution. It is the spatial equivalent of Fourier analysis. Mathematically, it is sometimes possible to convert a Fourier operator to a convolver but generally speaking convolution is not so flexible.

Convolution takes each point on the screen, and from this and the immediately adjacent pixels, it generates a new pixel value. How this works and what it is capable of is probably best demonstrated by an example.

Fig. 19a shows a section of an image which is boring, absolutely flat and dark grey in tone. Fig. 19b shows a convolver. How it is used is as follows: the central term in the convolver ('9' in this case) is placed over the pixel to be operated on, and the pixel and the surrounding pixels are multiplied by the equivalent terms in the convolver, as shown in Fig. 19c. All the resultant terms are added up to form the new pixel value, as shown in Fig. 19d. In this case the new pixel value is exactly the same as the old value. (Note to the mathematically-minded — this is not true matrix multiplication, thank Heaven!)

Let us suppose that a little further to the right of the same image there is an increase in the brightness, spreading over a couple of pixels, Fig. 19e. Applying the same convolver gives the values in Fig. 19f. Notice the extent to which the edge has been enhanced, the pixels adjacent to the edge being turned to reference black (−10 would appear as 0) and very nearly peak white (60, peak white is 63). If a threshold were imposed of, say, 32, so that every below 32 in pixel value were made 0 and everything above 32 were made 63, this convolver would have successfully picked the outline of the objects in the image in peak white on a black background.

This is one example of a convolver, which is 3 x 3 in size. There are a large variety of convolvers around, by no means all of them 3 x 3 in size. They perform a number of filtering routines — for example, the example shown could be considered the equivalent of a high-pass filter or differentiator — and some other quite 'intelligent' image manipulation functions.

This is unfortunately all the detail on image manipulation that I can justify here. Books on image processing tend to be very expensive and very heavy going. The one that I have found the easiest to get along with is 'Digital Image Processing' by Rafael Gonzalez and Paul Wintz, published by Addison Wesley Publishing in 1977. Perhaps it is high time that someone wrote a book aimed at the home micro user, as there are now a number of vision systems knocking around besides the framestore described in these articles.

**Editorial Note**

Far be it for us to discourage anyone from building an ETI project, but a few words on this framestore are needed. From the start, this project was conceived as being for experimenters, and by this, we mean someone with enough experience of electronics to fully understand a system of this complexity.

We hope that all our readers will have gained some insight into the techniques involved in storing and manipulating a TV picture, but, as this framestore uses an awful lot of expensive devices, some of them operating at very high speeds, we would expect relatively few readers to build it.

We strongly advise potential builders to be certain of their ability to de-bug a large digital system such as this before they begin. If you're not certain of your ability — or if you don't have access to the necessary test gear (say at least a 20MHz dual-beam 'scope) — leave it alone until you are fully ready to have a go.

One final factor we would mention is that we are having difficulty finding someone to replace our former projects editor, Phil Walker, so our ability to answer technical enquiries will be severely limited for the foreseeable future.

We're sorry if this all sounds so negative. However, it's distressing for us — as it must be for the readers concerned — to find a batch of enquiries from people who'll never get their piece of dream hardware to work because they are well out of their technical depth.
Fig. 20 The final overlay of the control card. Just a few things have changed between this overlay and the original circuit diagram published back in December '84. Firstly, the downward-pointing arrow close to pin 8 IC1 should have been labelled (CLK). The resistors around the inputs to IC8a and b and IC9a should be labelled R22 to R26. Finally, there were two devices marked IC17a; the one next to IC7 (top right on page 63, Dec '84) has here become C35; however, there is no reason why the unused half of IC should not be used for this purpose, if an alternative PCB layout were used.
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Electronics for Peace describe themselves as a network of people connected with electronics who share a concern for the military implications of their profession. ETI has been talking to their co-ordinator, Tony Wilson, to find out more.

Tony Wilson is an independent reliability engineer who has worked on commercial space projects and the UK Chevaline programme. He is currently engaged in work on military land systems. He has been a member of Electronics for Peace since the group was formed and has recently become their co-ordinator, giving up much of his time to writing and speaking on the group's behalf. He has written a number of articles on various aspects of defence and technology which have been published in a wide range of trade and other technical journals. His skills in publicity seeking seem to have been recognised by the TOBIE awards committee who have nominated him as one of the three finalists for the title of Electronics Personality Of the Year. The result will be announced at a special ball to be held as part of the All Electronics/ECIF show in April. We visited Tony at his Wiltshire home to ask him about his views and the objectives of Electronics for Peace.

When and where was EfP founded?

In October 1982, in Bracknell, Tim Williams and Steve Holmes had a letter published in Wireless World asking for people who were interested, and around twenty five got together as a result. I was one of them.

And has the membership grown since then?

It's been at between two and three hundred for the last eighteen months or so but I think it's going up a bit now.

Do people have to be employed in the electronics industry before they can become members?

We're open. So long as people are interested and concerned about the way things are, that's sufficient. At the same time, it's important that we're seen to have a certain level of expertise, so it's good that many of us do work in the industry and know what we're talking about.
Do many of your members work in the defence industry?

Our members cover a very wide field but are mostly engineers working in electronics or computing. I don't know exactly how many work in defence, I haven’t analysed it, but I would think maybe 20%.

Do those who work in defence openly criticise the system?

I don't know of anyone in EFP who actually criticises the system from the inside in quite the same way that I do and gets away with it. There is somebody who started at a defence establishment and objected to working on military things, and he was thanked and booted out. But most people don't speak out. It's very difficult.

But you do speak out and your employers know your views.

Yes, they do. They open their magazines and they see my face and what I've written. When I first joined EFP I thought that it would be incompatible with my job, but now I think it’s very good that I'm seen to criticise the system from inside. It gives me credibility. It also gives people inside the opportunity to do the same thing themselves, because there's this great fear when you're under the Official Secrets Act of opening your mouth at all, and that's absolutely wrong. People should be allowed to criticise any system that they're in, but they seem unable to do so. I've been there and I know what that feels like.

You say that you thought being a member of EFP might be incompatible with your job: did you think that you might lose your job?

I'm always prepared for that possibility.

Your promotional literature refers to "... the appalling unreliability of modern complex weapons systems ...". Your work involves trying to make weapons more reliable. Given your views, doesn't that create a conflict of interest?

In a better world than the one we live in now I wouldn't see any problem in working to make our weapons more reliable, because we wouldn't have so many of them, we'd only have enough to defend ourselves. In the world we're in at the moment it is a bit of a problem, but then I have to make the best of the situation.

Current complex weapons are not reliable. In two or three weapons generations' time, when design and manufacturing and other techniques have improved, they will be ultra reliable. They will be as reliable as the public seems to think they are now, and when the commanders actually think they are that reliable they'll want to use them. One of the things that stops people using their weapons at the moment is that they know they won't work very well.

So the risk of war may increase as weapons improve. Does that make you more concerned to get your message across now?

We haven't got long, I'm sure of that.

You spoke of a better world in which we had only as many weapons as we needed to defend ourselves. Were you thinking particularly of nuclear weapons or of all weapons?

To my mind, nuclear weapons are no worse than some of the conventional weapons we are now developing. It's the weapons themselves — weapons of mass destruction — that we're against. We need to bring down the amount of armaments we have, and we need to bring down the influence we have on the third world in selling armaments and encouraging them to use them. We also need to bring down the amount of military funding and orientation within our own industry. They're the three main aims of EFP in the long term.

What are EFP's other aims?

To bring together electronic engineers who are concerned about the military implications of their profession, to provide technical information for people working in the field of nuclear and conventional disarmament and to encourage the development of socially useful applications of electronics.
So you don’t have to believe in unilateral nuclear disarmament or anything like that in order to become a member?

I’d be happy if there were anarchists and unilateralists talking to people who drive nuclear submarines. We want to open up the debate, to cut out the paranoia and make it clear that we’re just people and that we have a cross section of views, instead of this left and right business.

So how is EfP related to the rest of the peace movement?

We’re making a conscious effort to get a cross section of people in, people of all points of view, and I’m not sure that that’s what other peace movement organisations are intending to do. That’s probably one difference. We want to remain politically unaligned, and that’s probably another difference between us and, say, CND who seem to get tied up with the Labour party. We want to provide very good technical information to everybody, not just the peace movement but to everybody, so we have to keep some distance in order to be credible.

So you see yourselves more as providers of information than as a group that’s going to sit down in front of cruise missile transporters?

We’re not involved in demonstrations or direct action. If individuals want to protest in that way then they’re free to do it, but not under the banner of EfP.

What practical steps have you taken in pursuit of your aims?

We researched and published a booklet called “The Ground-Launched Cruise Missile: A Technical Assessment” (reviewed in ETI January 1984 — Ed.). That was very well received and is about to be re-published. We want to keep up a steady flow of booklets and leaflets explaining modern weapons and other war systems and their implications for the UK and the world. Some of the topics we’d like cover are the effects of EMP and means of protecting against it, the link between arms spending and the crisis in the third world, the damaging effects of heavy military investment on commercial investment in research and development, and the effects of the Official Secrets Act on our economy and our freedom.

We’re also keen to provide material for people working in peace education in schools, colleges and other organisations. Peace education involves ensuring that students and pupils are presented with as wide a variety of points of view as possible, with undistorted and complete statements of fact on a variety of subjects. These should include national and world defence and militarism, third world issues, racism, multi-national companies, etc. people can then be encouraged to put their own point of view, join in the debate and make their own minds up. We want to be able to provide advice and information, to help plan sessions, to provide speakers who can talk about their personal experiences of the industry or about positive aspects of technology, and to help produce high quality software and text books on relevant topics.

That’s an ambitious program because we only have around 100 electronics students on engineering and, morality, talked about aspects of technology to 11 and 12 year olds and worked with a peace education working party to produce a PE programme and resources.

And what about the future?

I want to see EfP getting involved in arms conversion initiatives, in developing means whereby industrial plant and human and other resources currently used for military purposes may be switched over to work which is socially useful. It’s not a case of moral extremism, of unreasonable demands for the removal of all military capacity. There’s no reason why there shouldn’t be a gradual change of emphasis from the military use of particular resources to a commercially sound mixture of military and civil projects, with the military content perhaps forming less than half of the total. With this sort of balance the two can benefit each other, whereas at present the military side is all too often dominant and causes gross inefficiency in the execution of the civilian work. I’d like to see more co-operative working, between individuals and small companies, and education, which is my personal interest. I’m sure others in EfP have got their own priorities. But the arms conversion thing, I think we should be fairly big on that soon. I’ve put a proposal into the GLC Arms Conversion Council and I’m pretty hopeful that they’ll take at least some of it up.

Are there any particular questions you’d like people to ask themselves after reading this?

What sort of world do you want for yourself and are you happy with what’s going on? Do you believe that you could influence the world to be a better place? Do you really regard your job as part of your life, because, if not, you’re dead for much of the time. Is that what you want to happen? If not, you’ve got to take part in deciding what you want to see in the world and doing something about it. Our actions and inaction directly affect the state of this nation and of the world, whether we acknowledge it or not. People starve in Ethiopia largely because the US and UK governments disapprove of the politics of their government, and because we allow them to get away with it. We in the UK have a paramilitary police force which can easily gain access to records on every individual — because we allow them to get away with it. You may think that 1984 has passed: it hasn’t, it’s only just begun, but only if we allow it. My own life has changed incredibly since I decided to take responsibility for myself rather than sit back and let politicians, bureaucrats and business people screw things up in my name. I also enjoy life very much more now.

Tony Wilson and Electronics for Peace can be contacted at Townsend House, Green Lane, Marshfield, Chippenham, Wiltshire SN14 8JW, tel 0225-891710.
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CCD DELAY LINE EFFECTS BOARD

The man and his puns have gone, but the echoes linger. Phil Walker describes an add-on CCD delay line effects board for the ETI “Sonneti” combo.

This echo unit was designed as an add-on for the “Sonneti” combo unit published in last month’s ETI. It fits neatly into the space available and is wired to suit the unused effects board connector on the combo pre-amplifier PCB. It draws its power from the combo’s regulated supply, but there is no reason why it could not be built as a separate unit or installed in another amplifier provided the appropriate supplies are available and the signal levels are correct.

The Circuit

The input from the pre-amplifier section arrives via the plug at IC2a which acts as a mixer to combine it with a proportion of the output signal. The combined signal then passes via a low-pass filter whose cut-off frequency is about 8kHz. This filter was found to be essential to avoid aliasing in the delay line devices.

The signal then enters the first of the three bucket brigade delay line chips. This is either a TDA1022 device with 512 stages or a newer TDA1097 device with 1536 stages. Note that the PCB is laid out to take either device but R31 may need to be adjusted if the TDA1022 device is used since it has a loss of about 4dB per stage as opposed to a nominal 0dB for the TDA1097. For one 1022 R31 is 68k, for two it is 47k and for three it is 33k. This will not give exact compensation but should prove adequate. In our prototype the two devices were mixed quite successfully.

The output from the delay devices is passed via another low-pass filter to remove most of the switching noise which might otherwise upset the main amplifier. The signal then passes to

Fig. 1 Block diagram of the effects board.
In order for the delay devices to work properly they must be supplied with a two phase, non-overlapping clock signal. This is generated by IC3 and drives all the devices in parallel. The minimum frequency of this clock signal determines the maximum delay obtainable from the unit and should not be less than about 30kHz in this design. The maximum clock frequency limit is determined by the input filter.

Since the bucket brigade delay line devices work by sampling the input signal they are subject to the rules of sampling theory. The main requirement is that the clock frequency must be greater than twice the highest input signal component. Since we cannot be sure what the input signal contains, a 300kHz for 1022s. This determines the maximum delay obtainable from the unit and should not be less than about 30kHz in this design. The maximum frequency of the clock generator should not exceed 100kHz for 1097 devices or

![Circuit Diagram](image)

**Fig. 2** Circuit diagram of the effects board.

![Pin Connections](image)

**Fig. 3** Pin connections of the TDA1022.

![Pin Connections](image)

**Fig. 4** Pin connections of the TDA1097.

Another mixer stage and then to the output pin on the plug. There are extra input points on both mixers (marked A, B and C) to allow the more adventurous to try other effects.

In order for the delay devices to work properly they must be supplied with a two phase, non-overlapping clock signal. This is generated by IC3 and drives all the devices in parallel. The minimum frequency of this clock signal determines the maximum delay obtainable from the unit and should not be less than about 30kHz in this design. The maximum frequency of the clock generator should not exceed 100kHz for 1097 devices or rules of sampling theory. The main requirement is that the clock frequency must be greater than twice the highest input signal component. Since we cannot be sure what the input signal contains, a 300kHz for 1022s. This determines the maximum delay obtainable from the unit and should not be less than about 30kHz in this design. The maximum frequency of the clock generator should not exceed 100kHz for 1097 devices or

![Clock Signal Requirements](image)

**Fig. 5** Clock signal requirements for the CCD delay line ICs. These are supplied by IC3C and d in the circuit above.

![Part List](image)

**PARTS LIST**

<table>
<thead>
<tr>
<th>RESISTORS (0.25W 5% carbon film)</th>
<th>C7,14</th>
<th>150p polystyrene or ceramic</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>CB</td>
<td>10µ 25V tantalum bead</td>
</tr>
<tr>
<td>C2</td>
<td>C15</td>
<td>1µ0</td>
</tr>
<tr>
<td>C3,4</td>
<td>IC1</td>
<td>TL0072 or TL082</td>
</tr>
<tr>
<td>C5,6,11</td>
<td>IC2</td>
<td>TL074</td>
</tr>
<tr>
<td>C8,9,10</td>
<td>IC3</td>
<td>4011B</td>
</tr>
<tr>
<td>C10,11</td>
<td>IC4,5,6</td>
<td>TDA1022 or TDA1097</td>
</tr>
<tr>
<td>C12,13</td>
<td>Q1</td>
<td>BIC212L</td>
</tr>
<tr>
<td>C14,15</td>
<td>D1-4</td>
<td>1N4148</td>
</tr>
<tr>
<td>C16,17</td>
<td>MISSCELLOUS</td>
<td>SW1 single pole on/off switch — could be part of RV1 if desired</td>
</tr>
<tr>
<td>C18,19</td>
<td>PCB; DIL IC sockets — 1 off 8 pin, 2 off 14 pin and 3 off 16 pin; 5-way right angle PCB plug; 20 off vertical PCB mounting brackets and nuts and bolts to suit; 3 off control knobs; wire, terminal pins, etc.</td>
<td></td>
</tr>
<tr>
<td>C20,21</td>
<td>C4,13</td>
<td>220p miniature ceramic</td>
</tr>
<tr>
<td>C22,23</td>
<td>C6,13</td>
<td>560p polystyrene or ceramic</td>
</tr>
</tbody>
</table>

---

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low pass filter has been included to block frequencies higher than 8kHz. The rather simple nature of the filter does not allow a sharp cut-off and some signal will get through even at 16kHz, but the amount will be small enough to ignore.

If we did not comply with the sampling frequency rule mentioned above, frequencies above half the sampling frequency would appear as lower frequencies at the output. For example:

MOD ON OFF

RV1
MOD SPEED

ADJUST R14 TO ALTER REVERB TIME

(half sample = 30kHz,

signal = 21kHz,

output = 9kHz

Also, the output signal would often not have any musical relation to the input signal and would usually sound unpleasant.

For those who wish to experiment with chorus, phasing and flanging the PCB also contains a low frequency triangle wave

IC2a acts as a virtual earth mixer to combine the input signal with a proportion of the output. This mixture then passes to IC2b which is connected as a low pass filter with a cut-off frequency of about 8kHz. This filter is necessary to avoid problems with aliasing whereby high frequency components of the signal would be transformed into lower, non-harmonically related output frequencies.

The output from IC2b passes to IC4, 5 and 6, the three bucket-brigade delay line devices. Their signal input pins are biased by R22, 24 and 26 from the voltage at the wiper of RV4. This voltage is by-passed by C8 to prevent interaction and signal feedback. The signal is AC coupled by C9, 10, 11 and 12 and DC conditions at the outputs of the delay chips are satisfied by R23, 25 and 27. An additional bias signal is tapped off the RV4 divider chain by R20 and 21 to feed IC4, 5 and 6.

The output signal from the delay devices is passed to IC3c which is connected as another low-pass filter. Its purpose is to remove most of the high frequency switching noise generated in the delay line. After this the signal passes to IC3d which is connected as another virtual earth mixer.

The high frequency, two-phase, non-overlapping clock signal needed to drive the delay devices is generated by IC3. IC3c and d ensure that the outputs cannot be low simultaneously while IC3a and b provide a symmetrical square wave oscillator. By means of D3 and D4 the frequency of oscillation can be varied.

Q1 and its associated resistors and potentiometers allow the voltage applied to D3 and 4 to be varied and thus alter the clock frequency and hence the delay time. D1 and D2 are fitted only as protection for Q1 and may not be necessary. RV3 allows the steady state delay time to be altered while RV2 regulates the amount of modulation applied from the low frequency oscillator.

IC1 is the low frequency oscillator. IC1b is connected as an integrator while IC1a acts as a Schmitt trigger. In normal operation with SW1 closed, when the output of IC1a is positive a current determined by RV1 and R4 will flow into C1. IC1b will prevent the inverting input from going high by ramping its output pin negative. When it reaches about -7.5V (set by R1 and R2) IC1a will switch rapidly so that its output is negative. This will reverse the current flowing in RV1 and R4 and the output of IC1b will ramp in a positive direction. When it reaches about +7.5V IC1a will change state again and the process will continue.

If SW1 is opened then the oscillator action will cease and the output of IC1b should slowly settle to about 0V because of the action of R3. Note that R3 has no effect until SW1 is open.
generator which can be used to
modulate the frequency of the
clock oscillator and thus vary the
delay of the unit. This facility
together with the extra mixer
inputs should prove quite interest-
ing. It may be found for these
effects that one TDA1097 or up
to three TDA1022s are better than
several TDA1097s. In this case
the input link should be moved to
eliminate the IC4 and 5 positions
as necessary.

Construction

Begin assembling the PCB by
installing the wire link and, if
you intend using them, the IC sockets
and the right-angle PCB plug. The
ICs can, of course, be soldered
directly to the board if you prefer
but we would recommend sockets
for IC4, 5 and 6 at least because
these devices are expensive and
sensitive to static. The PCB plug is
only necessary if you are building
the unit for use with the “Sonnet!”.

Continue assembly by soldering
the resistors and capacitors
into place and finally install the
diodes, the transistor and the ICs.
If you do not require the variable
frequency oscillator section you
can omit IC1. The TDA 1022s are
sixteen pin devices and will
occupy the whole of the IC4, 5
and 6 socket areas but the
TDA1097s are 8 pin devices and
should be connected to the
middle eight pins only as shown
on the overlay.

The delay line PCB should fit
comfortably into the space be-
 tween the “Sonnet!” preamplifier
board and the mains wiring screen,
but you may find it necessary to
move the preamplifier along a
little to make room. If you have
used a case other than the one
specified and find you are short of
space, one solution might be to
take the mains switch and
indicator outside of the case pro-
per and mount them on the blank
section of the front panel at the
right hand end. That will leave
plenty of room inside for the delay
line board and also clear a section
of front panel for the controls.
Alternatively, the controls could
be mounted in the middle of the
panel between and just below the
input sockets.

The PCB should be positioned
with the component side facing
forward and then pushed into the
connector on the “Sonnet!” pre-
amplifier board. The wiring to the
three potentiometers and the
switch is not critical but it should
be kept away from the mains
wiring. The two PCBs are very
close together when the connec-
tor has been pushed home and it
may be found that there is not
sufficient clearance for the two
adjacent mounting brackets. A
little bit of filing should cure the
problem.

Begin testing the board by carry-
ning out a thorough visual check,
including the wiring to the poten-
tiometers and the switch, then
remove the delay line ICs and
switch on the power supply.
Check that the oscillator is work-
ing correctly and that all appears
to be generally well (i.e., no
smoke!). Switch off, set RV4 to mid
travel and insert the delay line ICs.
Switch on again and you should
find that the unit is working. If any
distortion is present, adjust RV4
until it goes. If you are using the
delay line as a self-contained unit
or in a piece of equipment other
than the “Sonnet!”, make sure that
the input signal level is less than
1.5V RMS because too high an
input level will also cause
distortion.

Experimental Effects

As designed, the unit can pro-
duce an echo effect with
TDA1097s or a shorter echo with
TDA1022s. For a chorus effect it
would be advisable to use
TDA1022s and increase the clock
frequency with RV3. The LF
oscillator should be used to modu-
late the delay. Both of these
effects should be obtainable with
the standard connection to the
pre-amp.

For phase and flanging effects it
may be necessary to take the out-
put direct from the unit. It may
also be necessary to adjust the
resistor values in the mixer stages
and provide variable gain controls
in places to get the best effects.
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Dear Sir,

It is about time that the ETI team realised that there are other computers that deserve attention besides the BBC, the Electron, the Spectrum and the ZX81. How about doing a project for the Apple II for a change? Or is it too upmarket for you?

I for one have got increasingly fed up with you just doing everything useful for the above mentioned machines but totally disregarding the Apple. Maybe you could produce a version of the Electron speech board for the Apple, or a morse decoder (I'm particularly surprised that this hasn't been done if the ETI editor is indeed a ham), or even an EPROM programmer. It's infuriating when people come up to you and say "Your Apple can't do that" or "in order to do it from BASIC we have to go into machine code".

So come on ETI, forget the brand new machines and help the old ones catch up. If you can't, who will?

Yours sincerely,
Ian Topliss
Chelmsford

Fruitless Wait

We'd love to help, but the solution is not as simple as you seem to imagine. Whenever we publish a major computer project we promptly receive hundreds of letters from people who want a version suitable for their machines, and given the wide range of microcomputers owned by our readers this is an impossible task. It would mean that for months after the appearance of such projects we would have to sacrifice new designs to make room for the modifications, and since most of our technical authors only have one machine the modifications would have to be developed 'in house', using up large quantities of our Project Editor's valuable time.

We have published designs for use with a wide range of microcomputers in addition to those you list, including the Ace, the Atom, the ZX80, the Sharp MZ80K and the Micron 65, but it is inevitable that the designs we present will reflect the popularity of individual machines among our readership and that the less popular machines will receive little or no coverage. However, we will be looking carefully at the results of the recent Readers' Survey to see how trends in computer ownership are changing, and we always welcome innovative designs whatever machine they are intended for. So why not have a go at designing something yourself and let us have a look at the end result?

As to your comment about the ETI editor, he is indeed a radio amateur (callsign G1HRT) but ETI has a sister magazine called Ham Radio Today and projects related specifically to amateur radio are usually presented there rather than in ETI.

STOP PRESS! The assistant editor has just passed his RAE (with a distinction and credit, no less, just like his Ed.) but has yet to get his callsign.

Walking Into The History Books

Dear Sir,

I read with great concern that you will soon be losing your Project Editor, Phil (pun -man) Walker, whose technical brilliance is matched only by his overloaded sense of humour.

Even though you are not in the habit of doing so, I think a brief resume of Mr. Walker coupled with a teensy photograph would be in order. This is absolutely necessary for my ETI hall of fame cabinet (I also need to locate him about projects that didn't work!).

Congratulations Mr. Walker (and ETI) for your excellent work. We appreciate it on this side of the globe too!

Sincerely yours,
Edwin Kinyanjui
Nairobi

Phil Walker has, alas, already departed, and he will not be an easy act to follow. As for publishing a resume of his career, the only aspects of it we are sufficiently familiar with are the bits he used to tell us about after the office Xmas party, and we're not going to publish things like that! We hope that the picture published in last month's News Digest pages looks good in your hall of fame.

Please send your letters for this page to: The Editor, Electronics Today International, ASP Ltd, 1 Golden Square, London W1R 3AB. And please note that any letter we receive is liable to turn up on this page unless it is clearly marked 'Not for publication'.
David Versus A Goliath Tank?

Dear Sir,

The review of the UK defence industry, under the title "System Failure" in ETI January 1985, brought out many relevant facts but also demonstrated the fundamental truth that different observers inevitably see a given situation in quite different ways.

Take, for example, the unfortunate Belgrano incident. Would it have been sensible to use an expensive Stingray in circumstances where an older type of torpedo was available and clearly adequate for the task? There are situations of conflict in which a stone and a catapult would be just as effective as the latest Armalite rifle, and there are circumstances in which the catapult would be useless. For that matter, so might the rifle...

The nominal object of defence development is to support the growth of technologies which will cope with increasingly difficult combat situations. A new weapon creates a new threat, and calls for an effective countermeasure. A very large proportion of the total defence expenditure is accounted for by that sort of activity. Unfortunately, those who hold the purse strings, under pressure from the services, prefer to place orders for specific equipment which may be outdated by the time it is ready. The cost of research is paid for out of overheads, or out of 'private venture' funding (i.e., out of profits!).

The regular difficulty in defence work is that it often calls for performance characteristics which arise nowhere else. Storage life may be important, and immunity from magnetic and radiation fields. This pushes up the cost, and makes adequate testing of specialised components more difficult.

Where the only possible test is a test to destruction, 'type testing' is the only option. Make a hundred copies of a certain device, test ten of them successfully, and you will have greater confidence that the ninety are made as a single batch, by identical methods and with identical pre-testing schedules.

The overall characteristics of a device are usually agreed by the purchasing agency and the supplier as a starting point. The supplier is then likely to sub-contract parts of the work on the basis of specifications drawn up to define each part precisely. There is usually a "fitness for use" clause which is intended to mop up anything that was left out of the specification, but the ploy rarely works.

An interesting example of this was a unit for use in civilian aircraft. Everything worked perfectly until ground pressurisation tests were carried out. Then the increased pressure pushed in the sides of the metal can until it touched internal circuitry. Who would have thought of specifying a test at atmospheric pressure plus? The expectation was that pressure would be more commonly below atmospheric.

The sub-contract specifications can be the weakest link in the whole chain, and administering them can call for expertise on a par with that provided by the sub-contractor.

The same piece of aircraft equipment also illustrates the proposition that 'preventative maintenance' meant work which prevented the equipment working properly. In early service, there was continual trouble until the maintenance staff were persuaded to leave well alone. When that was done, the equipment received the accolade of being "the most reliable piece of aircraft equipment ever made".

On the commercial side, it is true that 'cost plus' has given way (nominally) to 'fixed price', but matters have gone even further. It was normal for the MOD to retain rights of control over foreign sales of a product. Under some contracts they now yield that right, and the supplier is then justified in reducing his charges in the expectation of profiting from foreign sales.

The commercial haggling before an order is placed can be intense, especially if American competition is involved, and the pressures that are created can have an adverse effect on the validity of the technical claims which are made.

Back in the nineteen-fifties, a Technical Director remarked that his company's profits depended on development contracts rather than on manufacturing activities. This could still apply in some areas. Perhaps it should, since it is the research and development work that really matters.

Anyone who has worked in both commercial and military manufacturing and co-operated them — and most people stay on the side of the fence they know best — is aware of a vast difference of approach. A commercial company may cut corners, relying on the experience of their engineers to safeguard them from catastrophe. In a military manufacturing environment there is a profound distrust of engineering judgement, and a second line of defence in which Quality Assurance excercises control too many decisions. The control is mandatory for defence contracts, but it is no more effective in some cases than the blind leading the lame.

The furore over IC testing is an example of this. The ICs are said to have been tested to the 'wrong' specification, which was the normal standard version rather than one cooked up by people who know only a limited amount about the product, basing their requirements on an arbitrary set of rules.

This, perhaps, is the key to extended development timescales. There is a standard development cycle for electronic equipment, but it can be shortened, at risk, if a commercial approach is adopted. Quite probably, however, there will then be a demand for work to be repeated 'in the proper way', even if the result is entirely satisfactory.

One point was not covered in the original article. A high proportion of all ICs are partially or wholly made in Malaysia, Taiwan or Hong Kong. How could equipment using these devices be made in wartime? A sea/air blockade would cut off supplies only too easily.

Yours sincerely,

Bill Horne
Greenock
We are looking for an electronic circuit designer to complete the editorial team on ETI – the UK’s leading electronics magazine.

We need someone who can come up with their own ideas for designs, see them through from breadboard to working prototype, and write them up for publication. The person appointed will also act as technical adviser to other editorial staff and to magazine contributors.

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ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

Backnumbers

Backnumbers of ETI are held for one year only from the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service. We have made a full index to all projects and features available (see under Backnumbers, below) and we trust that wherever possible, readers will refer to this before getting in touch with us.

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- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, etc. we enjoy reading your opinions on world affairs, etc. We are not able to answer queries that are not accompanied by a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements, readers will have difficulty in what's wrong yourself. Please do not send us any hardware (except as a gift).

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