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OMP: MF300 Mes-Fet Power output 300 watts R.M.S. into 4 ohms. Frequency Response 1Hz - 100KHz - 3dB. Damping Factor 1000, Slew Rate 150V/µs, T.H.D. 0.01%, Input Sensitivity 500mV, S.N.R. -140dB. Size 360 x 200 x 180mm. PRICE £99.99 + £6.25 P&P.

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**Electronics**

- **Resistors**: 100Ω, 10µF, 1N4148, 1N5390, Y5V, 1N5390, diacs, diacs.
- **Capacitors**: 100µF, 100µF, 1N4148, 1N5390, Y5V, 1N5390.
- **Diodes**: 1N4148, 1N5390, Y5V, 1N5390, diacs, diacs.
- **Triacs**: 1N5390, 1N5390, Y5V, 1N5390, diacs, diacs.
- **Varicaps**: Y5V, 1N5390, Y5V, 1N5390, diacs, diacs.
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Acorn Masters Some New Tricks

The continuing association between Acorn Computers Ltd and the BBC has been reinforced with the introduction of a new range of microcomputers called the Master Series.

Said to have been developed as a result of feedback from users of Acorn's BBC Microcomputer, the main machines in the new range are fully compatible with existing software and peripherals yet differ markedly from both the original BBC B and the recent B+ 128.

The foundation of the new range is the Master 128, an 8-bit, 65C12-based machine with 128K of RAM. It incorporates all the features of the BBC B plus a battery backed-up real time clock, improved graphics, and a suite of on-board software.

An internal expansion slot allows the Master 128 to be upgraded by the addition of a co-processor board. By adding a 65C102 processor board the 128 becomes the Master Turbo, an 8-bit machine which offers an extra 64K of memory and increased speed. Acorn say the Master Turbo beats all records for BASIC interpreting that they are aware of.

Adding an 80186 co-processor board to the Master 128 produces the Master 512, a sixteen bit machine with 512K of RAM which uses Digital Research's DOS-plus operating system to enable it to run MS-DOS software. This makes it compatible with a wide range of commercial and professional software. It also comes complete with an Acorn mouse and Digital Research's GEM software including Gem Desk Top, Gem paint and Gem Write.

The top machine in the range is the Master Scientific which uses a 32016 co-processor board running at 8MHz. This provides 32-bit processing with 1Mbyte of RAM and hardware floating point support. It can handle a wide range of languages used in the engineering and scientific fields including Fortran 77, C, ISO Pascal and many others as well as BASIC.

The final member of the new range is the Master Econet Terminal, a modified version of the Master 128 which includes an Econet interface and the new Advanced Network Filling System. It excludes some of the features of the 128 which are not required on an Econet system and therefore costs about £100.00 less. Those who require full facilities plus Econet working can add an Econet upgrade board to the Master 128.

The external styling of the Master series is similar to that of the BBC B but the case is about 125mm (5") wider and is stepped so that the keyboard is lower than the rest of the case. The BBC B keyboard layout has been retained complete with ten function keys but a 20-key numeric pad has been added to the right of the main keyboard and the BREAK key incorporates a screwdriver lock to prevent accidental operation.

Two sockets are provided which will accept Electron-style ROM cartridges of up to 256K and there are also three internal ROM expansion sockets, one of which takes 128K ROMS while the other two will accept 128K or 256K ROMS. In addition to the internal TUBE connection used for the upgrade boards there is also an external TUBE socket. This will allow the connection of second `processors' other than those on the upgrade boards, for example, one of the existing Z80 second processors. All of the other connections present on the BBC B and B+ are included and there is also a new audio output socket.

The suite of on-board software includes a VIEW-3 wordprocessor package, a VIEWSHEET spreadsheet and BASIC 4, an enhanced version of the BBC BASIC programming language. New graphics commands extend the range of facilities available on the BBC B to include colour mixing and allow easier and faster graphics development and manipulation. 50 bytes of battery backed-up CMOS RAM is also provided, allowing power-up default conditions to be defined in a rather more comprehensive fashion than was possible using the keyboard links on the BBC B.

The Master 128 is available now and costs £499.00 including VAT. The Econet upgrade board for the 128 is also available now and costs £49.99 inclusive. The Master Econet Terminal should be available by the time you read this at a cost of £399.00 along with the Master Turbo upgrade board which will cost £125.00, both prices inclusive of VAT. The Master 512 upgrade board and the Master Scientific upgrade board will both become available during the second quarter of 1986 at prices which have yet to be announced.

Acorn Computers Ltd, Cambridge Technopark, 645 Newmarket Road, Cambridge CB5 8PD, tel 0223-214411.

The Newrad Case

Those who have followed the saga of Newrad Instrument Cases Ltd will be interested to learn that the Sheriff of the High Court has taken walking possession of the company's assets.

Whilst this does not mean that the company has gone into liquidation it does imply that Newrad will not be able to fully orders or make refunds in respect of orders already placed.

Under no circumstances should any further orders be placed with Newrad, nor should any money be sent to them for any other reason.

Unfortunately, it seems unlikely that those who have orders outstanding with Newrad will get either their goods or their money back. Readers who find themselves in this position are invited to contact us so that we can keep them informed should circumstances change.

Those who have ordered kits for the John Linley Hood Audio Design amplifier from Newrad and have not received all of the parts may like to know that Hart Electronic Kits can supply the MOSFET transistors required. Their address is Penylan Mill, Oswestry, Shropshire SY10 9AF, tel 0691-652 894. None of the other components specified should prove difficult to obtain. The cases shown in the illustrations in the article were made by Newrad and are therefore no longer available, but cases with similar dimensions can be obtained from a number of suppliers and should prove an acceptable alternative.

The printed circuit boards for the amplifiers have hitherto been available only from Newrad but we will shortly be able to supply them through our own PCB Service. We hope to include prices next month. Meanwhile, the complete series of articles has been reprinted in the Winter, 1985/6, issue of Electronics Digest and the boards can be obtained from them.
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**GrunDig For Victory**

As part of the efforts by the new Grundig management to revive the company's flagging fortunes, a new range of video products has been announced. The VS380 hi-fi stereo video recorder has reached the market after some delay. Like its smaller sister, the mono VS310, the 380 is a VHS machine offering 40 channels and up to ten pre-programmable events. The usual advanced features are included, and the 380 also offers 'long play' which doubles effective tape time to 8 hours. Both machines feature the new Auto Tape Time Select (ATTS) tape counter system which measures the exit and entry angles of the tape from and to its cassette and uses a microprocessor to calculate and display tape time used and remaining.

As if to demonstrate their firm commitment to the VHS system, Grundig have also released their first VHS camcorder, the VS150, which uses standard cassette and features autofocus, 6:1 motor zoom, electronic assembly editing and record review. The VS150 weighs 2.5kg, without its accumulator and sells for around £1350. The VS310 is priced at around £440 and the VS380 at around £650.

**Smooth Con Merchants**

A Welsh company, Conblock Electrical, are supplying a four outlet, domestic mains filter for use with home computer systems. The unit plugs into a standard 13A socket and is rated at 6A maximum.

Attractively styled in grey moulded polycarbonate, the Smoothline costs no more than a couple of computer games, 'say Conblock,' and allows the enthusiasts to almost totally eliminate system problems caused by interference transmitted via the mains supply.

The unit is supplied complete with mains lead, mains plug and four miniature plugs for connections to a computer and various peripherals.

Contact: Conblock Electrical Ltd., Mochdre Industrial Estate, Newtown, Powys SY16 4LF (tel: 0686-271100).

**EPSON-Line**

Purchasers of new Epson computers and printers will receive free membership of EpsonLink, an electronic mail service run on Telecom Gold. EpsonLink promises next-day delivery anywhere in the UK or USA and also allows users to transmit to any Telex terminal in the World without Telex equipment. The system also allows users to receive information from several databases not subscribed to directly. It is aimed particularly at the users of portable computers, which Epson specialises in.

**Not Discontinued**

Way back in our January 1986 issue (you know, the one that came out in December 1985) we offered a twin 3¼in disc drive unit in conjunction with Wardard Electronics at a special price.

Unfortunately, our February 1986 issue (which should come out in January but is printed in December to avoid the Christmas holidays) was distributed almost as soon as it was printed, appearing on some news-stands as early as the 19th December. As a result, the January issue (which comes out in December; remember) was on sale for less than two weeks and many people missed it (if all this sounds confusing to you, think how much worse it is for us as we sit here, in January, writing the March issue (which comes out in February,) and planning the April issue).

Because so many people missed the January issue, we have decided to extend the period for which the Watford disc drive offer is available.

The unit consists of two 3¼" 80 track, double-sided, double density disc drives in a steel case which is coloured and styled to match the BBC microcomputer. The disc drives will work with other machines, of course, but they are provided with leads ready for direct connection. A BBC and come with a free utility disc containing a game for the BBC. The capacity of the drives is two megabytes total unformatted which represents 327K per side printed.

The cost of the twin disc drive unit is £140.00 plus VAT, a total of £151.00. Postage and packing is included in this price. Cheques should be made payable to Watford Electronics and sent to us at the address on the contents page. Please mark envelopes ETI (DD) to ensure prompt attention.

**Be A PAL**

Copies of the latest edition of the Monolithic Memories Programmable Logic Handbook are available free from MMI. The catalogue includes PALs and Programmable Logic Elements applications and data sheets and a number of technical articles that might be of interest. The catalogue can be obtained from Monolithic Memories Ltd., Monolithic House, 1 Queens Road, Fareborough, Hants. GU14 6DJ (tel: 0252-517431).

**SeePROM**

The latest addition to Hitachi's growing range of CMOS microcomputer interface 8-bit PROMs is a single-chip device including an 8-bit microprocessor, 8k of EPROM and an 8 channel by 8-bit ADC on board. Hitachi say that the H636705Z also features a serial communications interface (8 parallel I/O lines and 8 interrupt lines. The chip is supplied in an 80-pin flat-pack for surface mounting and, in one version, includes a window for UV erasing.

Further details from Hitachi Electronic Components (UK) Ltd., Hitec House, 221-225 Station Road, Harrow, Middlesex HA1 2XL (tel: 01-861 1414).
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DIARY

Electronics In Oil and Gas — February 4-6th
Barbican, London. See November '85 ETI or contact Cahners at the address below.

Intellectual Property and Patents — February 18th
Institute of Physics, London. One-day meeting. For details and registration forms contact The Meetings officer of the IOP at the address below.

Power UK '86 — March 4-6th
Kensington Exhibition Centre, London. Exhibition and conference devoted to power supplies and alternative power sources. Organised by the Power Supply Manufacturers Association. For details contact TCM Expositions Ltd, Exchange House, 33 Station Road, Liphook, Hampshire GU30 7D0, tel 0428-724 660.

Electronic Production Efficiency Exposition — March 11-13th
Olympia, London. See November '85 ETI or contact Cahners at the address below.

Electro-Optics/Laser International — March 18-20th
Metropole Convention Centre, Brighton. Exhibition and conference on optics and lasers which includes a special focus on fibre optics. For details contact Cahners at the address below.

Low Energy Ion Beams — April 7-10th
University of Sussex, Falmer, Brighton. Conference on the production and use of ion beams, covering such areas as semiconductor processing and machining and material modification in metals and insulators. There will also be an exhibition of related equipment. For details contact the Meetings Officer of the IOP at the address below.

Electrical Insulation Conference — May 19-22nd
Brighton. International conference described by the organisers as the premier event in its field. For details contact the British Electrotechnical and Allied Manufacturers Association, Leicester House, 8 Leicester Street, London WC2H 7BN, tel 01-437 0678.

Advanced Infrared Detectors And Systems — June 3-5th
Institution of Electrical Engineers, London. Conference which aims to cover the developments in infrared detectors, systems and techniques and their relationship to developments in the field of millimetre waves. For details contact the IEE, Savoy Place, London WC2R 0BL, tel 01-240 1871.

Networks '86 — June 10-12th
Wembley Conference Centre, London. Exhibition and conference devoted to all aspects of data exchange networks. For details contact Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

Northern Computer Show — June 24-26th
G-MEX Exhibition Centre, Manchester. Exhibition aimed at professional computer users, from professionals in user departments to computing specialists. For details contact Reed Exhibitions, Surrey House, 1 Throwley Way, Sutton, Surrey SM1 4QQ, tel 01-643 8040.

KBS '86 — July 1-3rd
Wembley Conference Centre, London. Exhibition and conference devoted to knowledge based systems. Contact Online at the address below.

Voice Processing — July 1-3rd
Targ Hotel, London. Conference. For details contact Online at the address below.

Address:
Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.
Institute of Physics, 47 Belgrave Square, London SW1X 8QZ, tel 01-253 6111.
Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

ETI MARCH 1986

Getti ng Your Back Up

Battery backed-up memory is becoming increasingly important in microprocessor applications and can often be the most effective and efficient means of non-volatile data storage. Direct PCB mounting batteries are an attractive option where space is at a premium. A new range of batteries from the French company SAFT should meet most requirements.

The batteries are produced in upright or flat packs for either a small footprint or a low profile and the range includes rechargeable Ni-Cads and non-rechargeable lithium batteries with an operating life of up to 10 years.

- Mullard have announced a SECAM to PAL converter which distinguishes between SECAM and PAL signals, passing PAL directly to the chroma output but converting SECAM signals into PAL standard before output. The transcoder, as it is called, contains all necessary circuitry on a single chip, the TDA3592A, and operates by demodulating the SECAM signal and remodulating it in PAL format. The output is, therefore, a true PAL signal and the chip can be used with any PAL decoder in monitors, VCRs and video cameras as well as televisions.

- Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD (tel: 01-580 663).

- Pineapple Software have released a circuit-drawing program for the BBC micro. The program is called DIAGRAM and covers 39 screens in Mode B (high resolution). Individual screens operate as windows on this larger logical screen. The program supports printouts on most dot matrix printers in a variety of print sizes and can also be used to produce PCB layouts. DIAGRAM is supplied on 5 inch disc and costs £28.75 from Pineapple Software, 39 Brownlea Gardens, Seven Kings, Ilford, Essex IG1 9NL (tel: 01-599 1476).

- Halley's Comet disappears below the UK horizon on 31st March. Throughout March, it can be seen in Sagittarius having reappeared after its closest pass to the sun (perihelion) on 20th February before sunrise in the east at magnitude +3. Information from the European Space Research Unit, thanks to Oscar News, the magazine of AMSAT-UK, the Radio Amateur Satellite Organisation of the UK Contact Ron Broadbent G3AAJ, 94 Herongate Road, Wanstead Park, London E12 5EQ (tel: 01-989 6741).

- The new short form catalogue from British transistor manufacturers, Semelab, has been expanded to include devices distributed by the company as well as made by them. The catalogue also lists a range of USA replacement types and gives basic data and device characteristics. It is available free from Semelab Ltd, Coventry Road, Lutterworth, Leics. LE 17 4JB (tel: 04555-56565).

The Ni-Cads are produced in versions with nominal voltages of 2.4 and 3.6 and capacities of either 40 mAH or 100 mAH. The smaller capacity batteries require a trickle-charging current of 2mA, while the larger capacity versions need 4mA. The upright Ni-Cads are only available at 3V6.

The SAFT lithium batteries are produced in both upright and low profile packages, but only in a 3V0, 200 mAH version.

The range is supplied by MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27 9LH (tel: 01-670 4466).

ETI
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Social Consequences

Dear Sir,

I feel I must reply to Joseph Michael's letter (ETI, January 1986) concerning the inclusion in ETI of articles with political aspects. If I understand Mr. Michael's rather garbled argument correctly, he is presenting an attitude which, in my opinion, untenable. In the interests of brevity, and in order not to appear too didactic, I will make three simple points.

Firstly, those of us who are scientists or technicians of some description have a responsibility to pay heed to the social consequences of our work, a point which Alfred Nobel understood. How can we do this if we are not kept informed of how science and technology is (allegedly) being used?

Secondly, although as Mr. Michael says, 'Many hours of politics are screened on television each day' it is devoid of hard technical data, aimed as it is at an audience most of whom would not understand such details. What better forum for these details than a technical publication like ETI?

Thirdly, these articles do not pose a threat to the conventional contents of the magazine, as Mr. Michael seems to imply. The Greenham piece took up only half a page in an issue of sixty-six pages! Anyone who wished to ignore it could do so with ease.

In conclusion, I look forward to many thought-provoking future articles about the wider implications of electronics.

Yours faithfully,
Malcolm-Ray,
London NW6

Dear Sir,

On return from a trip abroad I welcomed the opportunity to peruse Dec. and Jan. issues of the magazine. After reading of Greenham Common and your reply to the letter from Sgt. R. Hailstones I have informed my newsagent to cancel my subscription.

I have no wish to encourage you to monitor any aspect of one of our defence establishments.

Yours faithfully,
C. H. Hargreaves,
Manchester.

The idea that 'our defence establishments' are above monitoring, I find frankly appalling. They are, I believe, there to defend us and, what's more, they hold the power to destroy millions of us and millions of our fellow human beings. If any institutions should be monitored as a matter of course, surely it is them. Like it or not, ETI belongs to the family of the media and the responsible members of this family should represent the interests of concerned citizens. Electronics is a hobby or a career for just about all our readers, but it is also an instrument of warfare (or, if your prefer, defence). I think it absolutely right and proper that ETI and its readers should be aware of this. Incidentally, the abandonment of the dual-key policy with regard to cruise missiles means that the Greenham base can hardly be described as 'one of our defence establishments. The decision to deploy the missiles sited there will, if that dreadful day ever comes, be entirely in the hands of the American Armed Forces. — Ed.

Alf — A Bet!

Dear Alf,

I spend a great deal of time doing puzzles of one sort or another, and enjoy yours very much. However, I think I've spotted a mistake in your solution in the January issue: the answer '(9R + 4R) / Alf' should read '9R + (4R / Alf)', with a similar amendment to the following line.

I wonder if you've ever come across the old favourite about the cube of one-ohm resistors? Twelve one-ohm resistors are wired together in the form of a cube and the problem is to determine the resistance between any two diagonally opposite corners; for instance, between point A and G in Fig. 1. A solution by the usual series and parallel resistor calculations is possible, but there is a much easier way.

From the symmetry of the cube, it is easy to see that the voltages at points E, D and B will all be the same, no matter what signal may be applied to points A and G. A similar argument applies to the voltages at points H, F and C, which will also be equal to each other. If the symmetry is not obvious from Fig. 1, the same resistor network is shown rearranged in Fig. 2 to make it clearer.

If the voltages at any two points in a circuit are equal, it can make no difference at all to the operation of the circuit if the points are shorted together, since no current will flow through the link. Therefore, points E, D and B can be joined together, and so can points H, F and C, as shown by the dotted lines in Fig. 2. With these links in place, the resistance of the cube can easily be calculated: it is 1/30hm + 1/6 ohm + 1/3 ohm = 5/6 ohm.

Yours sincerely,
Chris Finn,
Beverley.

Thank you for writing. It's not often I get a letter to myself, not being appreciated around here like I should. I can't speak about the brackets, not actually writing the puzzles myself, it's Auntie know-it-all Static to blame for that. She probably has a degree in brackets, I shouldn't be surprised. How would you like it if everytime you made a mistake, old smary pants let the whole world know about it? The puzzles would be a damn sight better if I did write them, I could tell you a few things about
Scopes for Improvement
Dear Sir,
I am interested in building the ETI Oscilloscope (May-July, 1982, and February, 1983) and as informed in the February 1983 issue, I sent a PO for £2 to obtain the pot core (ET30) from Neosid. This PO was sent in early August. Up to now, I have not received the pot core. Please clarify, I have not got any sort of acknowledgement from Neosid.

It was mentioned that other pot cores may not work because a large inductance factor is needed. What is the inductance factor — perhaps Siemens or others may have one suitable? Please advise.

Finally, please note, I have written many times on previous occasions and have got no replies. Please break your habit in this case!

Yours faithfully
K. G. Vergis
Malaysia.

Since the design was published, Neosid have been in trade supplies only. They will not supply individual orders for the ET30 but they should, of course, return your postal order.

Unfortunately, we have no specifications for the pot core used in the design. All is not lost, however. We have received a number of queries like Mr. Vergis’s and — as a result — the relevant parts of the circuit are being redesigned around a more readily available inductor. The revised design will be published towards the middle of this year. — Ed.

2001 Revisited
Dear Sir,
Reference ETI, September 1985, and the Cortex I/O article. Your circuit for the 74LS2001 has an error. Header pin 2 should be the output and pin 16 the input of IC2. By the way, if you have any info on the internals of the 74LS2001 or know where I can get info. on it, I would be grateful.

I built the header circuit (modified as above) and it works okay. I built mine a bit more compact than that suggested in your article — on a 20 pin DIL header (soldering the board directly on to pins 11 to 20 of the header and mounting IC2 above IC1).

Yours,
Mike Gallagher
Rugby.

Thanks for the correction, which will go straight into CJS! As for the 2001 we can only suggest you get in touch with Richard Roberts at Microprocessor Engineering, 21 Hanley Road, Shirley, Southampton SO15 1AP (0703 780084). — Ed.

CRI De Constructor
Dear Mr. Editor, Sir!
I am writing to you in hope that you might be able to help me get some components for the Barry Porter Modular Preamplifier (ETI, December 1983, January and February, 1984). Your were able to help before when I was building the System A Power Amps — which are still going strong and love CDs.

I need two sets of parts for the disc amps (I received the PCs from you) and a friend in the UK has been unable to contact XL Audio Parts either by phone or letter. They may have moved again or folded. I would be grateful if you could help with an address.

Incidentally the headphone amp sounds great (with mods to PCB and using TIP41/42Cs).

If XL don’t exist anymore, be so kind as to suggest someone else.

Thanks,
John Alderton
Republic of South Africa

XL have proved to be elusive for a number of readers. NP Electronics, The Mill House, Watlington, Kings Lynn, Norfolk PE38 9DW (tel: 0553 — 810 096) have offered to supply kits of the non-commercial electrolytic capacitors and none of the other components should present many problems. By the way, ‘Mr. Editor, Sir’ strikes just about the right note. Keep it up. — Ed.

Dear Sir,
In your July and August, 1984, editions of your magazine you featured a printer buffer kit. In Zimbabwe we do not have ready suppliers of electronic components and I would like to make up two of the above buffers, is there any supplier that you know of who could assist in making up the kits and at the same time give me some advice on connections, firstly to a Commodore which has only an RS232 interface and secondly to a Nascom 2. The printer in both cases has a Centronics interface. Will I require an additional adaptor for the Commodore to accept the Centronics interface?

Your assistance is appreciated.
Yours faithfully
P. Squair
Zimbabwe.

I presume you are talking about a Commodore 64, in which case the answer to that query is that you will definitely require a lead to connect the 64 user port to the printer Centronics input. You may also require some software, although most commercial programs include the routines as standard and, in any case, the routines are not complicated if you know how to handle the 64 user port.

For further information and advice, contact the PCB and EPROM supplier, Tronik Designs, 6BA Broomfield Avenue, Palmers Green, London N13 4JP. Cables and software for the 64 can be obtained from F4 Supplies Company, PO Box 19, Whistable, Kent CT5 7JJ.

Dear Sir or Madam,
I wish to construct a Digital Cassette Deck such as is described in your issue of ETI for September 1984, page 27, for computer use.

Could you please inform me where I can obtain the Tanashin Electric TN-3600 cassette deck required for this project.

As there is no mention of the renewal of your PCB service in your issue of ETI for this December I must assume it is not yet functioning. If you are not yet in a position to supply the PCB I require for this project, perhaps you would be so kind as to let me have a good fail protect so that I can etch a board myself.

Yours sincerely
D. Van Beirendonck
Flint,
Chwyd

The PCB Service is now back and raring to go. The Digital Cassette Deck PCB costs £10.25 and you will find details of how to order towards the end of the magazine. The deck itself is obtainable from Cirkit, Park Lane, Broxbourne, Herts. Stock number is 72-03600, price £43.95. — Ed.
Dear Auntie,

I have been following ETI's Sound Sampler project with great interest, but despite my degree in electronics I often find myself getting in deep water. For one thing, I have never heard of 'switched capacitor' filters. Will you please explain what they are and how they work? I am sure other readers would be interested.

W. Richards,
Chatham,
Kent.

A popular circuit for implementing standard filter configurations is the 'Universal State Variable' filter, shown in Fig. 1. The circuit gives high pass, band pass and low pass outputs, and with the addition of an extra op-amp will also give a band reject, or notch, output. In addition, with suitable choice of component values, the circuit can be made to conform to any of the classical filter responses: Bessel, Cauer, Chebyshev, Butterworth, and so on. You can't get much more universal than that!

Unfortunately, the circuit has a number of disadvantages, not the least of which is that the design equations are complicated enough to make you consider abandoning electronics and devoting your life to stamp collecting. Apart from that, if the response of the circuit is to be at all satisfactory, precision low-drift capacitors are needed. These tend to be rather expensive.

The switched capacitor filter offers all the advantages of the state variable filter with far fewer shortcomings. The design equations are simple, there are no external capacitors, and the turnover frequency is accurately determined by the frequency of the applied clock signal.

If you look again at Fig. 1, you will see that the filter consists, in essence, of an op-amp followed by two integrators. The resonant frequency of the filter will be determined by the time constants of the two integrators, R1C1 and R2C2 (and also by the ratio of RHP to RLP incidentally).

Using sampled data techniques, the resistor in each integrator can be replaced by a capacitor and two switches, as shown in Fig. 2. The two switches are closed alternately. With SW1 closed and SW2 open, C1 will charge up to VOUT. With SW1 open and SW2 closed, C2 is discharged into the virtual earth at the inverting input of the op-amp. Each time SW2 closes, a charge of C2 VOUT is transferred, and if the switches are opened and closed by a clock frequency f, with one operation of both switches every clock cycle, the average current will be VOUT/2f C2, so the capacitor and switches have an 'equivalent resistance' of 1/(fC2), and the time constant of the integrator will be C2/f.

Now, if the idea is to build a filter from discrete components, this has just compounded the problem. Instead of one precision capacitor for each integrator, we now need two! In the case of an IC, however, although it is still quite tricky to fabricate accurate capacitor values, it is relatively simple to maintain the ratio of two capacitors within very precise tolerances. For instance, if the IC designer intended C1 to be 10 F and C2 to be 50 F, variations in the production process may lead to their values being 10% higher than intended (say), but as both capacitors are subject to the same processes they will both be higher by 10%, and the ratio (11 F to 55 F) will still be 1:5.

The term involving time constants in the equation for the resonant frequency of the filter of Fig. 1 is 1/f2 T1 T2, where T1 and T2 are the time constants for the two integrators. If all other component values are held constant, the frequency will be directly proportional to the value of this term. Using the time constant of 1/f2 for each switched capacitor integrator (i.e. C1/C2, a constant determined by the IC manufacturer, as already explained), this term becomes \sqrt{k/kf}, or k, so not only is the resonant frequency dependent on the clock frequency, it is directly proportional to it! In the case of the MF10 IC, circuit parameters have been chosen by the manufacturer to make the ratio between the clock frequency and turnover frequency 50:1 or 100:1 (selectable), so the calculation could hardly be easier!

The complete diagram of the MF10 is shown in Fig. 3. It has various additional facilities to make the circuit more versatile, but still consists essentially of an op-amp and two integrators. There are two identical second order filters in each IC, which makes the circuit look more complicated than it actually is.

The MF10 family are the MF4 — a fourth-order Butterworth low pass filter in an 8-pin package, needing no external components at all, the MF5, which is just half of the MF10, that is to say just a single second-order filter, and finally the MF6, a sixth-order Butterworth low pass filter which doesn't even need an external clock.

Fig. 1. The Universal State Variable Filter

Fig. 2. A Switched Capacitor Integrator.
Almost An Audio Special!

10 Gigawatt Amplifier On A Pinhead
Well, Almost. Actually, it isn’t quite that powerful and it is a little bit bigger than a pinhead, but even so we think the ETI Matchbox Amplifier is going to be hard to... well, match. It’s a good bit smaller than the average matchbox, delivers up to 50 watts RMS and uses a standard power-amp IC in either a single-ended or bridging configuration. Even with a power supply and generous heatsinking attached, it should still be possible to produce a strikingly small amplifier system using this board. Get your magnifying glasses ready now!

Battery-Operated PA Amplifier
Continuing with the audio theme, we present a John Linsley Hood amplifier design which offers 50 watts of high quality audio and can be operated from a car battery or other 12V DC supply. Unlike some designs in which the amplifier stages operate directly from the low-voltage supply, this project employs a switch-mode power supply which generates a 55V DC rail, reducing the need for compromises in the design of the amplifier itself. The first article describes the design and construction of the PSU, a self-contained unit which can be used with this and with other amplifier units in any application where a 55V DC 2A supply must be obtained from a 12V DC input.

Constant Current Sources
Graham Nalty takes a look at the various types of constant current generator circuits in use and discusses their strengths and the weaknesses and the uses to which they are put. Taking up the audio theme which runs through this issue, he considers the use of constant current sources in audio amplifiers and describes the effect of introducing modified constant current arrangements into a proprietary hi-fi amplifier, raising some potentially controversial issues in the process.

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THE AUDIBLY-SUPERIOR APRIL 1986 ISSUE OF ETI, ON SALE MARCH 7th. HAVE YOU HEARD HOW GOOD IT IS?

Articles described here are at an advanced stage of preparation but circumstances beyond our control may dictate changes to the final list of contents.

ETI MARCH 1986
Why upgrade when you can expand? Do you really need Megabyte power, or can your micro do the job with a little ingenuity and a home-built add-on? Mike Barwise cuts through the jargon jungle to rescue the good old 8-bit from the inflated claims of the supermics.

The mushroom growth of the home computer industry has injected an almost maniacal sense of urgency into marketing strategy. No sooner is one model in the shops than the next is under development, in the hope that the public will buy and buy again.

This has had a significant influence on the design of the home micro. Short development times coupled with the need for obvious advantages in the next model has led the industry to provide micros which in essence cut down versions of the previous generation of business computers. But design concepts which have validity in high performance business computer systems can easily degenerate into mere buzz words when pared down and applied to the design and marketing of the low cost home micro.

Emotive descriptions of processor power, speed and memory capacity capture the imagination, frequently clouding understanding of the concepts involved and their currency. These descriptions often prove to be no more than sales pitch, having little relevance to the real performance of the home micro.

Megabytes: Who Needs Them?

As microchip design progresses it becomes possible to cram more and more microscopic hardware into a smaller and smaller space. Larger scale integration can run faster due to improvements in design, and costs less per function, since expenditure on die development is not directly proportional to gate count.

On the other hand, skilled technician time stays as expensive as always and various high level compilers are now almost universally used to speed up commercial software development. These produce bulky and slow code, but increase the productivity of software developers by up to 100 times, when compared to the output of programmers using assembler.

Faster and more highly integrated hardware systems running massive software at considerably less than maximum efficiency have become the order of the day in business computing. Since the tasks generally required for business applications are not excessively demanding, performance can be very high, but the high speed and enormous memory requirements of such implementations have created user expectations which are not really applicable to the 8-bit micro.

To keep the price down, the home micro uses much simpler hardware than its business brother, with an 8-bit data and a 16-bit address bus remaining the norm. The average business-oriented micro, with a 20-bit or 32-bit address bus, has an address map in excess of 1M byte, whereas the home micro usually has 64K bytes maximum. Ironically, home micro users are likely to demand a much wider variety of applications of their less complex and slower hardware.

There is nothing, however, to prevent the expansion of almost any 8-bit home micro into quite an advanced, fast and complex system. The first step is to appreciate some of the most significant machine-level design principles.

Micro Memory

The small micro address map may generally be divided into four or less functionally distinct areas: systems, program and data memory, and I/O space. As most recent micros have almost every available space already dedicated, it is important to take the maximum advantage of any 'user area' available.

Systems memory is that portion allocated to the hidden 'housekeeping' tasks of the micro, including the I/O drivers, the system control code, the variable and pointer stacks and the scratchpad areas. Different systems make widely differing demands on memory, but in general, the higher 'level' the micro, the more systems memory it requires. As a user of a ready-built machine, you normally have little control over the allocation of systems memory.

Program memory is the area set aside for user applications software. Strictly speaking high level language interpreters and compilers are situated in the program memory as well, although some micros will not allow the user to access the areas set aside for them when they are absent.

The way in which applications software is written largely defines program memory usage, so it is reasonably easy to adapt and make use of extensions if you are writing your own software. However, few efficiently written 8-bit micro applications should require in excess of 28-32K of program memory, so you shouldn't go mad.

Data memory is the real crunch when it comes to the small address map of the home micro. It is often
not delineated from program memory, there being a tendency to store data in array structures appended to the program. This is not necessarily the best answer. Depending on your application, you may need anything from a few bytes to a Megabyte or more. When data memory is separate from program memory, it is the easiest of all memory areas to adapt. Various approaches to unmapped and semi-mapped storage can extend it theoretically almost without limit.

I/O space is the easiest area to start from when post-implementing expansion on your micro. Almost all adequate micros have one or more (usually small) undedicated ‘user’ expansion areas. The trick is to cram as much as possible into these spaces.

**Commercial Micro Expansion**

Paged memory units, RAM-disk, files, second processors and buffers are optional add-ons available for an increasing number of home micros in an attempt to overcome capacity and speed restrictions. Unfortunately, it is rare to find add-ons from different sources which are compatible, and it is difficult to select the one which will perform best in a specific user-defined application. All of them have to be fairly general in their application, or else be dedicated to accompanying software packages, in order to cover an adequate market. The principles of these gizmos are nevertheless remarkably simple, and with a little ingenuity they may even be improved upon by the enthusiast.

**RAM Disk**

RAM disk is really a misnomer. The system is actually a type of buffer ported to look at high level like a disk interface. Without the disk drive emulation software, a similar buffer concept can be used with increased versatility, as long as the user keeps track of data structures. Such buffers are more suited to data than to program storage, but can also be used in interfaces to secondary or slave processors in multi-processor systems. The design of ported buffers will figure later in this series.

**Second Processors**

The second processor (Fig. 2) is essentially a special case of the multi-processor concept. Its aim is twofold: to increase the effective program and/or data memory of a limited map CPU, and to allow the running of non-native applications code.

Either or both these aims may be fulfilled in any given installation. The principle is that the second processor takes over the running of the application, while the primary processor performs the relatively simple but time-consuming tasks associated with I/O: keyboard input, printer output, disk storage, and so on. This not only relieves the second processor of interruptions and delays, but in addition releases for other uses the memory areas that would otherwise have to contain the I/O drivers and associated housekeeping code. A good example of this is the running of CP/M on the 280 second processor with the BBC micro.

The idea is not a bad one in principle, but it has a few drawbacks for post-implementation. In order to install a second processor of this type, the original host (primary) processor has to be working in a software environment which was created with a second processor in mind. Also, to write applications software which makes full use of the facilities available takes a great deal of systems knowledge. Both these cautions are due to the very general nature of the tasks being performed by both processors.
As a generalised system, the second processor will not necessarily perform specific tasks at optimum efficiency compared with dedicated multi-processors, but on the whole it is probably a great deal better than nothing. Several DIY second processors have featured recently in ETI, and it is well worth a look back at the concepts embodied in them. (See, in particular, 'Second Processor For The Electron', June and July, 1985).

**Paged Memory**

Paged memory (Fig. 3) allows whole large areas of the processor map to be replaced at will by others effectively wired in parallel. Whole or part applications can be rapidly exchanged for others during a program run. A high degree of consistency is required in the structure of software to be used in paged virtual memory systems, but the control overhead can be remarkably small. The BBC micro paged ROM system is an excellent example of the job done well. Commands included in different ROMs can be executed in succession, creating an effective program storage many times larger than the available real program memory.

**Multiprocessors**

The aim of a multiprocessor system (Fig. 4) is to enhance overall system performance by allowing dedicated sub-systems to handle specialised tasks concurrently and independently.

Significant losses of system efficiency occur when data has to be transmitted to and from the real world. The majority of I/O is painfully slow by CPU standards, due to its reliance on mechanical devices, with all their attendant problems of inertia, wear and tear and bits of carpet fluff. Some really complex maths problems can, if implemented in software, tie up the arithmetic logic unit and its associated areas for long periods, leaving the remainder of the system idle. It may also be necessary to acquire and/or transmit information asynchronously with a primary task, or in such volume that the memory constraints of the primary processor cannot accommodate it.

These problems can frequently be eliminated by the efficient linking together of single function subsystems which can perform the time-wasting or otherwise impossible operations concurrently with, and independently of, other primary processor operations.

An excellent everyday example of this is the printer buffer (see ETI, July and August, 1985). The dedicated system emulates a printer port as far as the primary processor is concerned, but can accept data as fast as it can be sent, rather than at the mere 100 or so characters per second of the mechanical printer.

A floppy disk controller chip is also a single function sub-system, although this is less obvious at first sight. In this case it normally shares the primary processor memory (either by primary processor intervention or by direct memory access — DMA), but the principle is the same. Without the FDC, the micro's CPU would have to send all the drive head stepping pulses with their associated timing, load and unload the heads, test the index pulses and write protect signal, identify the track and sector ID references and compute the CRCs. Some additional means of parallel/serial conversion and back would also be needed. This is altogether a massive task, which would take a great deal of the primary CPU time to perform without an FDC.

**Multi-User and Multi-Tasking**

These are two increasingly common buzz phrases, primarily of interest in the office environment, where they improve throughput and assist the efficient use of expensive peripherals such as Winchester disks and high speed printers. Either several workstations or terminals (multi-user) or several independent tasks on one micro (multi-tasking) are performed concurrently by multiplexing so that most of the hardware is active most of the time.

The principles are quite simple, but the adaptation of small systems to work in this way is probably too much effort for the return from a system not designed with multiplexed operation in mind.

Home micro users should consider enhancement of their systems primarily from the hardware standpoint. Adaptation of the operating system, apart from being frowned upon in the current contentious atmosphere surrounding the copyright situation, is really a very difficult job. The level of familiarity required to do it properly would enable the user to make a start on their own independent OS, and if you could do that, you would be unlikely to be reading this article.
The host (primary processor) software required to drive any extensions should be minimal, so we are really left with the addition of dedicated single function (possibly processor-controlled) sub-systems, allowing concurrency of independent tasks, controlled ideally by no more than short instruction sequences from the primary processor. Interdependent tasks performed in this way require more careful control in the time domain, but the problems are by no means insuperable.

Key Functions
The key to optimisation is to identify those functions of the overall system which are invariable or could advantageously be operating concurrently with other tasks. These will normally include:
1. Data file I/O operations via mechanical devices which constrain the processor system to low fixed transfer rates, frequently asynchronous with the system timing.
2. Protracted arithmetic on volume data (for example, encryption/decryption) where long delays can occur between provision of data and obtaining a valid 'answer', and where hardware arithmetic can substantially improve throughput.
3. Real world data interfaces such as analogue data logging where data may be presented unexpectedly or at high asynchronous rates, and are lost if the interface is not serviced in time.
4. Control interfaces to motors and experimental rigs where the control consists of the sending of one or two mode instructions followed by long sequences of, say, serial pulse trains which could be readily generated by simple hardware.

In the forthcoming parts of this series I will be discussing ideas for systems building blocks suitable for these and similar tasks. Design notes will cover inter-systems ports, buffer memory, hardware handshaking.

The 6500 series processor will be used as a model when specific details are called upon, as these processors are about the simplest in structure, but operate in a manner typical of the majority of 8-bit CPUs used in home micros.

Next month I will be concentrating on efficiency, reliability and dynamic investigation of microsystems, systems watchdogs and guidelines for a DIY logic analyser.

In the meantime, get out your micro technical manual and familiarise yourself with the address map.

Home micro users should consider enhancement of their systems primarily from the hardware standpoint...

Make notes first on the locations of designed-in 'user areas' dedicated to both RAM and I/O, and then on functions which you would like to see enhanced. For example, if you need a fast A-to-D interface (around 50kHz acquisition rate) it is worth considering exchanging it for the slow one built into your micro already.

Once you have a general idea of the address map which is free for post-expansion, the best approach can be defined. If your list is very short, the only answer is really to add intelligent peripherals, and finish up with a multi-processor system. Even if your list is quite long, this is, in my opinion, still the most exciting alternative.
THE SHOW MUST GO ON

Display technology is such a fast moving field that we felt it worthwhile to get up to date with some very recent developments. Keith Brindley was at the latest trade show in the cause of further enlightenment.

It's only right that we should give priority to age, and the CRT is certainly getting on a bit. It has been around for a hundred years or so in one form or other, although only as a display device in televisions since about 1930.

The resolution of a CRT display is dependent primarily on the distance between the phosphor spots produced by the electron beam as it forms the picture. In a colour CRT, the resolution depends on the distance between triads of primary colour spots, which in turn is dependent on the accuracy of the shadow mask used to direct the three beams to their respective colour phosphors. CRTs with spot distances (known as pitch sizes) of as small as 0.2 mm have been made, but typical television CRT displays have pitch sizes of about 0.6 mm. In terms of resolution, the CRT has a way yet to develop, but we can expect television pictures of tremendous clarity from high resolution CRTs.

The problems associated with CRTs are not to do with picture clarity. They are large, ungainly and heavy; their depth is often as big as or greater than the screen size. They consume a lot of power — up to 200 watts or so. They are fairly easily damaged. None of this is any great disadvantage for mains-powered, fixed-site equipment, as long as you don't mind your television taking up all of the corner of the living room, or your computer taking up most of the room on your desk. If lightness, durability, and power consumption are important, then the conventional CRT will not do.

Fig. 1 Philips flat-screen CRT (simplified).

The latest from Epson — the high-contrast 'Black Shutter'.

Sinclair's flat-screen CRT is one development of a traditional technology. As it stands, however, the device — though ingenious — is monochrome, difficult to view and constrained by its very ingenuity to remain small. Philips is one company developing a flat-screen colour CRT. While similar to the Sinclair device in that the electron beam is side-projected, it is totally different in other respects (Fig. 1). The Sinclair tube uses a familiar electron gun bent through 90°. To engineer such a tube for the accuracy required of colour television would be very difficult. Philips use a single electron beam — like Sinclair but it scans at three times the normal rate, so it can cover all three spots in a colour triad. It also has an unusual approach to deflection. After reversal of the beam, frame plates bend it to the required spot on the screen. Before hitting the screen the beam passes through an electron multiplier, increasing the number of electrons and so making a brighter spot. ITT and Siemens are the other two companies working on the developments of flat-screen colour CRTs.

The Liquid Crystal Ball

Apart from dabbling at new developments in CRTs (Sony's Trinitron CRT — a single electron beam device — and Toshiba's flatter, square tube) the Japanese appear to be leaving major CRT developments such as flat-screen devices well alone. Instead they are concentrating efforts towards flat-panel displays which do not use electron beam at all.

The main force of their work so far has been in the
development of LCD devices, but other technologies will probably form the display devices of the future.

There are a number types of LCDs, but the principle is the same in all of them (Fig. 2). A layer of liquid crystals is sandwiched between two transparent electrodes. The molecules of the liquid crystals are generally aligned in one direction and so light from behind the device can pass through. When a potential is applied across the electrodes, however, the molecules of the crystals all become polarised into another alignment, which prevents light from passing through the layer, making the layer appear dark.

Three main varieties of liquid crystal are used to make LCDs: nematic, cholestric and smectic (Fig. 3). The major difference is in how the molecules are aligned, and this produces greatly different LCDs.

Nematic liquid crystals are more commonly called 'twisted nematic' crystals, because the crystals sandwiched between the transparent electrodes are twisted through 90° between one electrode and the other when no potential is applied. Polarising sheets (at 90° to each other) are applied at the front and back of the device, so that light entering the LCD is polarised in one plane by the first polarising sheet, passes through the liquid crystal where it is twisted through 90° by the twisted nematic structure, then leaves the device through the second polarising sheet (Fig. 4). Typically the LCD wouldn't normally be used like this, but a reflecting surface would direct the emergent light back through the set-up, so that an observer on the same side as the incident light would see a 'transparent' area.

When a potential is applied across the electrodes, the crystal becomes active, and the molecules are all aligned in one direction. The incident light, which is polarised by the first sheet, now passes through the liquid crystal without being twisted. It cannot pass through the rear polarising sheet, cannot be reflected, and therefore cannot be seen by the observer. An opaque area is produced.

Cholestric crystals do not need polarising sheets since a dye is added to the liquid crystal to absorb the incident light. LCDs using this principle are sometimes known as 'guest-host' devices. Dichroic dyes, which produce a different colour depending on which way their cells are aligned, are the 'guests' in the liquid crystal 'host'.

In an inactive state, incident light passing through the liquid crystal is polarised by the natural twist in the structure, and because of the dye the emergent light appears coloured (Fig. 5). As with twisted nematic LCDs, when the activating potential is removed the structure reverts back to its inactive, though this time coloured, state.

Heat Waves

All liquid crystals have several temperature dependent phases, in which the ordering properties of the molecules change. Three phases: isotropic, nematic and smectic are used in smectic liquid crystal devices to create a different type of LCD. Smectic LCDs rely on three phenomena to do their job:

1. In the smectic phase, the molecular arrangement of the liquid crystals cannot be changed by an applied electric field.
2. When liquid crystals are heated to the isotropic phase then cooled to the smectic phase with no applied electric field, they become strongly disordered.
3. When heated to nematic phase, then cooled with an applied electric field to the smectic phase, the orientation of the molecules will be as in the nematic phase.

To exploit these phenomena, smectic LCDs use a matrix of electrical lines so that each display element in the display can be addressed and heated electrically.
By heating the liquid crystals to the isotropic phase, then cooling them to the smectic phase, incident light is prevented from passing (Fig. 6). By heating the crystals to the nematic phase, applying an electric field to align the molecules, then cooling them to the smectic phase, incident light is allowed to pass.

**Colour LCDs**

The LCD techniques we've looked at so far have been for dot-matrix displays — ideal for computers but not so good for televisions. There are three reasons for this. First, the displays are monochromatic — and who wants a black-and-white television? (Well, Sir Clive?) Second, the display type is dot-matrix — each dot can only be on or off, unlike CRT screen spots which are graduated in brightness. Most important is the response time of these devices (the time it takes for the device to switch between active and inactive states). Common response times are around 300ms — great for computer or alphanumeric displays, but certainly not fast enough for television where each spot on the CRT screen is addressed by the electron beam every 40ms.

Two of these problems, colour and response time, are being tackled by a number of Japanese manufacturers with LCD devices which use thin-film transistors (TFTs) mounted directly on the glass which forms the casing to contain the liquid crystal. The transistors are thus in direct contact with the crystal itself (Fig. 7).

The use of TFTs dramatically reduces the LCD response time, down to a level approaching that required to display television pictures. By making an LCD element so small that it can be considered as a spot, and by grouping three spots into triads, coloured filters can be placed over the individual spots so that the triads can be addressed much like the triads of a conventional CRT. And, hey presto, we have an LCD colour television display device.

A number of Japanese manufacturers, notably Sanyo, Casio, and Citizen, have recently shown prototypes of colour television using this method. Sanyo’s, the largest, is a 4-inch display. The Epson Elf, a colour television with a 2-inch display, was the first to be produced and has been on sale abroad for a year or so already.

The resolution of these displays is limited by the number of liquid crystal triads which can be produced in the device. At present the resolution doesn’t even approach that of typical low-grade television CRTs, but it is only a matter of time — and research money.

Size is probably the colour LCD’s greatest enemy. The quality of the colour display is limited by the constancy of the thickness of the layers in the device. The larger the device, the more difficult it becomes to maintain constant thickness. So, no wall-sized flat-panel television screens using LCDs yet, I’m afraid.

**Flat Contender**

A contender in the race to beat the CRT as the only viable television display device is the electroluminescent (EL) flat-panel. Electroluminescence occurs when certain phosphorescent materials are influenced by an electric field.

Figure 8 shows a cross-section of an EL display, with criss-crossed electrodes allowing each point where two electrodes overlap to be addressed. The material sandwiched between the layers of electrodes is typically zinc sulphide, which emits a bright yellow-orange colour when an electric field is generated through it, but red, green and blue emitting materials have recently been isolated.

EL displays are of four main types: DC thick-film, AC thick-film, DC thin-film, AC thin-film. Thin-film varieties have proved to be the most successful so far, in terms of reliability and power requirements. In these, a layer of powder phosphor, typically around 30µm thick, is deposited onto a sheet of transparent oxide which forms the front electrode. This layer is then covered by a vacuum evaporated aluminium rear electrode. After
etching horizontal and vertical rows and columns into the front and rear electrodes, the device is more or less usable.

Such displays are of monochromatic dot-matrix form suitable for alphanumeric computer displays and graphics. By overlaying thin-films of red, blue and green emitting phosphide layers, there is hope that EL displays suitable for reproduction of coloured television pictures can be made. Their availability on a commercial basis is many years off yet.

EL displays generally need quite a high operating voltage (over 100V) and considerable current, so they are probably not the display to be used in portable equipment, but for flat-panel home or office use their potential is great.

**Plasma Gas Discharge**

Plasma gas discharge of inert gases under a strong electric field is the basis of another type of flat-panel display — the plasma display panel (PDP). The gas breaks down into a plasma and gives off light. Neon indicators work in the same way.

The two main varieties of PDP differ in the applied voltages. In the DC plasma display the criss-crossed electrodes are in direct contact with the gas. In the AC plasma display, the electrodes are close to the gas but electrically isolated from it (Fig. 9).

Large sized PDPs have been developed, initially for military use, and now available on a commercial basis and used in many computers. Thomson-CSF, for example, has recently produced a 1024 x 1024 dot-matrix PDP display, whose resolution is not far short of a CRT.

PDP displays still have many disadvantages. Operating voltages are quite high (typically around 80V), they’re not solid-state devices and can’t be as rugged as LCD or EL displays. Colour displays suitable for television use are going to be difficult, if not impossible, to make.

**ECDs**

One new form of display device, just now reaching the market, looks as though it might topple the CRT in years to come. The electrochromic display (ECD) uses the fact that an electrochromic material changes its colour reversibly by redox reaction.

For example, amorphous tungsten trioxide (a-WO₃) turns reversibly from transparent to blue by reacting with lithium ions in an electrolyte, following the formula:

$$\text{WO}_3 + \text{Li}^+ + e^- \rightarrow \text{LiWO}_3$$

A simple display is illustrated in Fig. 10.

![Fig. 10 A simplified electrochromic display.](image)

This display is much simpler in operation than an LCD, and would be much cheaper to make. It does, however, have significant disadvantages, not the least of which is its response times (over half a second to change from white to blue, and over two seconds to change from blue to white). Significant development work is underway, and it’s probably true to say that ECDs are only at the stage which LCDs were at 15 years ago (nowhere). Given a few years and some hard research and development...

**Old And New**

The problem for manufacturers is not just one of research and development, but because other factors, mainly financial, are also involved. CRTs are an old technology. They’ve been made for many, many years by experienced manufacturers. They are used mainly as a television display device, but they’re also used in test equipment — oscilloscopes, spectrum analysers, logic analysers and frequency response analysers — as well as in computers. Because of the numbers involved and because of the tried and tested manufacturing techniques, they are very cheap.

Flat-panel displays, on the other hand, are new. They’re relatively difficult to make and therefore expensive. So, manufacturers are going to be very careful to analyse the situation before they decide on any one other display technology which they think can fit the bill. No one display technology is yet capable of being better than the CRT in all applications. LCDs use much less power, but they have a very restricted viewing angle, low contrast, and can’t be viewed in the dark (they are a non-emissive technology); EL displays are much thinner and are an emissive technology, but their power requirements are not much less than those of the CRT. ECDs are thin, have a wide viewing angle and high contrast, but they still have an unacceptably long response time.

At present, CRTs are unbeatable because technology rides on the back of its own success. New developments such as flat-panel, low-powered, high resolution colour CRTs will be along soon. But time is the CRT’s own worst enemy. Given a few years, easier manufacturing techniques and lower manufacturing costs, flat-panel displays must surely beat and CRT. The questions are: which flat-panel device will do it — and when?
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26 ETI MARCH 1986
BETTER BY DESIGN

Even professionals make mistakes, and Andy Armstrong is not afraid to point out some of the commonest. If you’re thinking of designing a circuit, the best place to start is here... 

...after inspecting many designs at the draft stage, it is clear that there are some misunderstandings and design errors which crop up again and again. Some aspects of circuit design, for reasons unknown, seem to be ignored or glossed over even by the most seasoned practitioners.

Most of the problems fall into the category of ‘things which will work most of the time or work with certain samples of the components used’.

A typical example was faced by a friend of mine, in a vacation job after his second year at college, and involved unijunction transistors. Someone had designed (by dint of sheer building) a control unit, incorporating a unijunction, for an electric arc welder. The first production batch of welders worked very well, but none in the second batch worked at all.

It turned out that the circuit had been optimised, by trial and error, to work with a batch of unijunctions which were at the edge of the specification. The next batch purchased had more typical characteristics, and the circuit could not cope. The configuration of the circuit was not designed to take account of the tolerances of unijunctions but a change of component values centred the circuit on the typical operating parameters. Subsequently only one component value had to be changed if a batch of unijunctions was too far from typical.

Design Posts

Nobody expects magazine projects to be designed to industrial standards, (although we prefer it if they are — Ed.). This would be uneconomic, because of the very large amount of time required to design even a simple circuit to production standard, and because of the need to make more than one prototype to double check a design. These limitations notwithstanding, a project design needs to be as close in standard to an industrial design as possible, and should, in particular, avoid problems connected with variations in the electrical and mechanical characteristics of components.

Of course, there are differences in emphasis. For example, a circuit may rely on a particular component characteristic, perhaps requiring that two diodes have a similar voltage drop at a certain current. The home constructor could happily select the components but, in an industrial design, the cost of paying someone to grade components would mean that the real price of a 5p diode would be a lot more than 5p!

On the other hand, if too much decision-making on the part of the constructor is necessary to make a project work, then some of the people who build it will simply never succeed.

Family Characteristics

Many of the marginal designs I have encountered have used CMOS, so this is the place to start.

The 4000 range of CMOS is designed to work over a wide range of power supply voltages. Different manufacturers specify slightly different operating characteristics at different voltages, but here I shall refer to the Mullard/Signetics HEF4000B range. Some of the family specifications are reproduced here for reference.

### Logic

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<td>Output leakage current HIGH</td>
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Note: (1) = Vcc = Vcc (2)

Family specification of HEF4000B devices (with thanks to Mullard)
A number of circuits use a CMOS gate output to switch a transistor, which is used to control a relay, lamp, etc. Normally, a small signal transistor such as a BC182 is used to drive the load and, in order to work well, the transistor must be switched on hard. This requires adequate base current — a rule of thumb is to use a base current of 0.1 times the required collector load current. This can exceed the current which the gate is guaranteed to supply, though in fact most gates manage well over the minimum specified current.

It is not a good idea to rely on your good fortune in selecting a gate. Back on the industrial front, I recently had to investigate a rash of mysterious board failures, and discovered that one of the CMOS gates was being asked to deliver about twice its guaranteed output current. After a while, most gates from one batch failed, though the design had been produced without problems for several years beforehand. Presumably this batch of gates was unable to exceed its specification without damage.

To avoid this sort of problem in home projects, a CMOS gate sourcing current should have a load resistance of at least 1 kΩ per volt of power supply. If this means that the transistor it is feeding receives insufficient base drive to switch properly, then the answer is to use a Darlington transistor, or two transistors connected as a Darlington pair.

**Most of the problems fall into the category of ‘things which will work most of the time or work with certain examples of components used’...**

Alternatively, you could use a power FET suitable for the desired load current. A power FET capable of switching several amps may be driven directly by a CMOS gate. The switching speed may be low, because of the limited rate at which the CMOS output can charge or discharge the FET gate capacitance. The heavy load presented to the CMOS gate output by this capacitance is of short enough duration not to risk damaging the CMOS chip unless a high frequency switching signal is used.

There is one exception to these stem warnings about overloading CMOS outputs. When powered from a 5V supply, most CMOS chips are designed to be ‘short circuit proof’. The practice of driving an LED from the output of a CMOS gate should not be harmful at this supply voltage, though the output will not provide a proper logic level when used in this manner. My recommendation is that this practice be confined to ‘novelty’ circuits, such as the infamous Thing.

---

**Clock Oscillators**

Many projects incorporate some sort of oscillator, which may be needed to clock a counter, or to generate an audible tone. Figure 1 illustrates a simple Schmitt trigger circuit, using a Schmitt trigger IC. As shown in the waveform diagram, Fig. 2, the capacitor charges through the feedback resistor until the voltage on it reaches the positive threshold of the Schmitt trigger gate. The output of the gate then switches to logic 0 and the capacitor starts to discharge until it reaches the lower Schmitt threshold.

There are two drawbacks to this circuit. The Schmitt levels may vary widely from batch to batch of the chip, and the output frequency of the circuit is directly dependent on these levels. Also, the threshold levels are not symmetrical with respect to the power supply (the characteristic of Schmitts known as hysteresis), so the mark-to-space ratio of the output wave is not unity. If the mark-to-space ratio is not important, the circuit may be made more acceptable by the addition of a potentiometer to fine tune frequency.

Some aspects of circuit design seem to be ignored or glossed over by even the most seasoned practitioners...

A more consistent circuit is shown in Fig. 3, and its waveform diagram in Fig. 4. The junction point of R2 and C1 alternately takes up voltages outside the power supply rails, and then charges or discharges to approximately half the power supply voltage. Because the voltage range over which the capacitor works is large, small differences in switching level between different samples of chip do not have much effect on the frequency or the mark-to-space ratio. The frequency is approximately 1/(2.2 × R2 × C1).

---

Fig. 1 Simple Schmitt oscillator. Fig. 2 Waveform diagram.
In some project designs, NOR or NAND gates are used instead of inverters. The 'spare' inputs may be used to gate the oscillator and turn it on or off in response to a logic signal. A logic 0 signal will stop a NAND gate oscillator, while a logic 1 will stop a NOR gate oscillator. If it is necessary to start to clock a counter immediately the oscillator is started, then the rest of the oscillator should be considered. For example, if the signal is generated by pressing a switch, the response should be immediate or the user may begin to wonder if it is working.

Data books never claim that a circuit will work precisely as well under all circumstances.

The circuit shown in Fig. 5 will generate a positive edge on its output immediately a logic 0 is applied to its control input. By its nature, the circuit in its inhibited state will always charge its capacitor in such a way that it ready to switch as soon as it is allowed to do so.

Op-Amps

The correct use of op-amps is another area which seems to be difficult for some project designers. There are several aspects which cause problems.

First of all, some designers simply fail to take account of the input bias and offset current. If a bipolar op-amp is used, the bias resistors should be of a low enough value that the voltage drop in them is small. I recall seeing a reader's circuit in one electronics magazine, showing a 741 connected with all the bias current for the negative input flowing through a 4M7 resistor.

A good rule is to make the bias resistors as low as the rest of the circuit design allows, and to make the total DC resistance connected to each input the same. In this way, the difference in voltage between the two inputs (the offset) is determined by the difference in bias current between the two inputs (the input offset current) rather than the total bias current. If the offset is still too large, then a FET input amplifier should be used.

The open loop gain of an op-amp also seems to confuse some people. The text of the reader's circuit mentioned above stated, 'The maximum gain of a 741 is quoted as 20,000, but in this circuit it is wired to provide a gain of 47,000'. This mistake arises from a misunderstanding about the way the op-amp's gain is determined. The gain is determined by the ratio of the two feedback resistors in the circuit. You can use any ratio you please, but you cannot make the op-amp give more than its maximum open loop gain.

![Fig. 5 An instant turn-on.](image1)

A typical op-amp frequency response is shown in Fig. 6. There are two relevant and related factors, the open loop gain and the gain-bandwidth product. The open loop gain defines the maximum low frequency gain the op-amp can produce under any circumstances, and the gain-bandwidth product indicates the increase in gain with decreasing frequency.

An op-amp having a gain-bandwidth product of 1MHz, for example, will have an open loop gain of unity at a frequency of 1MHz. As the frequency is decreased, this gain will rise until the maximum open loop gain is reached, often at a frequency of about 10Hz.

Totally Slewed

The effects of output slew rate limiting and of power supply variations on op-amp characteristics are clearly illustrated by a mistake of mine, made when 741s were the normal choice of op-amp for any task. In a car project, I used a 741 to clock a CMOS counter. According to the data books, the slew rate of the output of a 741 is inadequate to clock the CMOS counter reliably, but still the circuit seemed to work — at least some of the time. After a little experimenting, I found that the car battery voltage affected the circuit. It all worked well when the engine was running and the lights were turned off, but couldn't be relied on when the battery was being drained and its voltage dipped.

It seems that the op-amp's slew rate was slightly higher when the voltage was higher. This was just enough to make the counter clock on.

The moral of this is that the slew rate of the op-amp can be crucial, and that you should not assume that a characteristic which is specified to be just good enough with, say, +/- 15V power supplies will still be alright at lower voltages. This is true even though the op-amp may be specified to work at much lower voltages. Data books never claim that a circuit will work precisely as well under all circumstances.

Passive Components

There are two common areas of misunderstanding which I have noticed in the use of passive components. The problem with resistors is very simple: ordinary quarter-Watt resistors have too low a voltage rating to be connected to the mains. Resistors rated ½ Watt and greater have a higher voltage rating and are therefore generally okay to connect to the mains. The voltage rating of a resistor can limit the maximum power that can be fed into it to less than its nominal wattage rating.

The other point of misunderstanding is the use of non-polarised capacitors on AC, specifically when connected to the mains. Most people realise that a capacitor to be used on AC should have a DC rating equal to the peak of the AC waveform, but the problem does not stop there.

At any significant frequency, above a few Hertz, the voltage which the capacitor can withstand is reduced, because the chemical bonds in the dielectric material are stressed first one way then the other by an AC waveform, and in this process power is dissipated. Weak spots in the dielectric can become hot spots if subjected to AC waveforms, and can subsequently break down. Dielectric materials with higher levels of AC power dissipation suffer from this problem more severely. Generally, polypropylene capacitors are much better than polyester, while ceramics come in widely varying qualities.

One type of polyester capacitor, for example, is rated at 400VDC, 150VAC at 50Hz. A high quality polypropylene capacitor in the same catalogue is rated at 1000VDC, 350VAC at up to 5kHz. Some mica capacitors are rated to handle substantial RF signals.
CAPACITANCE METER MODULE

This free PCB project gives your multimeter extra capacity.

A multimeter is an essential item for anyone with an interest in electronics, but it has its limitations. Few will measure anything more than voltage, current and resistance, but there is no reason why this range should not be extended by the addition of a little extra circuitry. The module described in this project produces an output voltage proportional to the value of a capacitor connected to its terminals, and can be connected to a multimeter on a low voltage range to give direct capacitance readings. The accuracy is surprisingly good for such a simple circuit and you can have just as much confidence in the capacitance readings as you would in the meter's own resistance ranges.

Methods

Two common methods of measuring capacitance are the bridge method, which you can read about in the RCL bridge project (ETI August, 1985), and the monostable method. The bridge method is notionally capable of great accuracy, since its readings are independent of the accuracy of the meter movement, but the full potential is rarely realised in any but the most expensive instruments. Precision components must be used since the bridge effectively compares a known value and the unknown one at the terminals. The most awkward point, from a home construction point of view, is the need to construct an accurate scale for the balancing pot. If unlimited numbers of precision components are available, the scale can be calibrated directly. Otherwise the constructor is faced with the problem of trying to interpolate a highly non-linear scale between the readings that can be made. Unpredictable nonlinearities in the pot itself make matters worse.

An attractive idea is to measure some circuit parameter which is related to capacitance, and thus derive a direct reading. A common method is shown in Fig. 1.

The monostable is triggered at regular intervals by a pulse from an oscillator. The monostable is designed to have a timing period proportional to the value of the timing capacitor, which is the unknown capacitor. Assuming the oscillator runs at a fixed frequency and the monostable output pulses are of constant amplitude, the mark-to-space ratio of the monostable output, and hence the average voltage across C1, will be proportional to the value of the unknown capacitor. R1 and C1 are chosen to give a reasonable compromise between ripple and settling time.

This type of circuit can work well or not so well, according to the care taken over the design. One point to note, however, is that there are three circuit parameters which must be accurately controlled: the oscillator frequency, the output amplitude of the monostable, and the linear relationship between the unknown capacitor value and the monostable period. Drift in any of these will cause a proportional change in the output voltage. If the number of critical areas can be reduced, it seems reasonable to expect a corresponding improvement in the accuracy of the meter.

Without increasing circuit complexity, another arrangement is possible (Fig. 2a). The oscillator produces an output of constant frequency and amplitude which is applied via R1 to the unknown capacitor. When the oscillator output is low, Cx will discharge via D1. When the oscillator output rises, charge is transferred from Cx via D2 to C1. (R1 is just a current limiting resistor.) Assuming that the rise in voltage across C1 is negligible, the amount of charge transferred is easily calculated: it will be V.Cx, where V is the high output voltage of the oscillator. This charge transfer will take place f times a second, where f is the oscillator frequency, so the total charge transferred every second (in other words, the average current) will be f.V.Cx amps. The average voltage across R2 will therefore be R2.f.V.Cx volts. As R2, V and f are constant, the voltage across R2 will be proportional to Cx... or will it?

The assumption I slipped in earlier on, that the rise in voltage across C1 should be negligible,
imposes an unfortunate restriction since this is the voltage used as an output. As it rises, it reduces the voltage available to pump charge through Cx and so, as the value of Cx rises, the corresponding increase in the output voltage gets progressively smaller. In other words, the relationship between capacitance and output voltage is not really linear at all. Reasonable results can be achieved by limiting the output to a low voltage (0 to 100mV, say) but to make the circuit truly linear Cx should transfer charge into a constant voltage.

In the diagram of Fig 2b, a virtual earth current to voltage converter has been added to provide a constant voltage point for the charge transfer, as in this project. The diodes have been reversed so that an increase in capacitance will still give an increase in output voltage. As the average current flowing from the virtual earth via D2 will equal the average current through R2, the output voltage is still equal to R2.f.V.Cx. C1 is chosen to give a reasonable settling time without excessive ripple and R1 is chosen so that R1.Cx is very small in relation to the oscillator period for the largest value of Cx to be measured, while limiting the peak current to a value that the oscillator output can cope with.

**Circuit**

The final circuit is shown in Fig 3. IC1a forms the oscillator and IC1b the virtual earth current to voltage converter. The component values shown are for measurement of small capacitance values; RV1 is adjusted for an output of 1V per 100p, so on a 1V meter range you can make readings up to about 800p (remembering that the output voltage of the module is limited by the battery voltage) or readings of 0 to 100p on a 1V meter range. As the output is linear, a reading of 2V2 would mean 220p, 4V7 will be 470p, and so on.

**HOW IT WORKS**

IC1a and the components around it form an oscillator which produces a square wave output at about 8kHz, adjustable by RV1. One of the features of the LM358 is that its output is quite happy to go down to the negative supply rail without disturbing the operation of the feedback. Unfortunately, the IC won't pull the output down quite that far of its own accord so an external resistor (R5) is necessary. R5 performs two functions: it is the equivalent of R1 in Fig 2b, and it is also the ballast resistor for the zener, D1.

D1 clips the output of IC1a at about 5V, giving a square wave of fixed amplitude. D3 holds the 'right hand' plate of Cx at the negative supply voltage during high outputs from IC1a; D2 allows C1 to draw current from the virtual earth at IC1 pin 6 when IC1a output goes low.

The current to voltage converter around IC1b makes use of another useful characteristic of the LM358: it remains in linear mode when one or both of its inputs are at the negative supply voltage. This means that pin 5 can be taken directly to the negative supply, giving a circuit with very few passive components.

R7 produces a voltage at the output of IC1b proportional to the current drawn from pin 6. C2 smoothes out the fluctuations so that the voltage across R7 is proportional to the average current. R8 is once again included to pull the output of IC1b to the negative supply so that the meter will give a zero reading when no capacitor is connected.
For different ranges, all that is necessary is to change the value of C1, as shown in Table 1. Although there is no room for the additional components on the PCB, the circuit can be adapted without difficulty to give a multi-range instrument, as shown in Fig. 4. The additional capacitors and presets could be mounted on a small piece of veroboard, or could even be soldered directly to the switch. The values from Table 1 should be followed, so C1a would be 1n (for the 1V per 100p range), C1b is 10n, and so on. To make the best use of the higher ranges, it would be a good idea to increase the value of C2 to 10u.

Calibration
The component layout for the project is shown in Fig. 5. It is a good idea to check component positions carefully, since the locations are not all used and mistakes are easily made. To calibrate the instrument, you will need a 1% tolerance capacitor for each range. For best results, set your multi-meter to the 10V range and use a capacitor which will give a half-scale deflection. For instance, on the 1V per 100p range, use a 500p capacitor and adjust RV1 for a meter reading of 5V.

Table 1 Values of C1 required for various ranges.

<table>
<thead>
<tr>
<th>Range</th>
<th>1V=100p</th>
<th>1V=1n</th>
<th>1V=10n</th>
<th>1V=100n</th>
<th>1V=1µ</th>
<th>1V=10µ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1n</td>
<td></td>
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<td></td>
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<td>10n</td>
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<td>10µ</td>
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![Fig. 4 Switching arrangement for a multi-range meter.](image)

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<table>
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<tr>
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<th>Range</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>10n</td>
<td>1V=1n</td>
</tr>
<tr>
<td>100n</td>
<td>1V=10n</td>
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<tr>
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![Fig. 5 Component overlay for capacitance meter.](image)

Parts List

- Resistors (all 1/4W 5%)
  - R1: 100k
  - R2: 100k
  - R3: 100k
  - R4: 22k
  - R5: 2k2
  - R6: 220R
  - R7: 220k
  - R8: 4k7
  - RV1: 20k miniature horizontal preset

- Capacitors
  - C1: 1n
  - C2: 500n 10V tantalum

- Semiconductors
  - IC1: LM358
  - D1: 4V7 or 5V1 zener
  - D2, 3: 1N4148

- Miscellaneous
  - PP3 battery clip, PP3 battery, BC3 box with battery compartment.

Buylines

None of the components used in this project should present the slightest difficulty. However, you may be interested to know that the LM358 ICs are available to ETI readers at the special price of £2, inclusive, from: Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. A box with a PP3 battery compartment to house the project is available for £2.80 from the same address. Spare printed circuit boards can be obtained by sending £1 and a stamped, self-addressed envelope to: ASP Readers Services, PO Box 35, Wolsey Road, Hemel Hempstead, Herts. HP2 4SS.
In a phrase, a lighthouse on a board. Amazing, but true! ETI’s free PCB shows that it’s more than just a flash-in-the-pan. Not much . . . .

What ETI really needs, ruminated Alf, absentmindedly syringing his ears with a solder sucker, is something completely different. The wind howled around ETI Towers and rain lashed the windows of as Flea-byte drew his chair closer to the solitary candle which spluttered fitfully, as solitary candles will, in the centre of the floor. ‘What did you have in mind,’ he asked. ‘Well, I can’t remember the last time we had a project,’ said Alf thoughtfully, ‘to flash v. LED.’ Flea-byte resisted the temptation to put the solder sucker to better use and Auntie Static reverted to her background program. This would be a bad winter for her diodes, she sensed it in her sprockets, and having to listen to Alf’s blathering didn’t help matters in the least.

Alf, realising that his genius would once again go unrecognised, stomped off to make adjustments to an oscillator. Outside, it was raining cats and dogs, speckled geese and the occasional marmoset. It was that kind of day. A lone police car, searching for a mate, wailed plaintively from the Soho wilderness. Suddenly, Auntie’s photocells began to twinkle. A half forgotten mini-flop-popperama diskette, an unwise purchase from Carnaby Street in the late Sixties, had engaged in her disk drive and was infusing her with vital statistics. ‘Gather round, my friends,’ she said, ‘I think I’ve got the answer.’

The Auntie’s Tale

Auntie quickly outlined the story of the two itinerant coal porters who had patented a device for minding buildings when the owners were away. Their invention was a light which would be illuminated as long as the building remained in place, but would go out if it was stolen, so that anyone could see at a glance whether the house was still there or not. Theft of darkhouses, as they were called at the time, was rife, but since the invention of the ‘houseminder’ security light, very few of these seaside homes have been moved.

The next stage of development had to await the arrival of a child to the Kunn family, who had an astonishing degree of foresight in naming their offspring after the light he would one day invent. Belisha B. Kunn it was who adapted the lighthouse principle to produce a ‘roadminder’ to preserve small sanctuaries of whiteness on an otherwise black road surface. These areas are now great tourist attractions; indeed the more popular ones are so crowded that it is hard to stop and admire the handiwork of the artist who painted them on.

Further reference to the invention can be found in the diaries of Arthur Daley . . . ‘And that,’ concluded Auntie, ‘is the story of the minder. Why don’t we do a miniature version for looking after memos’.

Sounds OK to me,’ said Alf, ‘but what are we going to write about it?’ ‘Oh, I think we could get away with just a Parts List and a “How It Works”,’ said Auntie. ‘After all, nobody ever reads the rest of the article anyway.’

**HOW IT WORKS**

ICI contains an infra red LED and phototransistor. When the LED is illuminated the beam will normally fall on the phototransistor, allowing it to conduct and pull the inverting input of IC2a low. If the beam is interrupted by a memo being placed in the slot between the LED and detector, the phototransistor will cease to conduct and the inverting input of IC2a will go high. IC2b and the components around it form an oscillator to flash the LED once a second. When the output of IC2a is low, it has no effect on the oscillator since D1 will be reverse biased. If IC2a output goes high, the oscillator capacitor will be kept at full charge, since R5 is much smaller than R8. IC2b will cease to oscillate and the LED will be extinguished.

The result of all this is that when a memo is held in the slot of IC1, the LED will flash to attract attention to it.

**PROJECT**

**MEMO MINDER**

**Fig 1a Circuit of memo minder.**

**Fig 1b Pin-out of the SDA 231.**
PROJECT: Memo Minder

PARTS LIST

RESISTORS (all 1/4W 5%)
- R1: 3k3
- R2: 33k
- R3:
- R4: 47k
- R5: 220k
- R6: 10k
- R7: 100k
- R8: 47k
- R9: 100k
- R10: 470R

CAPACITORS
- C1: 10µ 10v tant.

SEMICONDUCTORS
- IC1: SDA231
- IC2: LM358
- D1: 1N4148

LED1: 3mm LED, the colour of your choice.

MISCELLANEOUS
- PP3 battery connector,
- PP3 battery.

BUYLINES

The SDA 231-slotted opto switch is available from Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. Price 80p. They will supply the LM358 ICs to ETI readers at the special price of £2. Extra printed circuit boards can be obtained by sending £1 and a stamped, self-addressed envelope to: ASP Readers Services, PO Box 35, Wolsey Road, Hemel Hempstead, Herts. HP2 4S.

Fig. 2 Component overlay for memo minder.
RIA AND NAB EQUALISATION STAGES

The free PCB demonstrates that it has an ear for a good tune. Start here for the ultimate in low-cost stereo.

A stereo pre-amplifier which can give either RIAA magnetic pickup equalisation, or NAB standard tape equalisation, is the final offering for this month. Used with the 'matchbox amplifier' to be featured next month, a low cost, powerful sound system can be assembled in no time!

Fig. 1 Circuit of the pre-amp, with RIAA equalisation.

Fig. 2 Circuit of the pre-amp, with NAB equalisation.

**HOW IT WORKS**

The LM358 is connected as a shunt feedback amplifier with some additional components in the feedback network to tailor the frequency response. The NAB equalisation standard requires a roll-off of 6dB per octave to begin at 50Hz and continue to 3180Hz, at which point it levels off again. In Fig. 2, if the effect of C2 are ignored, the low frequency gain of the circuit will be determined by R5 and R4, and will be 1000. By 50Hz, the impedance of C3 has dropped sufficiently for it to have a significant effect on the gain of the circuit, which will be reduced by about 30% at this frequency, giving the first -3dB point.

The gain continues to drop until the impedance of C3 is comparable with the resistance of R6, at which point any further drop in its impedance will have less and less effect on the gain. At high frequencies, therefore, the gain levels out and is determined by R6 and R4. It will be about 15.

The RIAA circuit operates in a similar way, with the addition of another turnover point introduced by C4.

**BUYLINES**

The LM358 ICs are available to ETI readers at the special price of £5 for £2 from: Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. Extra printed circuit boards can be obtained by sending £1 and a stamped, self-addressed envelope to: ASP Readers Services, PO Box 35, Hemel Hempstead, Herts. HP2 4SS.

**COMPETITION**

Why not use your own ingenuity to design a circuit for our free PCB? The sender of the winning entry will receive £40 and the two runners up will win £20 each. We will publish the winning circuits later in the year. The circuit should fit neatly onto the board, without components soldered to the back, and we will be looking for original, well presented and elegant designs.

Entries should include a circuit diagram, component layout, a parts list and a description of the circuit (typed, please, and not more than 750 words in length). If you are not the kind of person who has circuits published, have a go anyway. You may find out that you are!

Send your entries to: ETI (FP), 1 Golden Square, London W1R 3AB. Please enclose a stamped, self-addressed envelope if you want your entry returned and, please, no submissions after 2 May, 1986.
PROJECT: Equalisation Stages

PARTS LIST

RIAA
RESISTORS (all 1/2W, 5%)
R1, 101 47k
R2, 102 1M
R3, 103 1M
R4, 104 1k
R5, 105 100k
R6, 106 1M
CAPACITORS
C1, 101 220n
C2, 102 20µ 10V taut.

NAB
RESISTORS (all 1/2W, 5%)
R1, 101 47k
R2, 102 1M
R3, 103 1M
CAPACITORS
C1, 101 220n
C2, 102 20µ10V taut.

SEMICONDUCTORS
IC1 LM358

MISCELLANEOUS
PP3 battery connector, PP3 battery.

SEMICONDUCTORS
IC1 LM358

MISCELLANEOUS
PP3 battery connector, PP3 battery.

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Fig. 3 Component overlay for the RIAA circuit — duplicated components are distinguished in Parts List.

Fig. 4 Component overlay for the NAB circuit — duplicated components are distinguished in Parts List.

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Time Machine

Sound Engineering

of Devon

ANNOUNCE AN EXCITING NEW RANGE OF STUDIO QUALITY PROCESSORS, MULTI-BAND AND ANAMALLES, IN STACKABLE AS CASES UK HMOS.

DI Compression Gate

Butchery signal treatment. Perfect for mastering the tonal balance of MUSIC and incorporates a 3-band compressor capable of producing a full range of tonal control, from a full compression of 1:10 to a soft compression of 1:4. The DI Compression Gate has a 1:1 output. The DI Compression Gate also has an independent control for the output. A LED display of gain reduction and input indication is supplied.

Activator

A sophisticated, high-performance device offering performance matching that of DI gate units sold in the US and Europe. Featuring automatic calibration and intelligent output.

Microamp

Current meter. Power amplifier with the capability and superior performance of HIGH QUALITY technology. 20.000 x range. Top performance at any frequency. True-gate indication and high limiting.

PSU

The PSU provides up to 800W of power. The PSU provides up to 800W of power. The PSU provides up to 800W of power. The PSU provides up to 800W of power.

Coming soon: LEVELLOR MULTIBAND COMPRESSOR TIME MACHINE ONE REVERB/Delay Harmoniser

Time Machine at ETI, Abbotsford, Deep Park Avenue, Teignmouth, Devon, TQ14 0LJ. Tel: 06267 2353.

ETI MARCH 1986
In a follow-up to his article on programmable logic in last month's issue, Mike Bedford describes a simple evaluation board which will allow readers to experiment for themselves.

In last month's Digital Superglue article, the whole realm of custom, semi-custom and programmable logic devices was investigated. It is quite out of the question for the amateur electronics enthusiast to make use of custom or semi-custom chip technology but the use of programmable logic, on the other hand is quite feasible.

It was shown that programmable logic devices are divided into three categories, namely PALs, FPLAs and PROMs. Of these, PALs and FPLAs are the most flexible but, for reasons mentioned in the article, are also the most difficult to program. It would not be impossible for the amateur to design and build a PAL programmer, but whilst this would prove interesting it would also be extremely ambitious.

PROMs, on the other hand, although less flexible are more easily programmed. EPROMs in particular would make an ideal programmable logic device for home electronics use since many people now have EPROM programmers operating in conjunction with home computers. The theory of using EPROMs in programmable logic arrangements is identical to the concept of using PROMs and was fully covered last month. The purpose of this article is to present both a BASIC program and an experimentation board to allow the amateur to investigate this technology in a practical way.

Basic Program
To recap a little on what was said in the feature article, a PROM (or EPROM) is an example of an AND/OR array. This is an arrangement which allows any Boolean sum-of-products function to be implemented, dependent only on there being sufficient inputs and outputs. Since any Boolean transfer function may be expressed in this form, it follows that any such functions could be programmed into an EPROM. As in all custom, semi-custom and programmable chip design, computer assistance is required for all but the simplest of cases. The purpose of the BASIC program presented here is to convert Boolean equations entered by the user into a hex dump of the data required to program into the EPROM. Alternatively, the program will write the data to a block of memory where it may be accessed by an EPROM programmer.

The design software listing (Listing 1) is written in BASIC but not specifically for one machine. Instead of using a particular dialect and hence special features which may only be applicable to one computer, the program has been written in standard Microsoft BASIC. It should prove a simple task to get it running on any machine. The only areas which may prove to be a problem on some computers are the long IF statements, such as that at line 490. If the version of BASIC in use does not support sufficient continuation lines, it will have to be split into a number of separate IF statements.

The following is a brief description of the way the program works. Lines 300-700 prompt the user for the number of inputs and outputs to be used followed by the Boolean equations, one for each output in use. Within this loop, lines 430-570 carry out syntax checking of the equations, print an error message, indicate the offending character and re-prompt where necessary. Also in this input loop, lines 500-690 add brackets to the equations in order to prioritise the operators such that ANDs are carried out before ORs. The main loop of the program, lines 710-1000, then executes for each memory location used within the EPROM which in turn is equal to 2 to the power of the number of inputs used. For each location the elements of D%() are set to the binary bits of the address. These values are then 'plugged in' to...
100 REM ****
110 REM * PROGRAM : PROM
120 REM * AUTHOR : Mikel Bedfor
130 REM * DATE : AUGUST 1985
140 REM *
150 REM * PURPOSE : TO GENERATE PROGRAM
160 REM * INFORMATION FOR A 2716
170 REM * EPROM TO ALLOW A SET OF
180 REM * BOOLEAN EQUATIONS TO BE
190 REM * IMPLEMENTED.
200 REM *
210 REM ****
220 REM DIM ARR(2048), X$(16), Y$(8), EON$(B), BA$(2), IA$(20), NVS$(20),
230 REM $(10), 0$(11), 0$$(8), 0$(16)
240 UR%= 2:20000: REM $% SET TO HIGHEST AVAILABLE RAM ***
250 X$ = "0123456789ABCDEF"
260 FOR N=0% TO 1%
270 X$(N)= MID$(X$, N%+1, 1)
280 NEXT N
290 PRINT: PRINT "ETI BOOLEAN TO EPROM PROGRAM FOR 2716"; PRINT
300 INPUT "INPUTS,OUTPUTS USED:"; ITX, OTC
310 IF ITX%+11 OR ITX%+1 THEN PRINT "INPUTS SHOULD BE IN RANGE 1-11"; GOTO 300
320 IF OTC%>1 OR OTC%+1 THEN PRINT "OUTPUTS SHOULD BE IN RANGE 1-8"; GOTO 300
330 REM *** INPUT AND SYNTAX CHECK EQUATIONS - ONE PER OUTPUT USED
340 FOR N=0% TO ITX%+1
350 PRINT "OUTPUT"; N%+1; "=";
360 INPUT E$(N%)
370 EON$(N%) = E$(N%)
380 FOR I%=1% TO LEN(E$(N%))
390 C%=MID$(E$(N%), I%, 1)
400 IF C% = "E" THEN 420
410 EON$(N%) = EON$(N%) + C%
420 NEXT I%
430 IF LEN(EON$(N%)) = 0% THEN 350
440 B%=0%: L%= "="
450 FOR I%=1% TO LEN(EON$(N%))
460 C%=MID$(EON$(N%), I%, 1)
470 IF C% = "E" THEN 550
480 IF (C%<"B" OR C%>"D") AND C%="A" AND C%="C" AND C%="D") THEN PRINT TAB(I%+1):""; PRINT "INVALID CHARACTER"; GOTO 350
490 IF (L%="" AND C%="A" OR C%="B" OR C%="C" OR C%="D") OR (L%="" AND C%="E" OR C%="F" OR C%="G" OR C%="H") OR (L%="" AND C%="I" OR C%="J" OR C%="K" OR C%="L") OR (L%="" AND C%="M" OR C%="N" OR C%="O" OR C%="P") OR (L%="" AND C%="Q" OR C%="R" OR C%="S") AND (C%="=" OR C%="/" OR (C%="P" AND C%="G")) THEN PRINT TAB(I%+1):""; PRINT "SYNTAX ERROR"; GOTO 350
500 IF (C%="A" AND ITX%+1 OR (C%="B" AND ITX%+1)) THEN PRINT TAB(I%+1):""; PRINT "UNUSED INPUT"; GOTO 350
510 IF C%="E" THEN B%=B%+1
each equation in turn, and the appropriate bit set in the byte for this location if the result is 1.
Within this loop a record is kept of any output bits which are always high or always low. After executing this loop, lines 1100-1540 print out the results. These results consist of a summary of the equations followed by a hex dump of the EPROM contents. In the equation summary, if a particular output is always either high or low, a warning message is printed to indicate that a logical error has probably been made. Once the dump has been printed, the user is given the option of writing the data to a RAM memory block for subsequent access by an EPROM programmer package.

Turning to the user of the program, the variable UR% must first be modified to the highest RAM memory available on the machine in use. The line in question is 240. Equations may be entered in equations may be entered in virtually any format consistent with a few basic rules. Inputs 0-10 are represented by the characters 0-9 and A respectively, the + sign is used to signify OR and the * sign to signify AND. The / sign is used to indicate that the following term is negated and brackets may be used. The AND operator takes precedence over OR and spaces may be added to improve readability. The following

examples illustrate this notation:

0 * 1 = Input 0 AND Input 1
2 + 3 = Input 2 OR Input 3
A = NOT Input 10
0*1 + 2*3 = (0 AND 1 OR 2 AND 3)
0*(1+2) * 3 = 0 AND (1 OR 2) AND 3
/ (2 + 13) = NOT (2 OR 3)

If a syntax error is detected, the line in error is printed out with an arrow pointing to the location of the offending character. The nature of the error is also printed in plain English. The following error messages are possible:

1. INVALID CHARACTER
2. UNUSED INPUT
3. SYNTAX ERROR
4. MISMATCHED BRACKETS

A character other than 0-9, A, +, *, /, (,) or space has been entered.
An unused input has been specified.
For example the use of 5-A when 5 inputs (0-4) were specified.
An invalid combination of characters was entered. For example two consecutive logic operators (+).
The number of opening brackets is not equal to the number of closing brackets.
Apart from these comments, the only other point which needs to be mentioned is that warning messages may be printed with the equation summary and hex dump. The following examples illustrate this:

**OUTPUT 0 = 1 +/1**
***ALWAYS HIGH***

**OUTPUT 1 = 0 */0**
***ALWAYS LOW***

In these cases it is quite obvious that 1 OR NOT 1 will always give a high result and that 0 AND NOT 0 will always give a low result. Cases can be much more obscure, however, and the messages indicate that a logic error has probably been made. If a constant high or constant low signal is really required it isn't necessary to use an EPROM output to generate one!

### The Evaluation Board

To fulfil the requirements of an experimentation/evaluation board, the inputs should be easily programmable between logic levels and the state of the outputs should be displayed clearly. These requirements are provided by a row of DIL switches, one for each of the inputs (address lines) of the 2716 and a row of LEDs, one for each of the EPROM outputs (data lines). The 2716 EPROM was chosen purely because it is the least expensive yet still has 11 available inputs. The principles are clearly the same if a larger EPROM is used to give more inputs.

The circuit diagram is shown as Fig 1. The board requires a low current 5V power supply or could be operated from a battery. The operation of the board is very simple and doesn't really justify a separate section on how it works. The 11 address lines, which act as inputs, are held high by pull-up resistors R1-R11, logic lows being achieved, when required, by switching to 0V through the DIL switches SW1-SW11. The 8 data lines act as outputs and drive Darlington pairs Q1/Q2, Q3/4 etc and the LEDs are connected to these via current limiting resistors.
R20-27. CE and OE are held constantly low, ensuring that the outputs are always active and that any changes to the inputs will be reflected on the outputs immediately.

Construction of the board is quite straightforward and requires little comment. A socket must obviously be used for the EPROM, ICT, and care must be taken when installing the LEDs and transistors to ensure that they are the right way around. Some form of labelling will be required to identify the switch positions and LED numbering. On the prototype this was achieved simply by sticking down pieces of paper on which the required legends had been typed, but if you are after a really professional result you may prefer to use Indian ink or Letraset on the board and then apply a coat of clear lacquer for protection.

Using The Program And Board

For the purposes of this example, let us assume that it is required to implement 8 different functions of 6 inputs. This means that 8 outputs and inputs are needed and this is the answer to the first question asked by the design program. The functions required are shown in Fig. 3 as a verbal description, a circuit diagram of the discrete logic implementation and the Boolean equations. These functions are entered into the software in the form of the final equations given in each part of Fig. 3, and the program output is shown as Listing 2. It will be noticed that 64 values are listed (2 to the power of 6) and that inputs 6 — A should be tied low by closing the switches SW7-11. If a 2716 is programmed with this data, spending a few minutes with the evaluation board will confirm that the functions are correctly implemented.

Other Function Types

Although all logic transfer functions can be expressed in terms of a set of Boolean equations, this is not always the most obvious way to describe a particular function. Cases where there is an easier way to describe the function include code conversions, for example binary to decimal, binary to BCD, BCD to 7 segment, etc. In these instances, it is perhaps not immediately obvious what the discrete logic

Fig. 3 6-input logic function examples with their Boolean equations.

<table>
<thead>
<tr>
<th>BOOLEAN EQUATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT 0 = 0<em>1</em>2<em>3</em>4*5</td>
</tr>
<tr>
<td>OUTPUT 1 = 0<em>2</em>2<em>3</em>4*5</td>
</tr>
<tr>
<td>OUTPUT 2 = 0<em>1 + 2</em>3 + 4*5</td>
</tr>
<tr>
<td>OUTPUT 3 = (0<em>1) * (2</em>3) * (4*5)</td>
</tr>
<tr>
<td>OUTPUT 4 = (0<em>1</em>2) + (3<em>4</em>5)</td>
</tr>
<tr>
<td>OUTPUT 5 = 0<em>1</em>2 + 0<em>1</em>1<em>2 + 1</em>/0<em>2 + 2</em>/0*1</td>
</tr>
<tr>
<td>OUTPUT 6 = 2<em>0</em>4 + 4<em>0</em>1 + 4<em>0</em>1 + 5<em>0</em>1</td>
</tr>
<tr>
<td>OUTPUT 7 = 0<em>1 + 0</em>2 + 0<em>3 + 1</em>2 + 1<em>3 + 2</em>3</td>
</tr>
</tbody>
</table>

EPROM MEMORY DUMP (HEX) :

| INPUT(S) 6, 7, 8, 9, A SHOULD BE TIED TO 0V |

Listing 2 The hex dump which results when the Boolean equations of Fig. 3 are entered into the BASIC program.
implementation and hence Boolean equations would be. In cases like this it will often be found more convenient to write a dedicated BASIC program to calculate the EPROM contents.

The conversion of 6 bit binary to 2 digit BCD provides an ideal example of such a solution. This example could be worked out by hand without too much difficulty, but in the general case the software solution will be more effective in terms of effort expended. Listing 3 shows the main loop of a program to calculate EPROM contents for this function. Following this main loop, the hex dump and copying to RAM portions of the main program in Listing 1 could be added. The hex dump produced by such a program is shown as Listing 4. Even without blowing an EPROM and plugging it into the evaluation board, it is quite clear just by studying this dump that the function is truly implemented.

A rather more interesting example of code conversion is that of binary to decimal or hexadecimal 7-segment code. The driving of a single digit 7-segment display is quite trivial, requiring only ten values for the decimal case or 16 for hexadecimal. The calculation of the EPROM contents required can be done by hand as shown in Fig. 4.

For a two digit display the requirements are considerably more involved. The initial problem is that two digits require 14 outputs to drive them, compared...
with the 8 outputs available on the 2716 EPROM. The answer is to utilise the common LED driving technique of multiplexing the two digits. A simplified circuit diagram for such an arrangement is shown in Fig. 5. The common anode LED displays are both driven from the NPN Darlontons which in turn are driven from the EPROM output data. The clock signal will drive the anodes of each LED in turn by means of Darlontons (in this case PNP) and an inverter. The clock frequency is high enough to ensure both LEDs appear to be constantly illuminated even though only one is actually on at a time. Since the clock signal is also used as an input to the EPROM, the resident program can be made to output the data for one of the two digits for a particular value of the other address bits, depending on the state of the clock input. This causes the correct data to be supplied to the currently illuminated digit.

The program to generate the required data is shown as listing 5. Once again the hex dump routines and so on will require appending to the end of this code. The program will obviously generate the two digits for each binary value in pairs of consecutive locations, with the units in the least significant byte of the pair. Listing 6 shows the output produced by this program.

**Conclusions**

It is quite obvious that by the use of programmable logic in the form of an EPROM, it is possible to implement a wide range of logic functions varying from the very simple to the quite sophisticated. The board and software presented here provide a means of verifying this and makes an interesting and educational experimental project. It is hoped that the board will also be used to aid the design of practical projects making use of programmable logic. By using the evuluation board it will be possible to experiment with the programmable portion of such a project before incorporating it into the main design.
DIGITAL SOUND SAMPLER

Nothing could be sampler than building the analogue board. Paul Chappell shows the way.

The component layout for the analogue board is shown in Fig. 1. Construction should not present any difficulties. The main point to watch is that all the through-hole connections are made. It's easy to leave one out! Some through links are made via component leads, so be sure to solder these at the top whenever there is a pad for them.

Enclosed cermet trimmers are recommended for RV1 to RV6, although I have provided extra holes in the board to allow open cerments or carbon presets to be used (as a last resort). Good quality polystyrene capacitors should be used for the filters — the tighter the tolerance the better — and you may wish to use 1% resistors around the MF10s. The connectors for the power supply, bus and control lines can be of any type — if you have any problem finding a 12-way connector for the control signals, use an 8-way and a 4-way connector side by side. If you decide to socket the expensive ICs — the AM6072s, CMP01 etc. — the extra few pennies for good quality gold plated sockets will be well repaid. Some ICs cannot be socketed because through connections are made on their leads.

To test the analogue board, the circuit must be made to drive itself. The on-board oscillator can be used to drive the mobile filters and the ADCs can be made to sample continuously with a few temporary connections to the control lines. To test the signal path, proceed as follows.

1. Join FCLK(1) to FCLK(2) on the control line connector.
2. Wire IC7 pin r to FCLK (1), (2).
3. Connect OE to +5V.
4. Connect STM to 0V.
5. Connect SCS, SCC, SFM(1) and SFM(2) together.
6. Connect the keyboard trigger input to +5V.
7. Connect a signal source (microphone, signal generator, tape recorder output from hi-fi, etc.) to the signal input and an

PARTS LIST

RESISTORS (all \%W 5% unless stated)

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, 18, 22, 54, 69, 74</td>
<td>1kΩ</td>
</tr>
<tr>
<td>R2, 3</td>
<td>680Ω</td>
</tr>
<tr>
<td>R4, 5, 29, 30, 31, 46, 47, 48</td>
<td>12k</td>
</tr>
<tr>
<td>R6, 7, 19, 20, 32, 33, 49, 51, 52, 70, 73</td>
<td>10k</td>
</tr>
<tr>
<td>R8, 9, 11, 12, 13, 15, 34, 35, 37, 38, 39, 41</td>
<td>15k</td>
</tr>
<tr>
<td>R10</td>
<td>39k</td>
</tr>
<tr>
<td>R11</td>
<td>13k 1% metal film</td>
</tr>
<tr>
<td>R16, 17, 23, 56, 60, 71</td>
<td>100k</td>
</tr>
<tr>
<td>R21, 44, 45, 66</td>
<td>470Ω</td>
</tr>
<tr>
<td>R24, 25, 27, 28, 42, 43</td>
<td>2k 4% metal film</td>
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<tr>
<td>R26, 55</td>
<td>3k</td>
</tr>
<tr>
<td>R36</td>
<td>9k 1% metal film</td>
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<tr>
<td>R40</td>
<td>7k 5% metal film</td>
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<td>R50, 59, 62, 67, 68</td>
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<td>R53, 72</td>
<td>22k</td>
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<td>R61</td>
<td>56k</td>
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<td>R63</td>
<td>390Ω</td>
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<td>R64</td>
<td>82k</td>
</tr>
<tr>
<td>R65</td>
<td>3k</td>
</tr>
<tr>
<td>R67</td>
<td>2k</td>
</tr>
<tr>
<td>R68</td>
<td>20k</td>
</tr>
<tr>
<td>(all horiz. cermet trimmers)</td>
<td></td>
</tr>
</tbody>
</table>

CAPACITORS

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>100µ 25V tantalum</td>
</tr>
<tr>
<td>C2, 4</td>
<td>47µ 25V tantalum</td>
</tr>
<tr>
<td>C3, 5, 12, 13, 15, 20, 23, 29</td>
<td>100n ceramic</td>
</tr>
<tr>
<td>32-42</td>
<td>10µ 25V</td>
</tr>
<tr>
<td>C6, 7, 11, 14, 21, 22, 27, 31, 43-46</td>
<td>100n tantalum</td>
</tr>
<tr>
<td>C8, 9, 16, 17, 18, 20, 25, 26</td>
<td>1n polystyrene</td>
</tr>
<tr>
<td>C10</td>
<td>100p ceramic</td>
</tr>
<tr>
<td>C29</td>
<td>150p polystyrene</td>
</tr>
<tr>
<td>C30</td>
<td>47 25V tantalum</td>
</tr>
</tbody>
</table>

SEMICONDUCTORS

<table>
<thead>
<tr>
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<th>Description</th>
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</thead>
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<tr>
<td>IC1</td>
<td>NEC534</td>
</tr>
<tr>
<td>IC2, 12, 15, 16, 17</td>
<td>LM318</td>
</tr>
<tr>
<td>IC3, 20, 21</td>
<td>741</td>
</tr>
<tr>
<td>IC4</td>
<td>LM311</td>
</tr>
<tr>
<td>IC5, 13</td>
<td>MF10</td>
</tr>
<tr>
<td>IC6</td>
<td>CMP01</td>
</tr>
<tr>
<td>IC7</td>
<td>74LS86</td>
</tr>
<tr>
<td>IC8</td>
<td>74LS74</td>
</tr>
<tr>
<td>IC9</td>
<td>Am2502</td>
</tr>
<tr>
<td>IC10, 14</td>
<td>Am6072</td>
</tr>
<tr>
<td>IC11</td>
<td>74LS541</td>
</tr>
<tr>
<td>IC18, 19</td>
<td>74LS374</td>
</tr>
<tr>
<td>IC22</td>
<td>ZN448</td>
</tr>
<tr>
<td>Q1</td>
<td>BF244A</td>
</tr>
<tr>
<td>Q2</td>
<td>BC212</td>
</tr>
<tr>
<td>D1-4, 7-9</td>
<td>IN914</td>
</tr>
<tr>
<td>D5, 6</td>
<td>9491</td>
</tr>
<tr>
<td>LED 1</td>
<td>Red panel mounting LED</td>
</tr>
<tr>
<td>LED 2</td>
<td>Green panel mounting LED</td>
</tr>
</tbody>
</table>

MISCELLANEOUS

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC sockets (3x18-way, 1x8-way); Molex connectors (0.1&quot; pitch 12-way plug and socket, 0.1&quot; pitch 8-way plug and socket, 0.2&quot; pitch 5-way plug and socket); PCB;</td>
<td></td>
</tr>
</tbody>
</table>
amplifier to the signal output of the board.
B) Set all presets to mid position.

If the board is now powered up, the A to D section of the circuit should sample continuously and the D to A section should take each generated code and translate it back into analogue form. A signal applied to the input should therefore follow the entire audio path and emerge at the output.

**Fault Finding**

If there is no signal from the output, or if the sound is distorted, the following test procedure should identify the troublesome area.

First, check pin 6 of IC1 with a 'scope. The input signal should emerge from this pin considerably amplified and RV1 should control the gain. Next check pin 6 of IC2 to make sure the signal is present there too. Now proceed to pin 20 of IC5. If there is no signal, inspect pins 10 and 11 to make sure the clock signal — a square wave of about 1MHz — is present. No clock means that the circuit around IC7c/d is not oscillating (or possibly a faulty connection, of course. You did remember steps 1 and 2, didn't you!).

To check the A to D conversion, the best way is to synchronise your 'scope to SCC — either by connecting the external sync to this signal, or even better by viewing it on one channel of a dual beam 'scope.

The SCC signal should spend about 90% of its time at logic 1 and drop to logic 0 briefly about once every 10µs (assuming the clock is running at the nominal 1MHz rate). You can adjust the clock frequency with RV6). Check each data bit in turn (on the connector at the edge of the board) with the other 'scope channel. Each data bit should go to 1 at some time during every period when SCC is at logic 1, regardless of whether or not there is an input signal to the circuit (you are watching the trial setting of each bit by the successive approximation register). With an audio signal at the input to the circuit, you will see two traces on most of the data lines: one where the line drops back to zero again after about 1µs and one where it remains at logic 1 until SCC goes low and high again. You will see both traces at once because both situations will occur during each cycle of the input wave.

If everything is functioning correctly up to this point, the A to D conversion is taking place. Now we've got to test the audio signal back again. Check pin 11 of IC18 and the same pin on IC19. They should both follow SCC, since you effectively connect them all together in step 5. Keeping the 'scope synchronised to SCC, check the data on pins 2 to 9 of IC14. The voltage on all these pins should remain constant while SCC is high, but may change very low to high transition. Pin 9, the lowest order data bit, should certainly change, even with a very small audio input to the circuit. As the signal level increases, the higher order data lines will also change. On the data lines that do change, you will see both traces at once on the 'scope (one remaining at logic 0, one at logic 1) for the same reason as before.

From here the signal can be traced — back in analogue form — at pin 6 of IC15, pin 6 of IC12, pin 20 of IC13 (check the clock on pins 10 and 11 again if there is no signal from here), pin 6 of IC16 and finally at pin 6 of IC17. If the signal gets lost between IC16 and IC17, check the keyboard trigger circuit (Q1, Q2). If the keyboard trigger input is grounded, the audio output from the circuit should cease; taking it to +15V will allow the sound to emerge. There should be no 'click' when the trigger voltage is changed. The circuit around IC3 and IC4 must generate a logic signal to inform the control circuit that a suitable audio signal to be sampled is present at the input. Connect your 'scope to SOUND on the control line connector. With a very small audio input to the circuit, the signal should remain at logic 1; as the input level increases, SOUND should begin to oscillate between logic 1 and logic 0. The exact level at which this happens can be controlled by RV2. With the LEDs connected at the edge of the board, the green one (LED2) should begin to light as soon as the input level is great enough to trip SOUND; the red LED (LED1) will light when the signal reaches a higher level still, giving a rough indication of the input signal level.

**Testing The Keyboard Interface**

First of all, remove all the connections made in steps 1 to 8 for testing of the audio circuit, then make the following links.
1) Connect 0V to 0V
2) Connect STM to +5V
3) Connect EOC to SCK via the transistor circuit shown in Fig. 2.
4) Connect a variable voltage source of 0 to +5V to the 1V/ octave input. (A battery and a 1kΩ pot will do.)

![Fig. 2 Test circuit for the keyboard interface.](image)

With the input at 0V, adjust RV4 until the voltage at the junction of D7 and D8 is also at 0V. Check that pin 6 of IC21 is at 0V too. Keeping the meter on IC21 pin 6, increase the input voltage. The voltage shown by the meter should also rise, and should be about half the input voltage. (You can make its exactly half by adjusting RV5, but don't bother too much at this stage.)

Finally, check the data lines. During the time that EOC is high, the contents of the data lines will represent the voltage present at the input. If you have a steady hand on the input voltage control, you will see the data lines stepping through the normal binary sequence as the input rises from 0V. As the codes of interest occur when EOC is high — about 10% of the time — you will need a 'scope to see it.

This concludes the testing. Setting up the various presets for best results will be described in a later article.

**BUYLINES**

The ICs and various other parts for the sampler are available from Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. Please write for details. Metal film resistors can be obtained from Maple Electronic Supplies Ltd, PO Box 3, Rayleigh. Essex, SS6 8LR (tel: 0702 554155). The PCBs will be available from our PCB Service.
Gary Mills discusses the choice of I/O devices and case to complete the system before going on to describe the testing and initial power-up procedures.

With assembly of the boards complete, the next step is to select and interface the appropriate input/output devices, attach a power supply, and install the complete system in a case or cases. Diagnostic test routines can then be run using the ROM monitor program.

The board can be used either with a separate keyboard and video monitor or with a serial terminal which includes both keyboard and VDU. Unless you already have such a terminal, you will probably wish to use separate devices. There is a wide range of suitable equipment to choose from.

The video monitor chosen may have either a composite video or a TTL interface. Using the composite video interface, any monitor that sinks 1 volt into 75 ohms will do. Since this is an almost universal standard, most composite video monitors can be used. Because the video resolution of the board is very high, the higher the resolution of the monitor, the better your display will look. 20MHz or over is a good figure to go for. Also, the picture will improve significantly if the video phosphor is a long persistence type, for example P39 or amber. Monitors that satisfy the requirements above include the Phillips Computer Monitor 80, No. BM7502/05 G (green) or A (amber), and the Kaga/Taxan KX1201, KX1202, and KX1203.

Table 1 Pin connections on the TTL-Video output socket, SK8. Pin 1 is the pin nearest the composite video output socket, SK9.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gnd</td>
</tr>
<tr>
<td>2</td>
<td>TTLVID</td>
</tr>
<tr>
<td>3</td>
<td>HSYNC</td>
</tr>
<tr>
<td>4</td>
<td>VSYNC</td>
</tr>
</tbody>
</table>

Table 2 Pin connections on the RS232 serial ports, SK3 and SK4.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gnd</td>
</tr>
<tr>
<td>2</td>
<td>XMIT</td>
</tr>
<tr>
<td>3</td>
<td>RCV</td>
</tr>
<tr>
<td>4</td>
<td>RTS</td>
</tr>
<tr>
<td>5</td>
<td>CTS</td>
</tr>
<tr>
<td>6</td>
<td>Gnd</td>
</tr>
<tr>
<td>7</td>
<td>Gnd</td>
</tr>
<tr>
<td>11</td>
<td>-5v</td>
</tr>
<tr>
<td>25</td>
<td>-12v</td>
</tr>
</tbody>
</table>

Table 3 Pin connections on the parallel keyboard port, SK2.

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Inner row</th>
<th>Outer row</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>DO</td>
<td>+5v</td>
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<tr>
<td>3, 4</td>
<td>D1</td>
<td>Gnd</td>
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<tr>
<td>5, 6</td>
<td>D2</td>
<td>Gnd</td>
</tr>
<tr>
<td>7, 8</td>
<td>D3</td>
<td>Gnd</td>
</tr>
<tr>
<td>9, 10</td>
<td>D4</td>
<td>Gnd</td>
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<tr>
<td>11, 12</td>
<td>D5</td>
<td>Gnd</td>
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<td>13, 14</td>
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<tr>
<td>15, 16</td>
<td>NC</td>
<td>Gnd</td>
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<tr>
<td>17, 18</td>
<td>STROBE</td>
<td>Gnd</td>
</tr>
<tr>
<td>19, 20</td>
<td>RST</td>
<td>-12v</td>
</tr>
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</table>

TTL video monitors can also be interfaced to the board. One of the commonest types is the IBM compatible monitor. There is a slight problem here in that the signals required (HSYNC, VSYNC and TTLVIDEO) are active high while the signals coming from the board are active low. To get around this problem, inverting buffers can be connected to the TTL video output lines. This is not available as a modification from Micro Concepts, but those who require it should not have too much difficulty sorting it out for themselves.

Keyboards

As with monitors, the 6809 board can be interfaced to a wide range of keyboards, including both parallel and TTL-serial types. The WD2123 chip was expressly chosen because it can support serial TTL keyboards, and for greatest flexibility the RS-232 drivers were also provided. To interface a serial TTL device such as a keyboard, it is necessary to circumvent the drivers. Remove the 75189 receiver chip and replace it with a header, jumpered so that each input line connects directly to an output. When the port is required as an RS232 interface, swap back to the driver. Two serial TTL keyboards which would be suitable are the IBM Work-Alike from Diamond H Controls, Vulcan Road North, Norwich NR6 6AH, tel 0603-45291, and the CAT-0414.
The general requirements for the power supply are +5 volts at 2.5 amps, +12 volts at 2 amps, and -12 volts at 0.1 amps. This assumes that you will be powering two drives, and that you have a separate keyboard drawing a small amount of power. One supply which is suitable is the Model PRD 303 from Power Rail Electronics Ltd, tel 0582-600277. This unit is recommended for use with the Vero Total Access case used on the prototype because it fits easily within the limit the cabinet places on height.

### The Case

This board does not necessarily require a case. Indeed, as we mentioned in the last issue, a prototype can be found mounted to the wall of the designer's workroom. However, a case does protect things, and it can also help to collect and organize the cables, power supply and drives.

The case pictured is from Vero and is a Total Access case type 212-8154H. To use it you will also need a chassis plate type 212-27826K. Use of this case requires that you mount the disk controller cable socket and the buss extension socket vertically. The power supply should be the one mentioned above, or should conform to the dimensions of the case. There is sufficient room available inside it to mount one 5 ½ or two 3 ½ inch drives.

Further, a slot must be cut in the front of the cabinet to allow the EPROM disk to be installed. A connector cannot be taken out to the front of the case because the extension of the EPROM connector would create too high an impedance. Micro Concepts will substitute a reduced size EPROM board, in the kit if you specifically ask for it. This will fit fully within the cabinet but must be soldered on to the main board rather than socketed. In practice this only means you will have to replace EPROMs rather than replace the whole EPROM board.

The board should be mounted to the chassis plate with four standoffs. The fit is a bit snug, so make sure you mark the holes correctly before you drill.

The Total Access case is the only one we have tried using, but there is no shortage of other case designs for those who don't mind experimenting a little with mounting and connector positioning. Vero sell several larger sizes of Total Access case which would allow more flexibility in the choice of power supply, number and type of disc drives and in the use of the EPROM disc board. There are also a large number of other cases on the market which would not doubt be suitable. For those who want a really professional look, a number of manufacturers offer suites of matching cases to house processor, monitor, keyboard, disc drives and peripherals in several combinations of stacking and distributed units. One such packaging system from Vero was described briefly in a short item in last month's News Digest, and West Hyde Developments and OK Industries are among the other manufacturers who produce this type of case.

### Power-Up And Testing

Assuming that you have purchased your hardware, assembled the board, tested for continuity, inserted the ICs, and connected the peripherals, the next steps are as follows.

First set the switches on SW1 to match the peripherals you have connected. The appropriate settings are shown in Table 5. Now connect power to the board. If all

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PA4</td>
</tr>
<tr>
<td>2</td>
<td>PA3</td>
</tr>
<tr>
<td>3</td>
<td>PA2</td>
</tr>
<tr>
<td>4</td>
<td>PA1</td>
</tr>
<tr>
<td>5</td>
<td>PA6</td>
</tr>
<tr>
<td>6</td>
<td>PA7</td>
</tr>
<tr>
<td>7</td>
<td>PA5</td>
</tr>
<tr>
<td>8</td>
<td>PA4</td>
</tr>
<tr>
<td>9</td>
<td>Gnd</td>
</tr>
<tr>
<td>10</td>
<td>PC3</td>
</tr>
<tr>
<td>11</td>
<td>PC6</td>
</tr>
<tr>
<td>12</td>
<td>PC5</td>
</tr>
<tr>
<td>13</td>
<td>PC4</td>
</tr>
<tr>
<td>14</td>
<td>PC0</td>
</tr>
<tr>
<td>15</td>
<td>+3V</td>
</tr>
<tr>
<td>16</td>
<td>PC1</td>
</tr>
<tr>
<td>17</td>
<td>PB7</td>
</tr>
<tr>
<td>18</td>
<td>PB2</td>
</tr>
<tr>
<td>19</td>
<td>PB1</td>
</tr>
<tr>
<td>20</td>
<td>PB4</td>
</tr>
<tr>
<td>21</td>
<td>PB3</td>
</tr>
<tr>
<td>22</td>
<td>PB5</td>
</tr>
<tr>
<td>23</td>
<td>PB0</td>
</tr>
<tr>
<td>24</td>
<td>PB6</td>
</tr>
<tr>
<td>25</td>
<td>PB9</td>
</tr>
<tr>
<td>26</td>
<td>PB8</td>
</tr>
<tr>
<td>27</td>
<td>PB5</td>
</tr>
<tr>
<td>28</td>
<td>PB3</td>
</tr>
<tr>
<td>29</td>
<td>PB7</td>
</tr>
<tr>
<td>30</td>
<td>PB2</td>
</tr>
</tbody>
</table>

Table 4 Pin connections on the EPROM disc board connector, SK6.

from Verospeed. Any serial keyboard used should be set to 9600 baud, eight data bits and no parity on start-up.

The second keyboard option is the parallel interface. Quite a few low cost parallel interface keyboards can be found, but caution must be exercised. Make sure that the keyboard is ASCII encoded, and that it has a full set of upper and lower case letters, numbers and punctuation marks.

The keyboard must provide a negative going strobe of at least one millisecond width to the board with each character.

If you are going to use a serial terminal instead of a separate keyboard and monitor, it should be set to 9600 baud, 8 data bits and no parity. The board requires RTS/CTS handshaking. If this is not available from the terminal, link the two pins together.

### Power Supplies

The next piece of equipment is the power supply. There are two important considerations here, the dimensions of the power supply which must be determined in relation to the cabinet you are going to use, and the output current and number of voltage rails required. This in turn depends on whether you will also be powering your drive(s) with the same supply, whether you use the serial driver chips, and what the power requirements of your keyboard are.
is well a header and a prompt will appear. The prompt should look like this

```
=>
```

Try typing a few characters. If they appear correctly on the screen, use the TM (test memory) command to test memory from 0000 to DE00. While the test is proceeding, tap the board gently. This will show up any bad solder joints.

Now switch off disconnect all connections to the board and fit the NiCad battery. Be extremely careful not to short circuit it, as it can break open and foam over. Damaging the board and making a mess. Momentarily short pin 22 of the clock chip to ground. This will cause it to load the default values into its RAM on power up.

Reconnect the board. If you have drives, now is the time to hook them up. They should be set for head load with motor on and the drive selected.

A further suite of routines in the monitor which can be used for testing the disk drives is listed in Table 7.

If you have got this far and have Flex, you are ready to boot it. If you don't have Flex, you can still use some of the powerful monitor commands. A list of commands is given in Table 7, each with a short description.

If there are problems with the board here are some things you might check:

- Are the configuration switches set correctly?
- Are your serial devices connected correctly?
- Are any of the chips getting overly hot?
- Do any of the address or data lines look shorted?
- Is the 16MHz clock being generated?
- Are E and Q getting to the processor?
- Are the DRAMS getting the correct signals?
- Is the MONO9 EPROM getting the correct signals?
- Are there any spurious interrupts?
- Is there a video signal?

---

### Table 7 A list of monitor commands, arranged according to the area they serve.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>ASCII dump of memory</td>
</tr>
<tr>
<td>HD</td>
<td>Hex dump of memory</td>
</tr>
<tr>
<td>ME</td>
<td>Memory examine</td>
</tr>
<tr>
<td>PM</td>
<td>Poke memory with value</td>
</tr>
<tr>
<td>FM</td>
<td>Fill memory with value</td>
</tr>
<tr>
<td>SM</td>
<td>Shift a block of memory</td>
</tr>
<tr>
<td>FS</td>
<td>Find ASCII string in memory</td>
</tr>
<tr>
<td>TM</td>
<td>Test memory</td>
</tr>
<tr>
<td>DR</td>
<td>Display registers</td>
</tr>
<tr>
<td>CD</td>
<td>Calculate displacement</td>
</tr>
</tbody>
</table>

### Table 8 Pin connections on the printer port, SK1.

<table>
<thead>
<tr>
<th>Pin No</th>
<th>Inner row</th>
<th>Outer row</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>+5v</td>
<td>+5v</td>
</tr>
<tr>
<td>3, 4</td>
<td>Gnd</td>
<td>Gnd</td>
</tr>
<tr>
<td>5, 6</td>
<td>BA0</td>
<td>IC19 pin 6</td>
</tr>
<tr>
<td>7, 8</td>
<td>BRTS</td>
<td>BA1</td>
</tr>
<tr>
<td>9, 10</td>
<td>BD1</td>
<td>BD0</td>
</tr>
<tr>
<td>11, 12</td>
<td>BD3</td>
<td>BD2</td>
</tr>
<tr>
<td>13, 14</td>
<td>BD5</td>
<td>BD4</td>
</tr>
<tr>
<td>15, 16</td>
<td>BD7</td>
<td>BD6</td>
</tr>
<tr>
<td>17, 18</td>
<td>BA2</td>
<td>BR/W</td>
</tr>
<tr>
<td>19, 20</td>
<td>BA4</td>
<td>BA3</td>
</tr>
<tr>
<td>21, 22</td>
<td>16MHz</td>
<td>BE</td>
</tr>
<tr>
<td>23, 24</td>
<td>WDS</td>
<td>Q</td>
</tr>
<tr>
<td>25, 26</td>
<td>RTC</td>
<td>LPEN</td>
</tr>
<tr>
<td>27, 28</td>
<td>T/02</td>
<td>RDS</td>
</tr>
<tr>
<td>29, 30</td>
<td>T/O1</td>
<td>T/OBUFF</td>
</tr>
<tr>
<td>31, 32</td>
<td>SMI</td>
<td>RST</td>
</tr>
<tr>
<td>33, 34</td>
<td>FIRQ</td>
<td>IRQ</td>
</tr>
<tr>
<td>35, 36</td>
<td>TTLVID</td>
<td>VSYNC</td>
</tr>
<tr>
<td>37, 38</td>
<td>Gnd</td>
<td>Gnd</td>
</tr>
<tr>
<td>39, 40</td>
<td>-12v</td>
<td>+12v</td>
</tr>
</tbody>
</table>

### Table 9 Pin connections on the expansion bus socket, SK10.

- Next month's concluding article will discuss applications and the use of the machine and will include a list of some of the Flex software available. A basic kit for this project is available from Micro Concepts, 2 St. Stephens Road, Cheltenham, Gloucestershire GL51 5AA, tel 0242-510525.
THE DIGIBARO

Ken Wood supplies the EPROM listing to go with last month's digital barometer design.
RS232-CENTRONICS CONVERSION

D.J. Virden has come to the rescue of numerous readers who want to convert an RS232 into a Centronics output.

If you have a computer equipped with an RS232 port, but your printer has a Centronics interface then you will have to beg, steal or build a serial-to-parallel converter, not a cheap bit of equipment by any means. RS232 printers also tend to be more expensive than their Centronics equivalent, but many portable and cheap micros sport only the RS232 output.

The RS232 interface was developed as a standard to ensure compatibility between equipment from different manufacturers. The output levels from the interface can be anywhere between ±3V and ±15V for an on state and -3V to -15V for an off state. The area between -3V and +3V gives some degree of noise immunity. The output data is asynchronous, using stop and start bits to achieve synchronisation. Fig. 1 shows the transmission sequence of a complete byte.

The Circuit

The heart of the interface is the General Instruments AY-3-1015D UART (Universal Asynchronous Receiver/Transmitter), whose sole purpose in life is to convert serial data to parallel and vice versa. However, only the receiver section of the device is used in the circuit. The chip can also cope with parity and any number of data bits from five to eight. The number of stop bits can be one or two. The circuit is shown in Fig. 2.

Data from pin 2 (Tx) of the K5232 plug is fed to Q2 which converts the bipolar data signal to a TTL level. This TTL level is fed to the serial input of the UART. The UART strips the data byte of its sync bits, and presents the byte in parallel to the data lines RD1-RD8. Each time a data byte is received the DAV latch is set, signalling that data is available. This line is connected via a monostable (IC5) to the printer's data strobe. Data strobe is brought low and the byte is stored in the printer's buffer. While it is doing this the printer signals that it cannot accept more data by setting BUSY high, BUSY is connected via Q3 to CTS (pin 5). When the data byte has been stored, the printer sets BUSY low and sends an acknowledged pulse which is used to reset the DAV latch, enabling another byte to be sent.

IC2c and d and XTAL1 form an oscillator whose output is fed to the dividers. IC3 and IC4. The outputs from the dividers are used for the clock input of the UART. The clock rate is 16 times the desired baud rate. For example, the clock rate required for a receiver rate of 2400 baud is 16x2400 = 38.4 KHz. The baud rate is selected by connecting wire link LK1 to the appropriate divider output, marked A, B, C and D.

If lower baud rates are required, replace the 7493 counter with a CMOS 4040 12 bit counter. This will allow speeds down to 75 baud. This should only be required when the equipment you are using to transmit the data is incapable of higher speeds, as the Centronics itself is capable of keeping up with all but the highest baud rates.

IC6 and IC7 are used to buffer the signals going to and from the printer. These are open collector as the printer inputs are all pulled up to 5V.

In Use

A power supply for the unit is not given. It is worth examining the feasibility of using the printer's power supply. The Microline 80, for example, has a power pin at 10V DC, 150mA (P34), which could be used to derive the required TTL supply of 5V, and one at 23V AC, 50mA (P36), which could be the source for the bipolar swing required by the RS232 specification. Figure 3 shows the connections to this printer — other printers with Centronics inputs may differ slightly and you should check with the manual.

Pull-up resistors are not necessary with SW1 since all inputs to the 1015 are pulled-up internally. Table 1 shows the effect of each switch on the data transmission parameters.

After the unit is constructed select the transmission

<table>
<thead>
<tr>
<th>SW1</th>
<th>a</th>
<th>b</th>
<th>DATA BITS</th>
<th>c</th>
<th>d</th>
<th>PARITY</th>
<th>e</th>
<th>STOP BITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>5*</td>
<td>X</td>
<td>0</td>
<td>odd</td>
<td>1</td>
<td>2*</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>odd</td>
<td>0</td>
<td>2*</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>even</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

(*) Combination of two stop bits and five data bits gives 1½ stop bits.

1=Switch closed. Use DIL switch unit or independent miniature toggles.

Table 1 Transmission parameter selection using SW1.
parameters required — baud rate, parity and number of data and stop bits. Switch off the printer and computer while you connect up the leads. Test the unit is working by sending text to the printer. Refer to your users’ manual on how to do this.

If the interface does not seem to work, check the error LEDs. If the frame error LED is on, you are either running the unit at the wrong baud rate or have the parity switch in the wrong position. The overrun LED indicates that a byte has not been read from the UART. If this occurs check the connections from the unit to the printer. The parity error LED indicates that the parity check has returned an incorrect value. You will probably need to confirm the settings on your printer and adjust SW1 accordingly.

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DATA STROBE</td>
</tr>
<tr>
<td>2</td>
<td>DATA BIT 1</td>
</tr>
<tr>
<td>3</td>
<td>DATA BIT 2</td>
</tr>
<tr>
<td>4</td>
<td>DATA BIT 3</td>
</tr>
<tr>
<td>5</td>
<td>DATA BIT 4</td>
</tr>
<tr>
<td>6</td>
<td>DATA BIT 5</td>
</tr>
<tr>
<td>7</td>
<td>DATA BIT 6</td>
</tr>
<tr>
<td>8</td>
<td>DATA BIT 7</td>
</tr>
<tr>
<td>9</td>
<td>DATA BIT 8</td>
</tr>
<tr>
<td>10</td>
<td>ACKNOWLEDGE</td>
</tr>
<tr>
<td>11</td>
<td>BUSY</td>
</tr>
<tr>
<td>12</td>
<td>PAPER END</td>
</tr>
<tr>
<td>13-30</td>
<td>0 V</td>
</tr>
<tr>
<td>31-36</td>
<td>23 V AC (50mA)</td>
</tr>
</tbody>
</table>

Fig. 3 Connections to an Oki Microline 80 printer.

The CIRCUIT SOLUTION section is designed to provide original design ideas and solutions more comprehensively than TECH TIPS but without the complexities of a full-scale project. Readers are invited to experiment and design their own stripboard or PCB layouts.

ETI

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TECH TIPS

Torch Locator
LM. Loong
Hong Kong

Having been caught out on several occasions by unexpected power cuts, I resolved to find a means of making my torch easier to find in the dark. This circuit is the result of my efforts.

It consists of a simple oscillator which will flash an LED on and off. The current drawn by the LED is quite small and using a flashing rather than a steady illumination reduces the current demand. A further refinement is an LDR light sensor circuit which switches the LED off when there is sufficient ambient light to make it unnecessary. As a result, a battery life of at least a month can be expected even with torches which use penlight cells.

For construction purposes, the best type of torch to convert is one using D size cells (HP2, MN1300, R/LR20, etc.) and having plenty of space inside the case. It is also a good idea to get one with a lamp reflector made of silvered plastic, as the best place to mount both the LED and LDR is on the silvered surface. This ensures that the LED flashes are projected well and that the LDR picks up all the light around the reflector and biases the flashing circuit off, thus reducing the current demand. With care, the intrusion of these two components has negligible effect on the beam produced by the torch in normal operation.

The component values given are for 3 volt operation and allow the circuit to work down to 2.5 volts. As the current consumption is minimal, the normal 3 volt torch bulb, although still in circuit, is not illuminated whilst the flashing circuit is operational. The flashing circuit is effectively short-circuited when the normal on/off switch is operated to switch on the torch.

Whilst the circuit diagram gives Q1 as a CS 2082G and Q2 as a CS2004C, these being Hong Kong made transistors I had to hand, almost any small plastic cased silicon transistors will function in their positions.

Interfacing The QL
Greg Parker
London N11

Now that the Sinclair QL costs only £200 or so it is within reach of the electronics experimenter. It may even replace the Spectrum as the computer workhorse for which most interface projects are made. It is, however, a bit more complicated to interface than the old faithful Z80 with all its ideal I/O capabilities.

Looking at the edge connector pin-out (in the manual) it can be seen that various devices have been added to the basic 68008 to confuse matters. So I wrote to Sinclair Research for some explanation; they replied that a book costing £15 would help — please send a cheque. Unwilling to spend £15 on a book, I decided to rely on common sense and designed this circuit.

The standard 68000 accesses a peripheral by setting up the address and data busses and asserting the Address Strobe (ASL) line. If the address is correct the peripheral replies with a Valid Peripheral Address (VPAL) signal. The 68000 then confirms this with a Valid Memory Address (VMAL) signal, inserting wait states to allow for slow peripherals. On the QL the VMAL line is not brought to the edge connector so proper handshaking cannot be assured, but the circuit shown seems to work well.

The two NOR gates and IC4a decode the address bus — when the address 4000x(h) is accessed VPAL is pulsed low and IC1 is enabled. IC1 decodes the lower 6 address bits and outputs a SELECT signal to the appropriate peripheral. An output latch and an input 3-state buffer are shown as examples. The devices are selected from BASIC by PEEKing or POKEing the appropriate address (the addresses from 40000(h) to C0000(h) are specifically reserved for expansion I/O).
Self-Activating Siren
Steve Brown, Woking

This simple analogue self-activating siren for an intruder alarm offers several functional advantages over its more usual digital rivals but uses only one 8-pin IC.

The main features are:
- virtually tamper proof
- fault protected
- automatic reset
- siren disable
- retriggerable while siren sounds
- uses 4-core cable — 2 signals, 2 power.

The siren is activated by a retriggerable monostable (for example, a 4047B or NE555) in the control unit which sends a 2s duration logic pulse to input B. The pulse length is kept short for security reasons but is long enough to fully charge C3 via D1 and R1 (C3 will be 95% fully charged in three R1C1 time constants or about 1.5s.

Op-amp IC1b compares the voltage across C3 with the threshold voltage VTH which is set by the voltage divider R9, R10. For a +12V supply rail, VTH is 365mV. When VTH is exceeded at pin 5 of IC1b, its output saturates at +12V, Q2 turns hard on and its siren sounds.

As the siren sounds, C3 will exponentially discharge to 0V via R3. After a time t (=3.5xR3C3s), the threshold voltage begins to exceed C3 voltage and the siren switches off. In practice, this time may be double its theoretical values (Table 1).

A surprise result in Table 1 is the relatively poor performance of low-leakage tantalum bead capacitors against electrolytics. This may be due to the fact that electrolytic capacitors usually have a high over-tolerance (up to +50%) and consequently offer better value for money. For longer on-times, VTH can be reduced or R3 increased. However op-amp offset voltage and noise considerations will set a minimum VTH while leakage currents through C3 will set a maximum on-time.

IC1a and its associated components form a classic op-amp monostable. When the –ve supply is interrupted a 1-2s logic pulse is transferred to C3 via D3 and the siren sounds as before.

Input C allows the siren to be controlled from the control unit. When the alarm is armed, input C is latched low. In SIREN TEST mode, input B goes high for the test duration and input C is also latched high. C3 discharges via Q1 and R2 immediately input B goes low. Similarly, input C is latched high for SIREN DISABLE mode and the siren is switched off and held off.

The op-amp circuits are filtered from the siren switch-on transient by C1, C2 and R11. These components can be omitted if a low current drain electronic siren is used. C5 provides extra filtering for VTH and prevents oscillations around IC1b as the input voltages approach one another.

IC1 was selected for the ability of both inputs and outputs to swing from +Vcc to ground, although in practice, most op-amps can be used.

D1 and D2 provide tamper and reverse polarity protection while D4 would be added if the siren is an inductive device.

---

<table>
<thead>
<tr>
<th>R</th>
<th>theory</th>
<th>tant.</th>
<th>elect.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M5</td>
<td>247</td>
<td>345</td>
<td>400</td>
</tr>
<tr>
<td>3M3</td>
<td>543</td>
<td>780</td>
<td>850</td>
</tr>
<tr>
<td>4M7</td>
<td>773</td>
<td>1005</td>
<td>1440</td>
</tr>
<tr>
<td>O.C.</td>
<td>—</td>
<td>1860</td>
<td>2700</td>
</tr>
</tbody>
</table>

Table 1

---

CONSTRUCTOR SERIES SPEAKER KITS

Based on the famous Kef Reference Series, these three DIY designs give the home constructor the opportunity to own an upmarket pair of loudspeakers at a very down-to-earth price!

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Model CS1 is based on the Reference 101, CS3 is equivalent to the Ref. 103.2 and CS9 is based on the Reference 105.2 (but in a conventionally styled encl.).

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Our terms are strictly cash with order — we do not accept official orders. However, we can provide a pro-forma invoice for you to raise a cheque against, but we must stress that the goods will not be dispatched until after we receive payment.

<table>
<thead>
<tr>
<th>Year</th>
<th>Board Code</th>
<th>Description</th>
<th>Price</th>
</tr>
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How to order: indicate the boards required by ticking the boxes and send this page, together with your payment, to: ASP Readers’ Services, PO Box 35, Wolsey House, Wolsey Road, Hemel Hempstead, Hertfordshire HP2 4SS, tel 0442-41221. Payment in sterling only please. Prices subject to change without notice.

| Total for boards | £       |
| Add 50p p&p | £0.50 |
| Total enclosed | £       |

Please allow 28 days for delivery

Signed
Name
Address

Please allow 28 days for delivery

ETI MARCH 1986
The foil pattern for the programmable logic evaluation board.

The foil pattern for the free PCB, just in case you want to make up some extra ones! The board will not be available through our PCB Service, but we have had a quantity made up and these will be available until stocks are exhausted from Argus Readers' Services at the address given on the PCB Service page. The cost will be £1.00 each and cheques, postal orders, etc should be made payable to ASP Limited. Please enclose a stamped, self-addressed envelope.
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We receive a very large number of enquiries. Would prospective enquirers please note the following points:

- We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to add to the design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications.
- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillators if appropriate. With a bit of luck, by taking these measures you may be able to discover what's wrong yourself. Please do not send us any hardware (except as a gift!)
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- We will not reply to queries that are not accompanied by a stamped addressed envelope or (for international reply coupon). We are not able to answer queries over the telephone. We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.
- Brief be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our overworked editors to have to plough through several pages to find exactly what information you want.

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Backnumbers of ETI are held for one year only from the date of issue. The cost of each is the current cover price of ETI plus 50p, and orders should be sent to ETI Backnumbers Department, Infonet Ltd, Times House, 179 The Marlows, Hemel Hempstead, Hertfordshire, HP1 1BB.

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Backnumbers cannot be available through sales of the last twelve issues, but obviously, we cannot guarantee this. Where a backnumber proves to be unavailable, or where the issue you require appeared more than a year ago, photocopies of individual articles can be ordered instead. These cost £1.50 (UK or overseas surface mail), irrespective of article length, but note that where an article appeared in several parts each part will be charged as one article. Your request should state clearly the title of the article you require and the month and year in which it appeared. Where an article appeared in several parts you should list these individually. An index listing projects only from 1972 to September 1984 was published in the October 1984 edition. ETI Indexes will be made available on request, or by referring to the same way as our other photocopy. If you are interested in features as well as projects you will have to order an index covering the period you require only. A full index for the period from 1972 to March 1977 was published in the April 1977 issue, an index for April 1977 through to the end of 1978 was published in the December 1978 issue, the index for 1979 was published in January 1980, the 1980/81 index in January 1982, the 1982 index in December 1982, the 1983 index in January 1984, the 1984 index in January 1985, and the 1985 index in December 1985.

Photocopies should be ordered from: ETI Photocopics, Argus Specialist Publications Ltd, 1 Golden Square, London W1R 3AB. Cheques, postal orders, etc should be made payable to ASP Ltd.

Write for ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

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OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAC.

Single Board Controller (March 1985)
There were a number of errors in the parts list. RP2 is listed as a 10k SI LMN 0.65, but is actually four separate resistors, and the same applies to RP3. RP4 is also listed as a 5k SIHER but should consist of seven commom resistors. R13 is always required, not just when a cassette interface is used as stated.

The Real Components (May 1985)
In Fig. 1, on page 20, the connections for the Texas 6N and 2N transistors are incorrectly shown. They should read B, C and E from the top.

Hest Pen (June 1985)
The instruction in the penultimate paragraph on page 49 should read "... adjust R2 for 2.73V...". not 2.37V as stated.

Low Cost Audio Mixer (June 1985)
In Fig. 6 on page 39, the PCB foil pattern has been incorrectly shown as though from the copper side. The board is shown correctly from the copper side in the foil pattern pages. In Fig. 10 on page 40, the positive power rail at lower left should be shown connected to pin 8 of the T7072s, IC-5.

Noise About Noise (July 1985)
In Fig. 5 on page 24, no connection should be shown between the cathode of the diode and the negative side of the 470u capacitor.

Printer Buffer (July 1985)
The case specified is actually larger than the one used for the prototype. If so, work perfectly well, but if you want to a compact unit use a Verocase 202-2103JB (180 x 120 x 65mm) rather than a Verocase 202-2103S. The regulator IC17 should be bolted to the back of the case to provide heatsinking or, alternatively, fitted with a TO220 heat sink.

Please note that the designer, Nick Sawyer, has been in touch to inform us that the refresh problem we mentioned in September ETI is dealt with in the printer buffer software. In this case, however, you need to replace the TMS 4416 dynamic RAMs, although as far as we know the replacement parts mentioned (Hitachi H1M48416 DRAKs) will cause no problems. The full text of Nick Sawyer's letter will appear next month. Meanwhile, our apologies for any confusion caused.

Cortex Parallel I/O (September 1985)
Lines 1 and 2 of IC2 have been swapped over on both the circuit diagram (Fig. 1) and the Veroboard overlay (Fig. 2). Pin 1 should connect to pin 16 on the header and pin 2 should connect to pin 2 on the header.

Intel 8294 Data Encryption Unit (September 1985)
It should be apparent from the text, page 35, that an actual program has been omitted. This program is for use with the SXD 8085 kit only, and copies may be obtained from us on receipt of a stamped addressed envelope.

Tech Tips — Novel Input Stage (October 1985)
The caption against the lower figure should read "Low noise output atminium gain", not maximum gain.

Chorus Unit (November 1985)
IC3 is shown on the circuit diagram on page 49 connected to the 9V supply. It should be connected to the 5V supply. The foil pattern connections to this IC are correct.

Foil Patterns (November 1985)
The foil patterns for the Modular Test Equipment Waveform Generator and the Chorus Unit are shown from the component side rather than the copper side.
**REVIEWS — QL BOOKS**

Introduction to SuperBASIC on the Sinclair QL
Price: £6.95

Advanced Programming with the Sinclair QL
Price: £6.95

Hutchinson and Co. Ltd., 17-21 Conway Street, London W1P 6ID

QL COMPUTING
Ian Sinclair, Price £5.95
Granada Publishing Ltd., 8 Grafton Street, London W1X 3LA

With the Sinclair QL now selling (or, maybe, attracting dust) at £199, it seems a good time to look at some of the titles available for that machine. Hutchinson — like a number of other more-or-less foolhardy publishers — are in the throes of a QL series. The latest two additions add texts on Sinclair ‘SuperBASIC’ and ‘Advanced Programming’ to a list already featuring an introduction to the computer and books on word-processing and desk-top computing.

The SuperBASIC title contains all the usual ingredients, with chapters on topics ranging from how to plug the QL in to all the wonderful intricacies of procedure structuring and the like. Appendices deal with SuperBASIC keywords and computing terms.

All QLearn?
The layout is clear and the text fairly readable. Simple exercises are included at the ends of most chapters, but there isn’t anything outstanding to merit recommendation over many other books in the same vein — especially since the manual — although bad in many ways will probably serve for most would-be QL users.

‘Advanced Programming … should not be regarded as a sequel to the previous book. In fact, the contents aren’t so much advanced when compared to that book as just different.

Aimed at those people whom the author euphemistically calls ‘practical’ users, the book reminds me very much of books published around a decade ago with such unassumingly titles as ‘Computer Programming Made Really Easy’ which then proceeded to be as stodgy as a bowl of cold custard. In this case, ‘advanced’ seems to be a synonym for monotonous.

On the credit side, the last chapter contains some simple business and statistical programs which may be of some interest.

’QL Computing’ by the redoubtable Ian Sinclair is yet another (and, ahem, guide to SuperBASIC in an already flooded market. Much of the book is the usual standard fare we have come to expect from Ian Sinclair’s word-processor and is, as a result, no better than the manual. The main body of the book, however, departs from the manual style of presentation in which keyword functions are summarized in alphabetical order. It is arranged in a prosaic fashion, with examples of usage and simple demonstrative programs to type in and experiment with. Consequently, the book has some degree of continuity and is more effective at teaching the rudiments of SuperBASIC than a manual style book, which may be useful for reference at a later stage.

In ConQuision
All the QL’s assets are dealt with in this relatively comprehensive publication, including micro-drivers, effective graphics and the usually neglected sound producing capabilities of the QL. If you are bemused by BASIC or just confused by computer, you could do a lot worse than buy ‘QL Computing’.

None of the books dealt with have anything significant to say about the 68000 MPU at the heart of the QL. For electronics buffs, the presence of a 68008 (a 68000-series device with an 8-bit rather than a 16-bit data bus) is the most interesting fact about the QL. Next month, I hope to look at some books dealing specifically with machine code programming and assembly for the QL and, by extension, for 68000-family devices as a whole.

Leigh Chappell

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**CROSSWORD**

No. 2 Solution next month

```
   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
1  A  E  L  S  E     6  E  P  R  O  M  s
2  T  r  a  n  s  m  i  t
3  E  j  e  c  t
4  G  r  a  f  f  o  n  t
5  D  r  a  w
6  E  l  e  c  t  r  o  n
7  B  e  l  l
8  C  d  r  a  m
9  S  y  m  b  o  l
10  D  o  m  i  n o
11  T  d  x
12  I  n  t  e  g  e  r
13  S  p  r  i  t  e  s
14  D  f  m
15  D  r  o  p  p  e  r
16  D  a  c  e  d
17  E  m  e  t  e  r
18  T  u  r  n
19  E  l  e  c  t  r  e  t
20  S  p  e  a  k  e  r
21  R  e  m  o  t  e
22  N  p  n
23  P  o  t

ACROSS
1) ........... trigger, a circuit with hysteresis (7). 6) Elodea
7) The smallest dot a micro can define on its monitor (5). 8) Another term for a monostable (5, 4).
9) Transducer found on an electric guitar or record player, for example (4, 2).
11) Bidirectional silicon controlled switch (5).
13) BASIC command, followed by a sequence of numbers or strings (4).
14) Something metals do in adverse conditions (7).
15) Type of aerial, based on a sphere with a focused detector (4).
16) The opposite of cut (5).
17) Ratio, the ratio of the height of a display to its width (6).
21) Moving from channel to channel in a stereo image (7).
22) A soldered connection (5).
23) This is essential for radio transmission, according to the Department of Trade and Industry (7).

DOWN
2) The industry standard parallel printer connection (10).
3) Difference in impedance between an input and an output, leading to signal losses (8).
4) Hand-held or other utensil such as a screwdriver, soldering iron, spanner, etc. (4).
5) Better quality audio equipment (2, 2).
6) BASIC command (4).
7) IBM's disc operating system (7). 8) Memory (1, 1, 1, 1).
9) Above the upper frequency limit of human hearing (10).
10) Movement away from a desired operating point, usually associated with temperature changes (5).
13) To remove contact oscillations from a switched line (8).
16) Non-reusable, non-volatile memory (1, 1, 1).
17) Central part of a loudspeaker on which the coil is mounted (4).
20) The most popular type of television aerial, comprising a half-wave dipole with parasitic directors in front and behind (4).
```

Solution to Crossword No. 1.

ETI MARCH 1986
by Flea-Byte

I suppose, with great regret, that 1986 will become the year of Star Wars. Regret for a number of reasons. The first is in some ways the most profound — and that is a deep disturbance at the way Hollywood fantasies can be and have been co-opted by the real power-brokers in Washington and Moscow.

The public image of the latest American mega-plan to keep the world safe for democracy, applepie and Mickey Mouse comes straight out of James Bond movies and, of course, the Luke Skywalker saga. Actually, the Star Wars plan is known officially as the Strategic Defense Initiative (SDI), only I can't help but think that when an ageing Hollywood actor masquerading as President of the United States characterises a defence policy as though it was being produced by a special effects department, then things have got out of hand.

The core idea behind SDI is, of course, to buy enormous laser and pulse-beam weapons directed from earth-orbit at the missiles and missile installations of hostile foreign powers. That such weapons could just as easily be directed at civil nuclear installations, city centre skyscrapers, factories, schools and hospitals seems to have been overlooked by the commen-
tators. Even fewer people seem to have taken the trouble to ask whether such weapons are feas-
ible or, more importantly, whether the idea of controlling them with super-intelligent computer systems via a super-fast and secure communications network is anything more than a scriptwriter's dream.

Everybody knows the disasters and mistakes that can and do plague quite simple exercises in satellite deployment and space transport. The space shuttle is routinely required to deal with rogue satellites, and the shuttle itself has very nearly come to grief on more than one occasion (most notably in its early days when heat deflecting panels kept falling off because of the glue used to attach them). And yet the advocates of Star Wars are preparing, so they say, to risk millions of lives to the protection of such imperfect technology.

The kind of thinking that suggests these people may be as far out to lunch as their satellites are out in space is best illustrated by the now-classic tale of the quest for a zero-gravity writing instrument. The problem was that even the most sophisticated capillary action pens don't work in zero-gravity conditions. The ink blots, doesn't run freely or fails to adhere to the writing surface. NASA's best minds were put on to the job of coming up with a new kind of writing implement that would function both on and off this planet. Some took notes and jot down readings in space with 100% reliability. It took them months before they came up with the humble pencil.

The fact is that much of the time, the scientists and technologists live in a kind of fantasy world of gleaming machines and say the minds were ordered, well-behaved and well-intentioned. That's okay, because occasionally the machines do gleam and the simple and the elegant thing goes according to plan. The problems arise when dirty and complex reality intrudes.

Now, politicians are supposed to inhabit this real world. Poor someone once said, is the art of the possible. So when politicians slip into improbable fantasies it's time to worry. None of this is too new. The Star Wars concept was work. It may do, but 'may' isn't enough. The people who claim to protect us from megalanomic excesses and totalitarian paranoia have slipped, with no apparent effort, into megalomania and paranoia. Surely that's what has happened when a film actor promotes a movie scenario as the policy of his government and has officials of other governments across the world actually listen to him. The worst thing, of course, is that many ordinary citizens with no power at all find the Star Wars concept convincing — plausibly because they've seen it at the movies or on their TV screens already.

Everybody knows the disasters and mistakes that can and do plague quite simple exercises in satellite deployment and space transport. The space shuttle is routinely required to deal with rogue satellites, and the shuttle itself has very nearly come to grief on more than one occasion (most notably in its early days when heat deflecting panels kept falling off because of the glue used to attach them). And yet the advocates of Star Wars are preparing, so they say, to risk millions of lives to the protection of such imperfect technology.

RASCHEL PAD

Kings Of The High Frontier

The Star Wars concept is a direct descendant of a notion called 'The High Frontier', developed in the seventies by a group of right-wing thinkers in the US who, I'm told, still operate today. The High Frontier is, of course, the modern equivalent of the old American frontier — the Wild West. By analogy, life in the High Frontier will be violent and any latter-day Indians who get in the way had better watch out.

The old frontier, in case you'd forgotten, was merely another way of talking about the expansion and conquests of the original Union — the 13 Eastern states who broke with British rule in 1776. The white settlers of these states moved westwards at the point of a gun, taking land from the American Indians and attempting genocide on the way. (In this attempt they were very nearly successful.) They didn't use lasers, of course, but they did use a revolver known as the Colt Peacemaker.

Perhaps the movie Ronald Reagan thinks he's in is not a science fiction epic at all, but an old-fashioned western.

Resigned To Their Fate

I was interested to read of the resignation of Richard Ennals from his post as Alvey research manager at Imperial College. The Alvey project — under the auspices of which government funding is being distributed to academic and research institutions is Britain's response to the Japanese programme to develop a fifth-generation computer.

Ennals' resignation followed Margaret Thatcher's reply to a letter from Imperial College computer scientists asking her not to participate in SDI. Thatcher emphatically declared her unwavering commitment to Ronald Reagan and all his works. The price of her commitment was high — a pat on the head, in return for which Britain will hand over to the US the results of all its research in areas related to SDI. Some crafty negotiating here!

Interestingly, the Imperial letter followed a visit to the college by executives from the American conglomerate, United Technologies (they own Mostek), who were interested in getting their supercomputers and computing systems adopted by the college for use in their SDI work. Ennals' comment was that the Imperial research 'ain't for sale.

It would appear, however, that Ennals' feelings and those of his team do not count for much. Not only are we selling-off the family silver (as Lord Stockton put it), but we're selling off the family silicon, too.

Heriot-Watt University has eagerly exchanged its expertise in opto-electronics for what appears to be a mess of potage!

Imperial College, along with Manchester University, is engaged in the biggest single computer development project in the UK. Scientists in collaboration with Plessey and ICL and with funding from Alvey. The Flagship project is a three-year research programme aiming at developing a parallel-processing computer based on experimental machines already installed at Imperial and Manchester. Researchers at both institutions have sought a formal agreement from Plessey and ICL that their work will not be put to military use. No such agreement has been forthcoming, and there is clearly consternation that Flagship is destined for a part in SDI.

So far, Richard Ennals has been the only resignation stemming from worries over Britain's attitude to SDI. However, feeling against the military use of high tech research is very strong among many academic circles. Meanwhile, United Technologies — in the shape of their helicopter company, Sikorsky — are set to snap up Westland Helicopters, another piece of the British technological jigsaw. If they do so, it will — ironically — be in the face of determined opposition from former Defence Minis-
ter, Michael Heseltine, who now finds himself an uneasy bedfellow in Richard Ennals, son of a former Labour minister.

It may be that Heseltine knows more about SDI and its impact on British high technology industry than he is saying at the moment. It is certainly the case that Reagan's defence policy is causing havoc to the high-tech industry, and is supposed to aid and assist. To paraphrase that national hero, the Duke of Wellington: I don't know if it frightens the Russians, but by God it frightens me!

PLAYBACK

'CD or not CD, that is the question, whether 'tis nobler in the mind to suffer the slings and arrows of outrageous price-rises...'. There can be no doubt now that the very notion of it is already established as the hi-fi audio record format. The market for players trebled last year (1985) to 530 million, and forecasts for this year are at least as high. Thousands of titles are listed on CD, of all types of music.

Virtually noise- and crackle-free and with minimal distortion, the medium has caught on in a big way. So, the writing is on the wall for the familiar vinyl LP. Nimbus is ceasing to manufacture its own label LPs, while a number of CD pressing plants at Monmouth to increase its present capacity from six to 15 million discs. Undoubtedly, other LP manufacturers will follow suit before long.

This will be the fourth major format change in the history of the gramophone. First the original cylinders gave way to shellac 78s. Then came the mono LP from which we progressed to the stereo 45/45 grooved disc. And now to CD, the biggest change of them all. The stereo disc served us well for some thirty years, but few will bemoan the passing of scratchings,
OPEN CHANNEL

Historically, the PTTs (postal, telegraph and telephone companies) around the world were set up to ensure that a level of standardisation was maintained. Thus, any letter posted in one country, correctly addressed of course, would find its way to the addressee quickly and efficiently. Any telegraph written would be one-time, one-way work. Any telephone call would be instantly received. The PTTs of each country were given a monopoly over the control of postal, telegraphic and telephone services in the land to make sure they had the power to enforce standardisation. The CPO was the British PTT, with complete control over the service. Accordingly, knowledgeable authorities were set up, comprising representatives from member nations, designed to specify standards which the PTTs were advised to follow. So far as telecommunications is concerned, the CCITT (International Telegraph and Telephone Consultative Committee) was, and still is, the main standards approving and advising authority. In effect, however, as the PTTs were generally the only provider of the services in any one country (such as the power of a monopoly), what they wanted was most often granted or implemented without approval anyway.

In recent years, cumbersome organisations as the PTTs, time was of little concern. They had more-or-less the sole right to supply and take away services to/from the user (that is, thee and me) and it was not unknown to have to wait for months on end to have a telephone line installed after application. New grades of service and new standards usually took years to be implemented, if at all. After all, that’s what a monopoly is for, isn’t it?

In the days of yore, this was of little problem. Few new services or standards appeared, anyway. And if too many telephones were rented to users the whole system would have to be updated, so it’s better that users don’t have an efficient service, otherwise they all will want a phone, eh what?

Times change, however. New services are desired by users. Some want data communication facilities; some want facsimile communication; some even want to be able to hold a conversation over the phone without having to shout over the crackles, hisses and pops (heaven forbid!). Eventually even the monopolising PTTs realise they cannot cope with the increased demands of the user and regulations are altered to de-monopolise them. Hence, the birth of British Telecom. Now customers (note the use of the word customers and not users) can have a phone installed within just a few days, and, what’s more, they can buy it too rather than having to rent. New digital services are being passed. Without the monopoly, other organisations may provide parallel services which rival or even better BT’s. The PTTs now have to compete to stay in existence. This all sounds too good to be true.

It is. Without monopolies the whole telecommunications area is much improved. Standards are, without doubt, advised and more are developed and accelerated than ever before. But new telecommunication services still take a long time to appear because the regulations governing them are still based around the PTT’s monopolising capability. It has been some years since the new European service providers face a regulatory burden 100 times greater than those in America.

The problem is that each European country has its own set of regulations which must be adhered to if services are to be sold in that country. Not only that, there are often a number of bodies in each country interested in such things as electrical safety and electromagnetic interference which proffer their own sets of regulations. A service provider wishing to introduce, say, a new system, must have it approved by the telephone regulatory body, the telephone regulatory body, the electromagnetic regulatory body, etc. etc. In many cases the standards of each country are different, so the whole procedure must be gone through again, at each new country where the service is to be provided.

This situation must be changed. Yes, regulations must still be there, but they must be reduced to the minimum needed to protect the customer and the services, and they must be unified so that they are similar in all countries. Preferably, one regulatory body in each country should maintain all/ regulations, be they of safety, interference, telephone standards and other categories. Then the prospective providers of a new service would just need to apply to the regulatory body to have the service approved. Once approved the service may be marketed worldwide.

After all, this is surely the whole purpose of having worldwide standards — without this capability there is no point in having standards at all.

Keith Brindley

surface static, warps, chipped styli, arm balancing and all the other irritations that have accompanied it.

The compact disc is not confined to audio. Laser video discs are well-established and are being developed in Authority 2, in the latest mass-storage medium for computing. Recently, two huge computing giants, Philips and Du Pont, have gone into partnership in a new venture called Philips Du Pont Optical (PDO) to produce and market CD-ROM discs for storing computer information. Philips, of course, introduced the laser video disc and (lest it be forgotten) the compact cassette.

Pressing On

In manufacturing terms, CD-ROMs and audio CDs are identical (like computer cassettes and music cassettes), only the software is different. PDO plans to set up a disc pressing plant sometime this year in North Carolina with a capacity of 50 million discs a year. The associated PolyGram factory is also planned to increase production from 25 million to 50 million, and the field is wide open for growth.

One of the problems of disc manufacture is the time taken to apply the reflective aluminium coating to the plastic. This must be done in a high vacuum. At present a small batch of discs are treated at a time in a vacuum chamber which takes 40 minutes to completely evaporate. PolyGram have developed a technique whereby each disc is treated in its own Tiny Cell, the vacuum taking only four minutes to achieve. This will greatly accelerate disc production.

The new EMJ is due to start pressing discs in Britain during March, the planned output will be 10 million discs a year. Another firm, Distec also has plans to start a plant this year.

The disc shortage caused by the worldwide boom is therefore likely to be soon turned into a surplus. But here’s the rub, to quite the barding once again. Disc-player prices have been tumbling in spite of the complexity and minimal production savings of the market. They have fallen by 50% in the space of two years. On the other hand, disc prices — which should have dived as a result of mass production have climbed steeply, up to 25% in some cases. Why? Steve Dowdie, Sony’s Hi fi products manager, says, ‘CD is already more profitable than LPs and cassettes.’ So the manufacturers must be taking advantage of the boom to make quick profits. Existing owners are unlikely to abandon the format because of escalating disc prices, so they are sitting ducks for the big rip off.

Take heart though. Think of all that over-production looming over Europe. CD-ROMs can continue to be upmarket for some time to come as player costs can’t dip much more. We are unlikely to see a repeat of the 45 single, portable record player boom with CD — although a few over-priced CD portables have hit the streets. So, with those millions of excess discs hit the market, the tables will turn — and they won’t be just those of the CD player manufacturers.

Vivian Capel

ALF’S PUZZLE

All is inclined to get so carried away with his projects that he often works late into the night, long after the rest of us have gone home. Although we admire his determination, there are times when the mistakes he makes by pressing on circuits when he is tired cause enough problems to keep him working late for the next fort night.

One evening last week, we left him hard at work taping a printed circuit board for a small microprocessor board. The board contained a 8-bit micro and 64 K of RAM. When we arrived at ETI Towers the next morning there was the completed PCB master, all finished. Except that when we tested it there were several mistakes. The address lines from the micro to the RAM section were all back to front so A15 on the micro joined to A0 of the RAM address, A1 to A15, and so on. The data line connections were mostly correct, but D0 and D1 had somehow been swapped over on the way from the micro to the RAM.

The PRD were cursing Alf loudly when Auntie Static walked in. She started to explain the problem to her, but she didn’t seem at all worried. ‘There’s no need to alter the address lines,’ she said. ‘It will work as it is.’ And without offering any explanation she dashed off to an appointment with her hairdresser. ‘Well, if it will work with the address lines back to front, I don’t suppose it matters about the data lines either,’ said Alf, ‘Let’s build it and see.’

Now we all know that when Auntie Static is in working order her mind is never wrong, but could she have blown a diode? Alf, on the other hand, is almost always wrong since he makes wild guesses about anything he’s not sure of. But could luck have been on his side this time? Did the board work?

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