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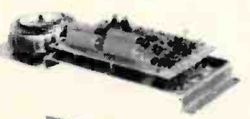

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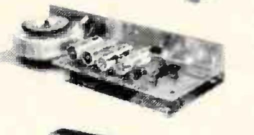

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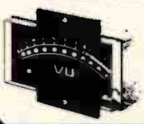

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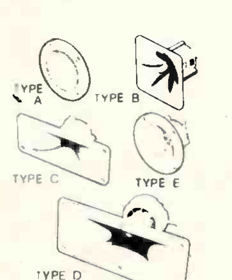

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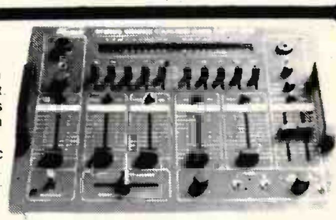

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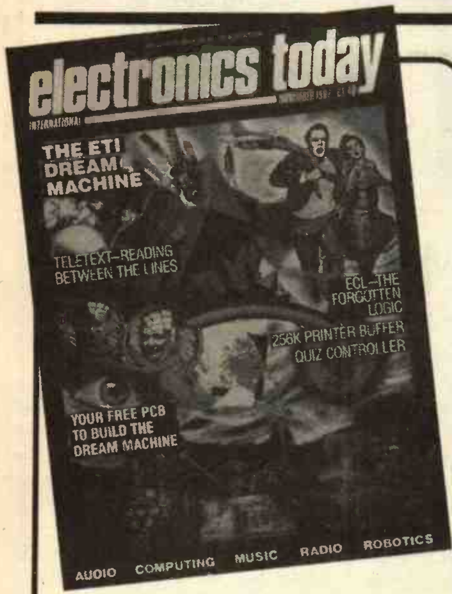

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● **British customers can now buy components from Conrad Electronic, a West German company which claims to be the largest specialist mail-order component supplier in Europe. The complete range is described in six catalogues, one of which describes the more popular product lines and is written in English. The others are in German but the samples we have seen are well illustrated and fairly easy to understand. Prices are quoted in Deutsch Marks but the order forms explain how to convert to Sterling. For details contact Conrad's distributors, Smith Electronics, 157 Chapel Street, Leigh, Lancashire WN7 2AL. Tel: (0942) 606 674.**

● *In 1990 a new EEC directive will come into effect requiring employers to check noise levels and reduce them where appropriate. Workers in noisy environments will also have the right to demand ear protectors and to have regular hearing checks. To help us understand the new regulations (and presumably to advertise its own services), a company called Noise Reduction Ltd has prepared a series of factsheets looking at various aspects of noise pollution and the new regulations. Copies can be obtained by writing to them at Factory 1, Phoenix Park, Chickenhall Lane, Eastleigh, Hampshire SO5 5RP. Tel: (0703) 611 611.*

● The British Standards Institution has published two new papers relating to broadcast video tape recorders. BS 6758 covers type C helical VTRs and is designed to ensure compatibility between machines from different manufacturers. BS 6865 specifies time and control codes for VTRs, providing a standard digital code format in accordance with IEC 461 which allows VTRs to be linked to one another and to separate audio recorders. Copies of both documents can be obtained from BSI Sales, Linford Wood, Milton Keynes MK14 6LE. Tel: 01-629 9000.

● **IOTech is based in Cleveland, Ohio, and manufactures controllers, converters, buffers, extenders and software for use with equipment employing the IEEE488 bus standard. The range includes interfaces which allow any computer with an RS232 port to communicate with IEEE488 equipment using simple commands in BASIC or other high-level languages. A catalogue describing the IOTech range is available from the company's distributors, Keithley Instruments Ltd, 1 Boulton Road, Reading, Berkshire. Tel: (0734) 861 287.**

Colour Portables On The Way

The race to put a pocket LCD colour television on the market is hotting up with both Sharp and Ferguson due to launch products in the next few months.

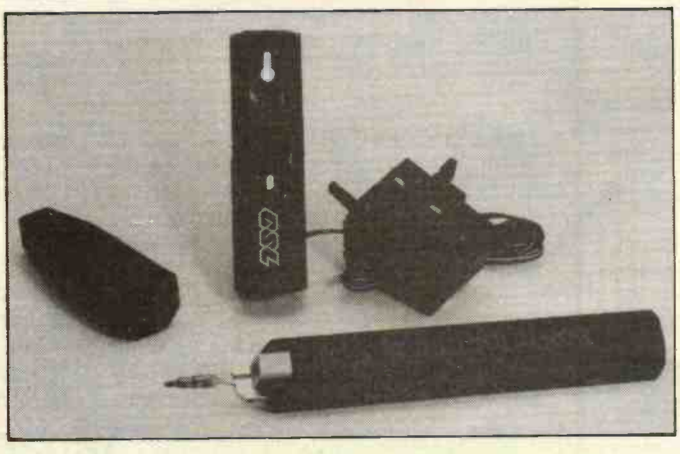
The Sharp model was previewed at the recent Brown Goods Show and is due to go on sale before the end of the year.

Now Ferguson has announced its PTV01 pocket television which has a 2.6in LCD screen. It receives all four UK television channels and features a built-in loudspeaker which can be disconnected for earphone listening, a telescopic aerial and a socket for use with an external aerial. It offers up to 2½ hours continuous operation on alkaline batteries and can also be powered by a rechargeable battery pack or from the mains or a car battery using optional adaptors.

The screen uses an efficient backlighting system to ensure bright pictures even in the dark and Ferguson says the viewing angle is large enough to allow more than one person to watch the picture simultaneously. The LCD has a resolution of 56,000 pixels and uses an MIM (metal-insulator-metal) active matrix system.

The PTV01 measures 85 x 145 x 35.5mm (3.35 x 5.7 x 1.4in) and weighs 330g (11.8oz). It should be on sale in November at a retail price of around £250.

Ferguson, Cambridge House, Great Cambridge Road, Enfield, Middlesex EN1 1UL. Tel: 01-363 5353.



Fast Soldering Takes To The Road

Cirkit has introduced a rechargeable soldering iron which it says is ideal for use on static sensitive circuitry and in situations where no mains supply is available.

The Turbo Solderor is rated at 12W and can be recharged either from the mains or a car battery. Features include a 2mm diameter illuminated tip, fast warm-up time and a capacity of around 200 standard joints on each 12-hour charge.

It comes complete with a wall-mounting socket, a mains charger unit and a 12V charging lead which plugs into a standard car cigarette lighter socket. A safety hood is provided for protection during operation and Cirkit says it will also be supplying spare illuminated tip assemblies.

The Turbo Solderor costs £15.00 plus VAT and postage from Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire EN10 7NQ. Tel: (0992) 444 111.

DAT Arrives — For The Few

The first digital audio tape (DAT) recorders are due to go on sale in this country in the next week or two.

Manufactured by Sony, the machines will sell for around £1300 and will include a 'spoiler' to prevent direct digital copies being made from compact discs.

The DTC1000ES is described as a full-function DAT player. It can record from analogue signals in the normal way and will also accept digital signals sampled at 48kHz. It will not accept digital signals sampled at the 44.1kHz rate used on compact discs, although CDs can be copied by going through an intermediate analogue stage.

Sony expects the DTC 1000ES to be bought by professional and semi-professional recording engineers and musicians. The company accepts that the high price will deter all but the most affluent of hi-fi enthusiasts.

The launch of DAT outside Japan follows a long period of heated debate between the recorder manufacturers and the record companies. Many believed that DAT would kill off the market for compact discs, threatening a technology in which record companies have invested hundreds of millions of pounds.

In response to this threat some record companies have announced that they will not produce pre-recorded DAT cassettes and have urged other companies to do the same. There has also been a coordinated demand for some form of spoiler system which would prevent direct digital copying from compact disc. Without pre-recorded tapes and with no ability to record from CDs, the average hi-fi enthusiast would be unable to make use of the high quality offered by the DAT system and would therefore be more likely to stick with CDs.

Sony insists the attitude of the record companies is 'misguided' but is very careful to stress DAT as a successor to the compact cassette rather than the compact disc.

It points out that digital tapes will wear out just as analogue cassettes do and also that the access time for tracks on the cassette is far higher than on CDs. Because of this, DAT is seen as complementary to compact disc with particular advantages in the car or, eventually, in Walkman-style tape players. However, Sony says it will be some time before DAT players become as small as present day compact cassette players.

Sony (UK) Ltd, Sony House, South Street, Staines, Middlesex TW18 4PF. Tel: (0784) 67000.

IC Industry Short Of Staff

Senior figures in the UK semiconductor industry believe the current recession may be nearing an end but fear that a shortage of skilled staff will hinder future progress.

These are the findings of a survey carried out by Plus Four Market Research on behalf of Cahners Exhibitions, organisers of the Semiconductor International Exhibition held in Birmingham at the end of September. The survey found that 76% of senior engineers and managers in UK semiconductor manufacturing companies expect to invest more in plant over the next three years and 52% expect to take on more staff.

Sixty percent felt that the levels of trained staff in the industry have risen over the last three years but over 80% confirmed that electronics designers and engineers are still in short supply. A significant number believe the situation is actually getting worse.

The survey also noted that 22% of respondents are looking at the use of gallium arsenide.

Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ. Tel: 01-891 5051.

UK Out Of Step On Robots

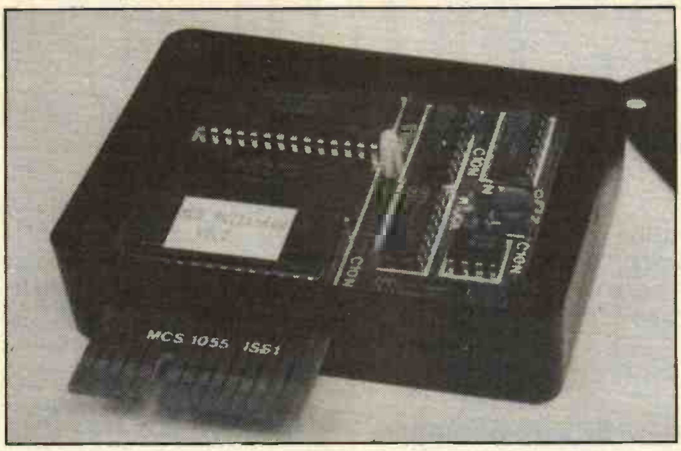
The UK is a 'notable exception' in the general trend towards increased use of robots in industry.

A recent report by international market analysts Frost & Sullivan shows that the total number of robots in this country in 1986 was only around 3200 — less than the increase alone in West Germany in 1985.

Japan and America have both invested heavily in industrial automation and the report claims that Japan in particular has gained definite economic advantages through the use of robots. By the same measure, many of the weaknesses in UK industry are attributed directly to our failure to automate fast enough.

The report predicts that European countries will increase their total spending on robots by around 20% a year in an effort to catch up with Japan and America. On present form the highest rates of growth are likely to be in West Germany and Italy with the rest of Europe well behind and France and then the UK trailing the field.

Frost & Sullivan Ltd, Sullivan House, 4 Grosvenor Gardens, London SW1W 0DH. Tel: 01-730 3438.



ROM Switching On The Sinclair QL

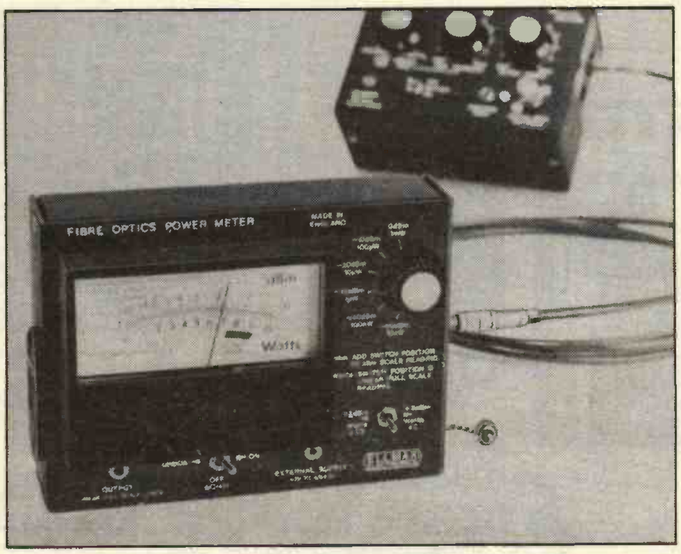
Micro Control Systems says its new Multi-ROM interface is the first device to allow easy switching of ROMs on the Sinclair QL micro-computer.

The Multi-ROM is a 16K RAM pack which stores the contents of several ROM cartridges, allowing the cartridges themselves to be swopped in and out without having to switch off the computer. Operation is by simple commands which can be loaded into a bootfile so that the correct ROM is selected for each application.

The device can also be used to develop ROM-based software, allowing code to be downloaded for testing without blowing an EPROM. It includes a facility which convinces the QL that it has only 128K of memory, making it easy to run programs which do not like expanded machines.

The Multi-ROM measures 90 x 60 x 20mm (3.5 x 2.4 x 0.8in) and is backed by a two-year warranty. It costs £49 plus VAT.

Micro Control Systems, Mita House, Hamm Moor Lane, Addlestone, Weybridge, Surrey KT15 2SB. Tel: (0932) 58266.



Power Meter For Fibre Optics

A new, low-cost optical power meter is now available and should prove of interest to anyone who is experimenting with optical fibres.

It's made by Ellmax Electronics and uses a large analogue scale to display optical levels from below 1nW up to 1mW and from −60dBm up to 0dBm. The calibration wavelength is 820nm and detection is by means of a large area silicon photodiode contained in either an SMA or STRATOS connector housing.

The unit is battery operated and has a current consumption of around 1mA, giving a typical battery life of some 500 hours. An output socket is included for use with a DVM where greater scale reading accuracy is required.

The meter comes in a carrying case complete with manual and accessories and costs £275.00 plus VAT and postage.

Ellmax Electronics Ltd, Unit 29 Leyton Business Centre, Etloe Road, Leyton, London E10 7BT. Tel: 01-539 0136.

- **Lightning strikes and mains surges have been responsible for some rather nasty incidents lately, as anyone who reads a newspaper will know. It therefore seems a good time to tell you about a new designers' guide from Texas Instruments which explains how to protect against lightning and accidental mains incursion in modern telecommunications equipment. The guide is 40 pages long with illustrations and is called 'Telecommunications Protection Circuits'. It is available free-of-charge from Online Distribution Ltd, Melbourne House, Kingsway, Bedford MK42 9AZ. Tel: (0234) 217 915.**

- Solex International supplies multi meters, frequency counters, bench power supply units and various instruments for measuring chemical and physical parameters such as pH, temperature, relative humidity and even blood pressure. The instruments carry either the Solex or Soar brand names and are described in a full-colour 32-page A4 catalogue. Contact Solex International, 44 Main Street, Broughton Astley, Leicestershire LE9 6RD. Tel: (0455) 283 486.

- *RR Electronics has put together a quick reference guide to the OP series of op-amps from PMI. Plastic laminated for durability, the guide is A4 size and lists the op-amps against a range of major parameters. This makes it easy to select a device for high output current, low noise or any other desired characteristic. For further details contact RR Electronics Ltd, St. Martins Way, Cambridge Road, Bedford MK42 0LF. Tel: (0234) 47211.*

- ***The latest catalogue from J.A. Crewe and Co lists engineering materials, tools, electronic components and various surplus stock items. Electro-mechanical components are particularly well represented and the range includes solenoids, relays and many types of AC and DC motors, among them a 200 step/revolution miniature stepping motor which can be supplied complete with a dedicated development board in kit form. The catalogue costs 75p from J. A. Crewe & Co, Dawn Edge, Spinney lane, Aspley Guise, Milton Keynes MK17 8JT. Tel: (0908) 583 252.***

- Power Development Ltd manufactures a range of ceramic NTC thermistors specifically designed to limit high switch-on surge currents. The latest additions to the range are described in a new brochure which is now available. For further details contact Power Development Ltd, Cadmore lane, Cheshunt, Waltham Cross, Hertfordshire EN8 9SE. Tel: (0992) 34266.

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION

electronics today INTERNATIONAL

THE HEAT IS ON

The December ETI is the fitting place to find the electronic answer to your fuel bill problems. Next month sees the project to computerise your central heating system. Save money and keep warm this winter with ETI!

SWR METER

No, it's nothing to do with small white radiators despite the central heating controller. If you know a little about radio you'll know this stands for *standing wave ratio* and you'll know why you want one. If you don't, read ETI next month and find out.

TESTING TIMES

We all know that some kind of test equipment is a good idea but with such a bewildering variety around, mostly at mind boggling prices, it pays to know exactly what you need and how to use it. ETI reveals all next month. If you spend your last few pennies on the mag you'll also be pleased to read the article on making your money go further — what to look for and what to avoid when buying second hand test gear.

AND FREE WITH EVERY COPY...

Of course, next month sees the free components to build the Dream Machine on this month's free PCB. There's also all your favourites packing out next month's issue — Hardware Design Concepts, Circuit Theory, News, Diary, Open Channel, Playback, Keynotes, Readers' Ads and so on. Don't miss your copy of ETI — **the** mag to be seen reading this winter.

The articles listed are all under way but unforseen circumstances may prevent publication.

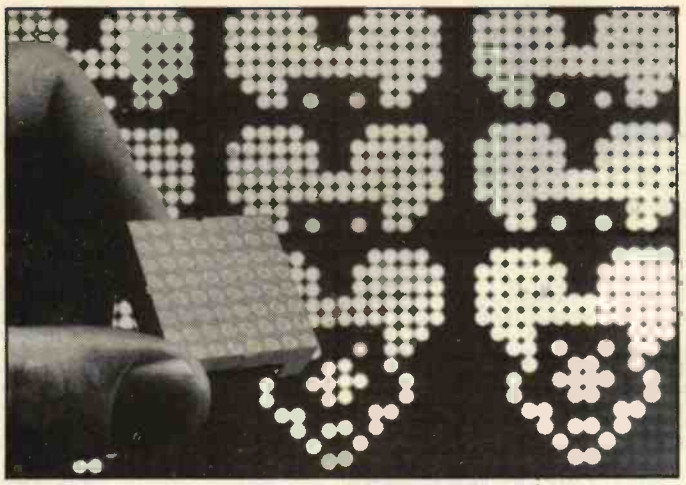
DECEMBER ETI — OUT NOVEMBER 6th

Stackable Display IC

Large, flat-panel graphics displays can be constructed with ease using a new 8 x 8 dot-matrix LED array from Siemens.

Available in orange or green, the displays incorporate a CMOS IC which handles multiplexing, memory, lamp drive and internal logic. Each dot is separately addressable via an 8-bit TTL-compatible data bus.

Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS. Tel: (09327) 85691.



● Those of you who read about the FLT-101 analogue workstation in the August issue may be interested to learn that Flight Electronics has introduced a digital version. The FLT-100 has thirty logic gates with mimic diagrams and a large solderless breadboard which allows gates and other components to be connected up as required. Also included are a pulse generator and dual-rail stabilised power supplies with short circuit protection. For further details contact Flight Electronics Ltd, Ascupart Street, Southampton S01 1LU. Tel: (0703) 227 721.

City Of London Gets High-Tech 'Craft Guild'

Tradition and innovation are to meet head on with the formation of a new Company of Information Technologists.

Alongside such ancient Companies as the Weavers, the Cutlers and the Grocers, many of which began their lives as craft guilds in the middle ages, the new Company will concern itself with the setting and maintenance of standards in business conduct and with charitable works.

The City Companies are generally known as Livery Companies because many of the craft guilds adopted distinctive dress for use on ceremonial and other occasions. As with other Companies formed in modern times, the Information Technologists will not be adopting a livery but they have applied for permission to use armorial bearings.

In keeping with City traditions the new Company has 100 founder members and its management committee follows the historic structure with a Master, Senior and Junior Wardens, Assistants and a Clerk. All the founder members have strong connections both with the City and with information Technology, many holding senior positions in UK computer and electronics companies.

The Company of Information Technologists, 25 Enford Street, London W1H 2BH. Tel: 01-723 5882.

● STC has produced a 4-page full colour brochure on its range of Union Carbide Kemet capacitors. Among the product lines featured are two different types of dipped tantalum capacitors, several multilayer ceramic types and a number of axial and radial moulded capacitors. Full product specifications are included and there are also some notes on applications for some of the BT-approved capacitors in the range. Contact The Capacitor Group, STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DF. Tel: (0279) 26777.

DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY: DIARY:

Capacitor And Resistor Technology Symposium — October 6-8th
Ramada Renaissance Hotel, Brighton. Organised in conjunction with the American IEEE and staged outside of the USA for the first time. Contact CARTS-Europe on (0425) 73578.

Internepcon — October 6-8th
Metropole Convention Centre, Brighton. See July '87 ETI or contact Cahners at the address below.

Digital Audio Post Production — October 11th
BAFTA, London. Training seminar organised by the BKSTS. Contact them at the address below.

Automotive Electronics — October 12-15th
The IEE, London. See July '87 ETI or contact the IEE.

Computer Graphics Exhibition and Conference — October 13-15th
Wembley Conference Centre, London. For details contact Online on 01-868 4466.

Starting Your Own Business — October 16th
The IEE, London. Discussion meeting featuring speakers from the small firms centre. Contact the IEE at the address below.

Conference For Young Engineers — October 16-18th
Strand Palace Hotel, London. See July '87 ETI or contact the IEE at the address below.

International Video & Communications Exhibitions — October 18-21st
Metropole Exhibition Centre, Brighton. See July '87 ETI or contact Peter Peregrinus Ltd at the IEE address below.

Room Temperature Superconductivity — October 19th
The IEE, London. For details contact the IEE at the address below.

Radar '87 — October 19-21st
Kensington & Chelsea Town Hall, London. See July '87 ETI or contact the IEE at the address below.

Testmex '87 — October 20-22nd
Business Design Centre, London. See July '87 ETI or contact Network Events at the address below.

Amstrad Computer Show — October 23-25th
G-Mex, Manchester. For details contact Database Exhibitions on 061-456 8835.

Analogue IC Design — November 5th
The IEE, London. Tutorial lecture. Contact the IEE at the address below.

Reproduced Sound Conference — November 5-8th
Hydro Hotel, Windermere. Topics covered include acoustics, digital techniques, measurements and electro-acoustic music. Contact the Institute of Acoustics on 031-225 2143.

The Future Of The Personal/Home Computer — November 10th
The IEE, London. Lecture by Sir Clive Sinclair. Contact the IEE at the address below.

Electronic Displays — November 17-19th
Kensington Exhibition Centre, London. Contact Network Events at the address below.

Interact '87 — November 17-19th
Kensington Exhibition Centre, London. See June '87 ETI or contact Network Events at the address below.

Satellite Communications And Broadcasting — December 1-3rd
London. For venue and other details contact Online on 01-868 4466.

The UK Space Programme — December 7th
The IEE, London. Lecture by R. Gibson of the British National Space Centre. Contact the IEE at the address below.

The Which Computer Show — January 19-22nd
NEC, Birmingham. Contact Cahners at the address below.

Electro-Optics And Laser UK — March 22-24th
NEC, Birmingham. Exhibition which runs alongside the Optics-Ecoosa '88 conference at the Birmingham Metropole Hotel. Contact Cahners at the address below.

HF Radio Systems And Techniques — April 11-13th
The IEE, London. Conference organised by the IEE and the Institute of Mathematics and its Applications. Contact the IEE at the address below.

Addresses:

British Kinematograph Sound and Television Society, 547-549 Victoria House, Vernon Place, London WC1B 4DJ. Tel: 01-242 8400.

Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham TW1 3SZ. Tel: 01-891 5051.

Institution of Electrical Engineers, Savoy Place, London WC2 0BL. Tel: 01-240 1871.

Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX. Tel: (0280) 815 226.

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TELETEXT ADAPTER

Would you like access to free high quality software and over a thousand pages of information, but Prestel access charges and phone bills too expensive? Then read on!

The answer is Teletext. Yes the same system everyone has seen incorporated into television sets, but with a difference. When Teletext is read by a computer you can actually use the data.

The MORLEY TELETEXT ADAPTER introduces you to the world of Teletext at a price that won't break the bank. Inside it you will find the latest in second generation Teletext chip technology, which unlike our rivals who are still using chips designed more than ten years ago, will be fully compatible with any future advances in the Teletext system.

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* Advanced design uses the latest technology, will handle ANY future enhancements to the Teletext system e.g.: full field; 8 bit data transfer; 2k pages etc.
* Simply plugs into the user port.
* Low power consumption, less than 200ma. Optional power supply available.
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* Full access to all Teletext services and channels e.g.: CEEFAX, ORACLE, 4-TEL.
* Gives you a real-time clock at your disposal (*TIME).
* Software upgrades to allow for any enhancements to the Teletext service, e.g.: extra channels, full field data on cable & satellite systems etc. (only the media charge).
* Easy to follow comprehensive user guides.
* No hardware limitations, it can for example receive virtually unlimited numbers of channels.
* Utils disc available including printer drivers allows pages to be selected and dumped direct to a printer (no more TV or Radio Times to buy).

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"...In terms of price, performance, future expansion possibilities and those little touches that show thought for the end user I would recommend the Morley unit."–*(Acorn User, January, 1986).*

"...The Morley unit has been designed to ensure that its operation is simple and smooth. It is the ideal Teletext adapter for school use."–*(A&B Computing, June, 1986).*

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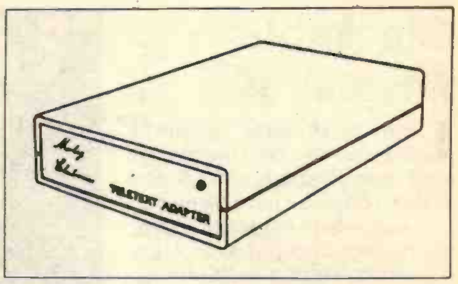

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ETI/11

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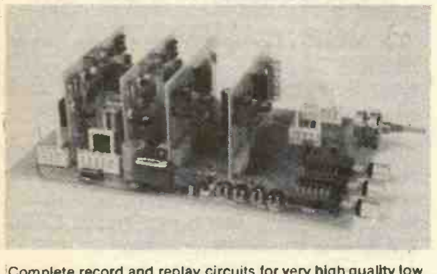

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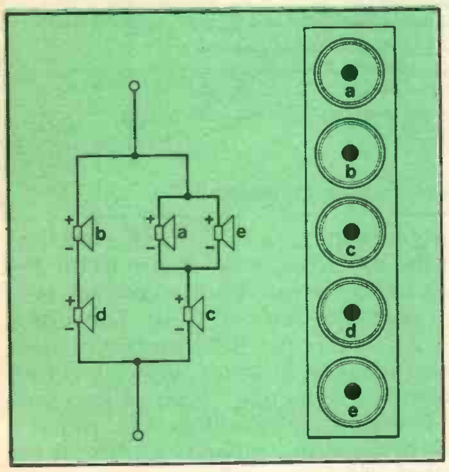
READ/WRITE

Portable Problems

Alan Watling appears to have things in a slight muddle when he wired up the speakers for his portable PA system (ETI September).

He says the ideal loudspeaker system would be a line source. He could have achieved that in effect if he had wired up the five loudspeakers as shown.

John Tyzzer
Guildford, Surrey.

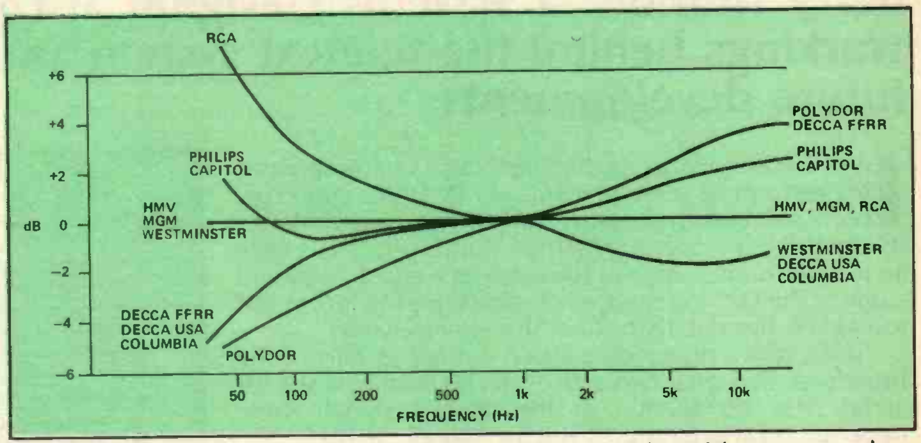


Mr. Tyzzer's arrangement will give maximum output in the centre of the line (C), a lower level of output from the loudspeakers on either side of the centre (B and D) and a lower level still from either end of the line (A and E). This gives a reasonably close approximation to ideal line-source characteristics and works well when the loudspeakers can be pointed directly at an audience. In the Portable PA, the loudspeaker column has been deliberately tilted backwards by a few degrees to provide mechanical stability. To counteract this, the loudspeakers are arranged so that there is more output in the lower part of the sound distribution pattern. This involves a further departure from true line-source characteristics but works well in practice.

RIAA (Again)

In Read/Write of the August ETI Mr. Leach wonders whether the equalisation used by record companies is sufficiently accurate to justify the use of precise RIAA replay networks in hi-fi amplifiers.

The listening chain contains a number of elements (microphone — record cutter — cartridge — amplifier — loudspeaker, to mention just the major ones) and it is possible to take the view that highly-accurate equalisation at one point in the chain will almost certainly be compromised by greater variations elsewhere. I remember a graph prepared in the 1960s (I forget the source) which showed wide variations in recording equalisation from one company to another, some being as much as 6dB out from the RIAA standard over certain parts of the audio spectrum.



Fortunately things have changed since then. Recording equalisation is necessarily more complex than replay equalisation because it has to take into account the characteristics of the cutting head but even so the better record companies aim for an accuracy of 0.2dB.

Surely Mr. Leach cannot be satisfied with errors of the order of 1dB in his replay network, especially when greater accuracy can be achieved at trifling cost?

Wilfred Harms
Bexhill, East Sussex.

Circuit Theory

I have read many electronics magazines and books but have always found them empty. It has taken me seven years to *see* this emptiness.

People read electronics magazines with a goal of understanding what electronics is about. How It Works sections of your published projects help towards achieving this goal but in themselves are not enough.

To understand would need more than giving component values in circuit diagrams. How they are *arrived at* must be shown. It would be a blessing to show, using intermediate mathematics (not a minefield of equations and theory) where and how component values are obtained.

This would enable many readers to do a lot of thinking for you and contribute projects rather than just building them parrot fashion.

N. Gharebeigui
Chiswick, London.

It is indeed one of the aims of ETI to teach an understanding of electronics and we try to do this in several ways. The How It Works sections of projects are the simplest attempts. We run two regular series teaching the principles behind electronics design. *Circuit Theory* is intended to cover the more fundamental end of the spectrum and to introduce basic mathematical tools. *Hardware Design Concepts* is for more advanced readers and looks at the latest ICs available and advises on design techniques when using them. Other features go into specific topics in more depth.

A good many ETI projects do include some history of their design. Many are arrived at by a good deal of trial and error which cannot be 'taught'. If we were to include a full mathematical explanation of every project we would not only repeat ourselves continually but only publish around three projects a year!

ETI

Winter's drawing in. The days are shortening and soon leaves will bespeckle the otherwise immaculate tarmac of Golden Square. Now is the time for settling down of an evening with a good book, a good electronics project or even with pen and paper to compose a letter to bolster those ever-labouring boys in the ETI office. Write now and you may catch the December issue.

Electronics Today International
1 Golden Square
London W1R 3AB.

TELETEXT

Barry Thurlow, a Systems Designer at Logica, explains the workings behind the teletext system and delves a little into future developments.

In its common form, as the Ceefax and Oracle services, teletext can be seen on display in TV stores and many homes all over the country but few people really know its capabilities nor how it arrives at the set. This article aims to introduce some of the services available now and some of the exciting services proposed for the future and to explain the details of how the system works.

Teletext is a digital data signal carried as part of the broadcast TV signal and arrives in the home via the TV aerial. The explanation of the teletext signal, then, depends on the nature of the TV broadcast itself.

In a TV camera the picture is scanned from top to bottom in 312.5 evenly-spaced lines. Then it is scanned again making another 312.5 lines positioned in the gaps between the first set. This two-pass scanning is called interlacing (Fig. 1).

The total number of lines for a full resolution picture is 625 which is why the system is often referred to as the '625-line system'. The scanning is interlaced to reduce flicker in the scanning process. The analogue waveform which represents the luminous intensity along the lines is transmitted along with added pulses which mark the start of each line.

It takes 52µs to transmit the picture information for one line of the picture. A further 12µs is allowed for the receiving monitor to reposition for the start of the next line. During this time a negative going pulse (the 'line sync') is transmited (Fig. 2a). So a total of 64µs per line is required, giving a line rate of 15.625kHz.

The full 312.5 lines displayed in one sweep from top to bottom is called a 'field'. The two separate fields in the interlace system are called 'odd' and 'even'.

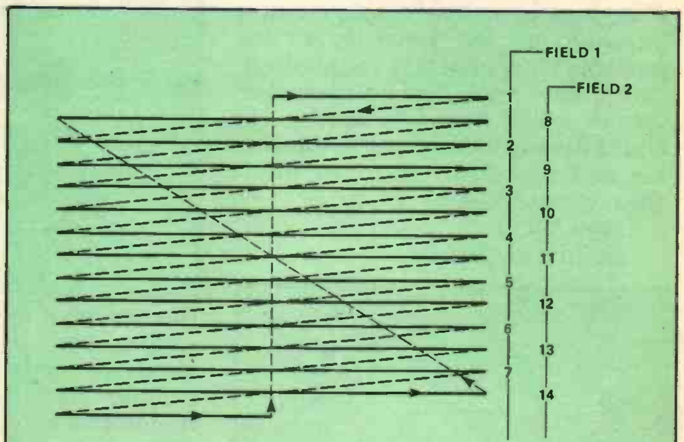


Fig. 1 Interlace structure of a TV image.

When the bottom of the picture is reached, extra time must be allowed for the receiving set to return to the top for the next field. This period before the start of each field is called the vertical blanking interval (VBI). The VBI is 25 lines long leaving 247.5 lines per field for the picture.

To indicate to the receiving monitor when to return to the top of the picture the regular chain of line sync pulses is changed. The normal 4.7µs line sync pulse is extended to 27.3µs with a second pulse occuring in the middle of the line (Fig. 2b).

Since many old TV sets take a long time to recover from the return to the top of the screen, the picture information is held off until line 23, leaving lines 7 to 22 unused.

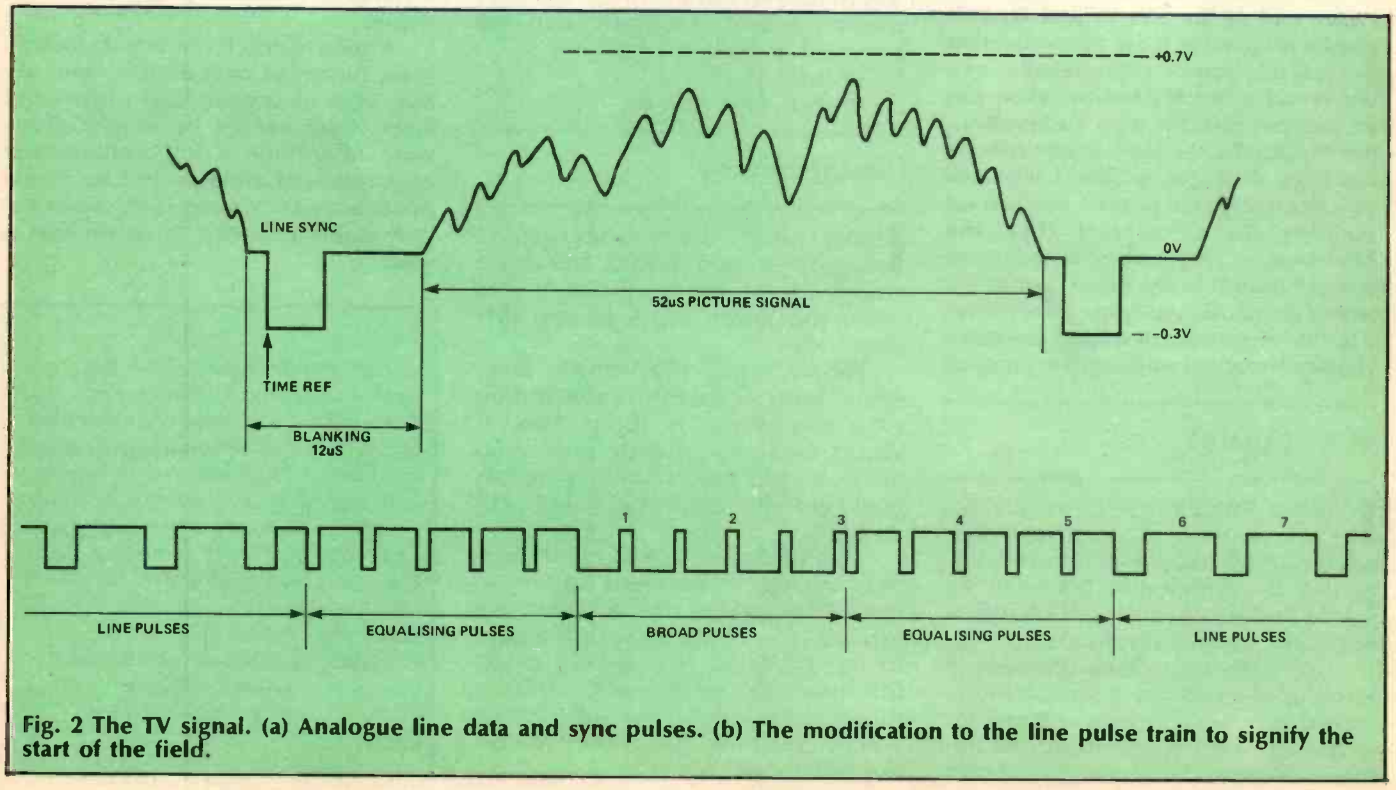


Fig. 2 The TV signal. (a) Analogue line data and sync pulses. (b) The modification to the line pulse train to signify the start of the field.

However, the broadcasters are not ones to let these lines go to waste. Lines 19 to 21 are usually used for test signals which allow for constant monitoring of signal path quality. Line 22 is usually quiet and is used for noise measurements. Lines 13 to 18 carry a digital signal — teletext.

The Teletext Waveform

Figure 3 shows the line sync pulse for line 13 and the digital signal which follows it. The first eight cycles follow a fixed regular pattern. These 16 alternate 0's and 1's are known as the clock run-in. This enables the receiver to lock-in to the centres of the data bits.

Following the clock run-in is another fixed pattern of eight bits known as the framing code. These bits read 11100100 (from left to right) and as the data arrives eight consecutive bits are compared with the expected framing code. This is done at each bit boundary by shifting the data through an 8-bit register and testing the parallel output.

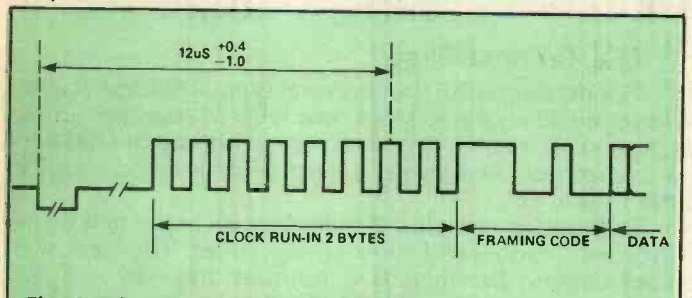


Fig. 3 Teletext data following the line sync.

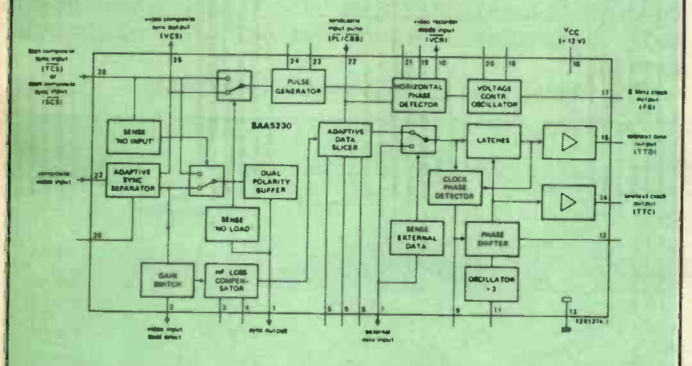


Fig. 4 Block diagram of the SAA5230 (courtesy Mullard).

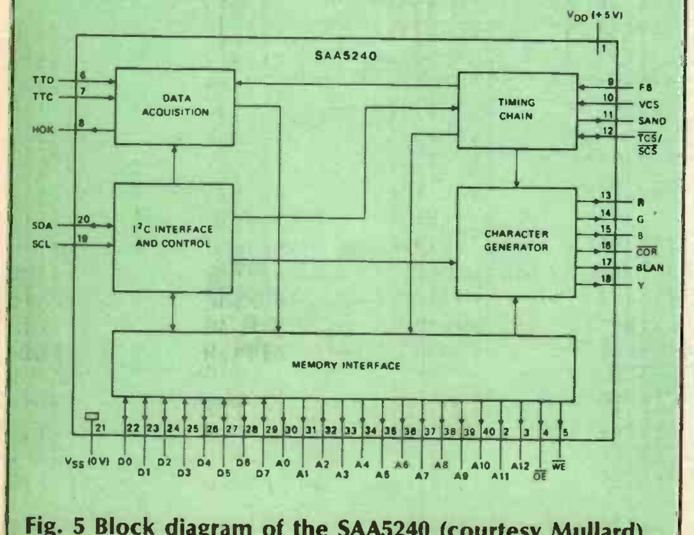
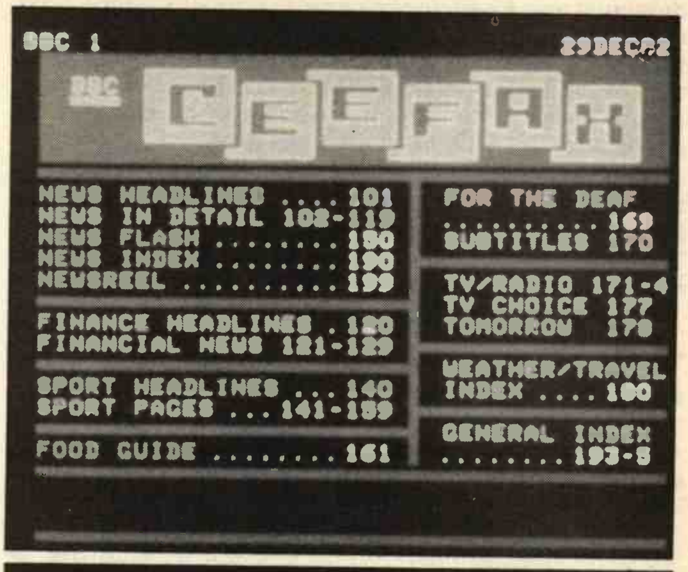


Fig. 5 Block diagram of the SAA5240 (courtesy Mullard).



When the 11100100 pattern is seen in the 8-bit window the receiver knows it is looking at a whole byte rather than eight bits from two adjacent bytes. During the rest of the line, allocation of groups of eight bits into bytes is done by counting bits from this known reference.

The SAA5230

There are a number of ICs on the market which perform the task of recovering the teletext data stream from the video signal. One of the most common is Mullard's SAA5230 (Fig. 4). The Mullard chip performs all the video processing functions required to turn the 1V composite video waveform into serial data and clock.

The main functions of the SAA5230 are sync separation, 6MHz voltage controlled oscillator (VCO), adaptive data slicing and data clock regeneration.

Sync separation is the process of recovering the start of line and start of field pulses from the video signal. The chip first slices the video signal at about 0.15V to produce a TTL waveform corresponding to the negative or sync part of the video. This signal (VCS on pin 25) contains line sync pulses of about 4.7μs width at 64μs separation and the field pulse encoded as broad pulses for 2.5 lines every 20ms.

The 6MHz VCO is used in conjunction with an external divide-by-384 counter in a phase locked loop to make a locked dot-clock for a character generator. The SAA5240 chip (Fig. 5) contains both a suitable divider and a character generator.

The adaptive data slicer is used to convert the video data bits to TTL. It comprises maximum and minimum detectors and an analogue comparator whose threshold is the half-way point. The capacitors on pins 5 and 6 store the signal peak and zero levels respectively. The sliced data at TTL level is available at pin 15. The use of adaptive slicing makes the circuit insensitive to changes in amplitude and DC offset on the input.

A clock signal (TTC on pin 14) is generated using an accurate crystal oscillator. The oscillator runs at twice the teletext bit rate and is divided down and re-phased from transitions in the data. TTC is timed to have a rising edge in the centre of each valid data bit.

Specification

After successful trials with teletext at the BBC in the mid 1970's it was realised that commercial teletext would only take off if the cost of including the decoder in the TV set was low. The target figure was for the teletext-equipped set to cost no more than £50 more than a similar model without.

This meant the set makers would need a special chip set to do the complex decoding task instead of the 30 or so TTL chips used in the experimental decoders. Such chips are easily connected to form a complete teletext decoder (Fig. 6). However, the chip manufacturers needed a fixed specification to work to before they could commit to the large development cost required to design and produce such a chip. Jointly the BBC, the IBA and BREMA published the 'Broadcast Teletext Specification' in September 1976.

This document defines the signals and data which are transmitted and the characters, colours and other responses which are expected of the receiver. Both the BBC's Ceefax service and the IBA's Oracle service work to this specification.

The specification ensured the chip manufacturers knew what was being transmitted and the broadcasters knew how their pages would look to the viewer. It is still the reference document for Level 1 Teletext.

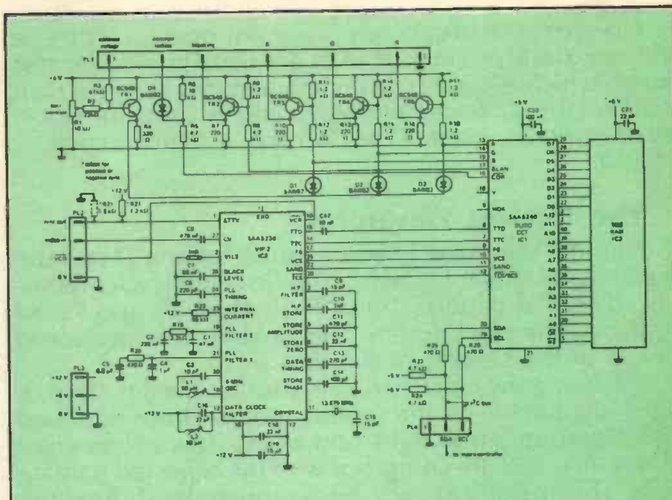


Fig. 6 A simple single page decoder circuit based on the SAA5230 and SAA5240 (courtesy Mullard).

The Teletext Page

The photographs show several typical teletext pages. There are 40 characters per row, with 24 rows including a page header at the top. Each row (including the header) is transmitted as a single packet of data filling one TV line in the VBI.

Each packet contains 45 bytes including the first three (the clock run-in and the framing code). The next two bytes contain the magazine number and row address used to position the row on the screen.

For example, the header has an address of 0 as it is the top row. Addresses 1 to 23 give the row position down the page. As there are no rows 24 to 31 packets with these codes are treated differently and we'll come to these in a while.

The header (packet 0) is required not only as the top

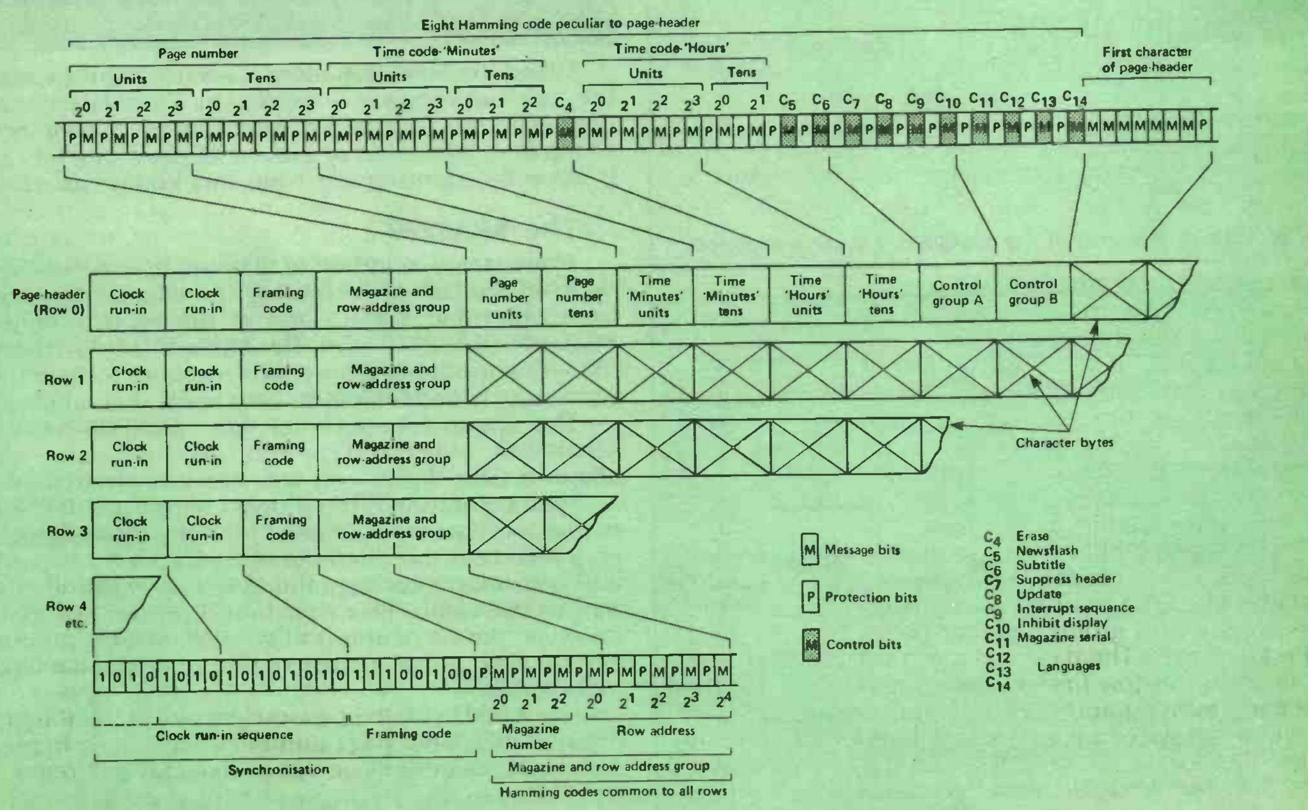


Fig. 7 The format of the header (packet 0).

row containing the familiar service name and date but also as a key to decoding the rest of the page. It contains (in binary) the page number and various flags indicating the type of page display required. It is always transmitted one field before the rest of the page to allow the decoder time to act on the information. The format of the header is shown in Fig. 7.

The decoder compares the transmitted page number with the one selected by the viewer and updates the page display only if a match is found. Having the page number only in the header packet is a great saving in bytes over each row being explicitly addressed.

The price for this is that an error in receiving the header would render the whole page unreadable. To alleviate this difficulty the eight control bytes are Hamming coded for error recovery.

MESSAGE BITS (b7, b5, b3, b1 — shaded columns are PROTECTION BITS)

b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1
0	0	0	1	0	1	0	1
0	0	0	0	0	0	1	0
0	1	0	0	1	0	0	1
0	1	0	1	1	1	1	0
0	1	1	0	0	1	0	0
0	1	1	1	0	0	1	1
0	0	1	1	1	0	0	0
0	0	1	0	1	1	1	1
1	1	0	1	0	0	0	0
1	1	0	0	0	1	1	1
1	0	0	0	1	1	0	0
1	0	0	1	1	0	1	1
1	0	1	0	0	0	0	1
1	0	1	1	0	1	1	0
1	1	1	1	1	1	0	1
1	1	1	0	1	0	1	0

HAMMING CODE BYTES

	b_8	b_7	b_6	b_5	b_4	b_3	b_2	b_1
A	•		•				•	•
B	•				•	•	•	
C			•	•	•		•	
D	•	•	•	•	•	•	•	•

TESTS FOR ODD PARITY

PROTECTION BITS (shaded)

• TESTED BITS

RESULTS OF PARITY A,B,C	RESULTS OF PARITY D	INFERENCE	ACTION
All correct	Correct	No errors	Accept message bits
All correct	Not correct	Error in b_7	Accept message bits
Not all correct	Correct	Multiple errors	Reject message bits
Not all correct	Not correct	Single error	Refer to table 1(b) to identify error. Correct error if in message bit

DECODING ACTION

Table 1 Hamming codes and error checking.

Table 1 shows the Hamming codes, how the protection bits are generated and how they may be checked. Hamming allows for the correction of single bit errors and for the detection of two bit errors.

When the Mullard SAA5240 decoder is used, the Hamming corrections are automatically performed on the appropriate bytes. If you plan to make your own decoder the job can also be done using a 256-byte EPROM.

Hamming coded data is applied to the 8-bit address input. Four of the output bits are programmed with the message bit patterns corresponding to the Hamming correction algorithm. Further bits may be programmed to indicate that an error was found and corrected, that no error was found or that the byte contains an unrecoverable number of errors.

As the first eight bytes of the header are used for the control bytes, the top row is displayed with the first eight positions blank. This space is usually used by the decoder to show the keyed-in page number.

Bytes 6 and 7 hold the page number in binary form and bytes 8 to 11 contain a sub-page code. This code is usually set to the number of the page within a group. It is common to group together pages such as the TV schedule pages. The page changes by itself about every 60 seconds to show first the morning program list then the early evening and then the late programs.

Such sub-pages are termed a rolling set and have sub-page numbers 1, 2 3 . . . The sub-page code may be selected specifically on most decoders using the 'timed page' buttons (so called as the sub-page code was originally intended only for the time on the alarm clock page).

Figure 7 shows a number of single-bit flags in the control bytes of the header. These are denoted C4 to C14.

C4 is the Erase Page bit and is set when the broadcaster requires the decoder specifically to clear the old page before showing the new one. This is usually done between rolling pages or when the contents of a page have been updated. It gives the editor the flexibility to have an obvious change of content or (by not setting the bit) to have a page change only in part. This is also done sometimes to give an impression of animation.

C5 is the Newsflash bit, set if a page contains information which the viewer may wish to see superimposed on the TV picture. Most decoders will allow the viewer to select the newsflash option in such a way as to allow continued viewing of the program until the newsflash occurs.

Pages intended to be seen as subtitles to a program will have bit C6 set. This allows the decoder to display them with the text set in a dark background cut into the picture.

C7 is the Suppress Header bit. Setting this bit causes the decoder to blank the header row. This feature is used at the editor's discretion to enhance the appearance of the page.

Pages in teletext are transmitted repeatedly so someone who has just switched on will not have long to wait to see their chosen page. However, once the page has been read the viewer may wish to go back to watching the TV program until the page changes. This is particularly true of a rolling page. The transmission computer will automatically set C8 (the Update bit) for the first transmission of a page after it has been updated. The decoder may then signal to the viewer that a new page is ready (usually by showing the page number in the corner of the screen).

Some pages in teletext are transmitted more frequently than can be allowed by sequential transmission of all pages — for example, the index page which the viewer may refer to more often than any other page. Transmissions other than the first in a cycle will be out of sequence and this would have the effect of making the page number shown in the header roll in an erratic way if it was not for the use of Out of Sequence bit, C9.

The decoder, detecting that a header is not in sequence will leave the previous header at the top of the screen. The rolling page numbers may pause briefly as the out of sequence page goes past but will remain in order.

C10 is the Inhibit Display bit. Setting this bit prevents the page from being seen by a TV set not specially modified. This is used to avoid showing meaningless displays such as would result from a page whose contents were encrypted.

The Magazine Serial bit, C11 is used by the broadcasters to allow flexibility in transmission methods without adversely affecting the quality of the viewer's teletext display.

Bits C12 to C14 contain a 3-bit code for the language of the page. More advanced decoders such as the Mullard SAA5240 will use these bits to enable foreign character sets to be used automatically.

Editing

Now we have seen how pages are addressed, we should consider how these mechanisms are put to work by the teletext editor when preparing pages for transmission.

Teletext pages are accessed by the viewer using a three digit code (000 to 799) and optionally by a sub code. The editor may use the page number to group together pages of a particular type. The hundreds digit of the page number is termed the magazine number and has the special property of being present in all packets. The editor may choose to transmit the magazines in serial:

100 101 102...
200 201 202...
300 301 302...

or in parallel:

100 200 300 400...
101 201 301 401...
102 201 302 402...

If parallel transmission is chosen the viewer will see only page numbers from the selected magazine rolling round.

On the transmission computer the editor will have a library of 26 magazines (A to Z) from which he may assign any eight to the transmitted magazines (0XX to 7XX). (As the magazine number is three bits long, 0XX and 8XX may be used interchangeably according to taste).

The editor can further control the transmission ot magazines by setting a transmission order in which a magazine may appear more than once. During Saturday afternoon, for example, the magazine used for sports (say 300) may be considered to require faster access than the total number of pages in all magazines would allow. The editor could therefore choose to transmit the magazines in the order:

100 300 200 300 700 300...

thus cutting the waiting time for a 300 page to one third that of the other magazines.

Subtitling

One of the most important uses of teletext is to provide subtitles on broadcast programmes for the hard of hearing. The subtitles which we see on foreign films are inserted into the video signal at the time the film is edited so there is no choice about seeing them. Not everyone, however, would want to watch English subtitles all the time so a choice is provided.

Teletext subtitles are inserted in the picture by the receiving set and, like other teletext pages, they are only shown when selected. Insertion is done with boxing where the text from a specified part of a teletext page is made to appear on its own background superimposed on the picture.

The teletext characters 10 and 11 (hex) are placed at the points on each row where the changes from picture to text and back are to be made. The subtitle creation computer will allow the editor to choose whether the box is rectangular (fitting the widest line of text) or variable (following the shape of the text). The editor may also position the boxed text anywhere on the screen so as not to obscure the action.

In preparation, teletext subtitles are viewed against a tape of the program and the tape positioned to the exact instant the text should appear. The time-code of the tape position is stored with the text on the computer. This way the text can be synchronised to a change of scene or a movement of the lips. It can take several hours to prepare the subtitles for a half hour show.

In transmission, the subtitles are read on the transmission computer and their times for appearance and disappearance compared to the time-code from the video tape or film. When the times match, the transmission computer schedules the subtitle page for immediate transmission, out of the page sequence to preserve the timing accuracy.

A recent development in teletext subtitles is live subtitling. A news interview or sports event may be subtitled. Obviously, the difficulty is how to enter the subtitle into the computer when it is not known what will be said. The subtitling computer helps greatly by allowing for the use of 'short forms'.

In a political interview it may be a reasonable assumption that the phrase 'the Conservative government' may crop up. Before the interview the computer is given a large number of such phrases and shortforms such as 'GVT.' If the operator uses the shortform during live subtitling the computer will automatically expand it up to the long form and fit the other text after it.

The SAA5240 provides a switching signal (BLAN) which is used in the colour decoder chip to switch between text and picture. This signal is used for boxed subtitles and for superimpose mode where the text is cut-into the picture.

Full Level One Facilities

So far we have been talking about what is called Level 1 teletext. That is to say, Level 1 as was cost effective to implement in 1976. It has basic textual features and simple graphics. Pages are all accessed by three digit numbers which can take time to get used to.

Full Level One Facilities (FLOF) is the implementation of several advanced features not very different to level 1 but which could not be economically processed by the chips of the first generation.

Technology has moved on a great deal since 1976 and now it is possible to put a lot more intelligence inside a TV set. Appearing in the shops now are TV sets with CCT (computer controlled teletext). The Mullard SAA5240 is a CCT device. Much higher integration density than was previously possible has enabled more functions and a serial computer interface to be provided by only two chips.

Remember the row address number — a 5-bit number which only requires values 0 to 23? Some of the missing codes are used in FLOF. Packet 24 is used to provide an extra row of text which will contain operational prompts as defined by the editor. Packet 27 contains link control information for linked pages. Packet 8/30 (packet 30 of magazine 8 only) contains various flags and digital information.

Linked Pages

One of the infuriating facts about teletext is that there is a wait for the selected page to appear. This problem could be overcome if there was sufficient memory in the TV set to hold all the pages, using the live signal only to update this database. However, as there are typically about 400 pages on the cycle, this would require a very large memory. Page linking gets around the access time problem while requiring only a modest amount of memory.

For any given page there are a small number of likely next pages. For a sports page, say, the viewer would typically want to step on to the next sequential page, go back to the sports index, go back to the main index or go to a profile of the goal scorer mentioned in the page he is reading.

The four associated pages are made the 'linked pages' for the current page. The editor decides which pages are to be linked to which and will enter the information on the computer when the page is compiled. The computer will also fill in any unused links if possible and inform the editor of any inconsistancies before allowing transmission.

Packet 27 contains a list of linked page numbers readable by the CCT computer. These are used by the decoder to acquire the linked pages in advance of the viewer selecting any of them. This requires a memory of only 4K.

Packet 24 of the current page will be displayed (normally at the bottom of the screen) to indicate the contents of the local memory. This might read:

NEXT SPORT INDEX MAIN PROFILE

Each choice is in a different colour corresponding to four coloured buttons on the remote control. The viewer may choose one of the linked pages by pressing the appropriate coloured button and as it is already stored in the local memory there is no need to wait for the page to come around.

Of course, if the page the viewer wants is not one of the four then the page number may be keyed-in explicitly and the page will be picked up as it is transmitted.

Television Service Data Packet

Packet 8/30 contains information about the broadcaster whose signal is being received and about the time and date. It is intended to be processed by the CCT computer and so the use made of the data will differ from one set to another depending on the software supplied by the set maker.

Home Computer Teletext

It is possible to receive teletext data, including the extra FLOF packets, on a home computer. A special teletext adaptor is needed and several manufacturers produce these.

Acorn and Morley produce models for the BBC micro and a unit from Volex is available for the Spectrum and Amstrad CPC micros as well as the Beeb.

Morley's decoder for the BBC micro contains the Mullard CCT chip-set and a tuner making it straightforward to connect, requiring only an aerial. The unit comes complete with software for the BBC micro to load and display pages.

The use of teletext with a home computer allows more than just paper printout. Pages can be stored in RAM or on disk for really fast access. It is possible to have your morning paper printed for you by your computer accessing the news pages. Your paper will be hours ahead of those in the local newsagent.

In the future you could have your computer controlling the video recorder from the information in packet 8/30 and record your favourite programe when it actually comes on — without the 15mins of overruning cricket causing you to miss the end of your film.

Telesoftware

Telesoftware is the name given to the service by which free software may be broadcast via teletext. The software appears as tokenised Basic or machine code bytes compressed so the lines of the program wrap around the teletext rows. Telesoftware is intended only for machine reading and makes use of packets 27 to link pages and hence allow programs to be longer than 24 lines.

Teletext decoders for home computers are usually supplied with software to make use of the broadcast telesoftware.

Datacast

The latest use of Teletext is Datacast — the BBC's data broadcasting system. This uses teletext packet 31 in a special format to carry information on behalf of private data providers.

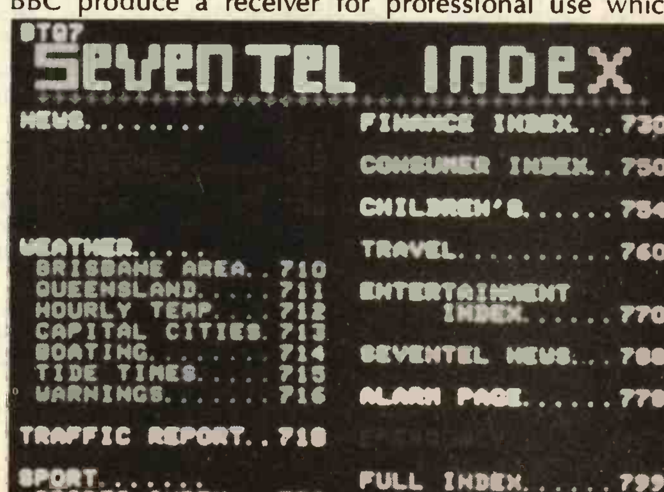
Packet 31 is not received at all by the SAA5240 so a purpose-built decoder is needed in order to receive it. Such a receiver is available from Volex to work with the BBC micro, Spectrum and Amstrad.

Datacast is intended for retail chains, financial institutions and the like wishing to send data simultaneously to many branches. One newspaper is currently considering installing a Datacast receiver in each of it's newsagent shops to be connected to a suitable moving message display.

The headlines would then be received simultaneously in all the shops each morning and displayed in large letters in the window to attract the attention of passers by.

To make use of the Datacast system the data provider sends data to the BBC in London by landline where the Datacast computer will format it for transmission. The BBC is constantly improving the service and will be able to help with the latest information on how to access Datacast as a data provider.

For the data user, only a suitable receiver and a computer is required to decode the special format. The BBC produce a receiver for professional use which



contains a Z80 microprocessor to recover the data from the packet structure and to output it as an RS232 signal suitable for a printer, computer or display.

This is a sophisticated receiver to allow it to process the data it receives in an intelligent manner, programmable to check errors and only send out error free packets or try for an error free packet and then pass-on the last copy of that packet error-free or not.

At present the system is using one line on BBC1 and BBC2 for a combination of real and test data. With a single line an end-to-end throughput of 19,200baud is possible. By contrast, a modem directly coupled to the phone line can only usually achieve a throughput of 1200baud.

The contrast is further emphasised when comparing the time taken to phone individual destinations with the time taken on Datacast to broadcast to all at once. Take a typical news headline of 100 characters which is to be sent to each of 1000 shops. A modem would take about a second to transmit the data and around 10 seconds to dial. For all the shops this would take around three hours. Datacast would take about 55ms to send the data plus the time taken to send the data to the BBC by phone, say, around 15 seconds. A ratio of over 700:1!

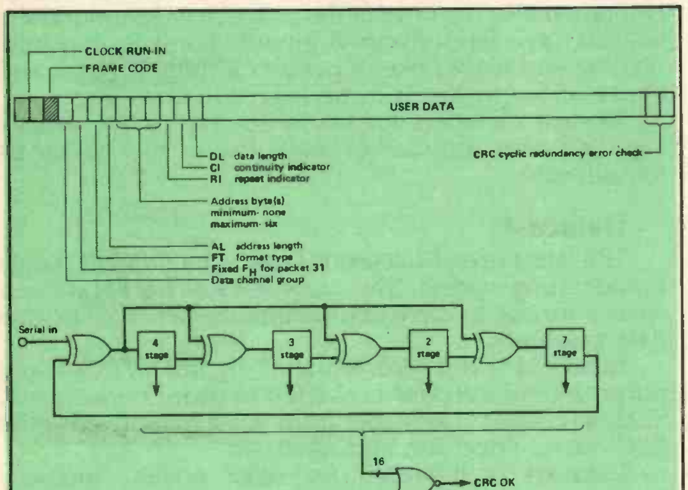


Fig. 8 The format of the Datacast packet (packet 31).

Datacast Packets

Figure 8 shows the contents of the Datacast packet (packet 31). Individual receivers may be addressed using an address field which is up to six bytes long giving a 24-bit address. The packet is further identified within the users data stream by the continuity indicator (CI) and repeat indicator (RI). The RI gives the number of a packet, which has been repeaed, within the set of repeats. The RI is modulo 16 and uses the lowest four bits of the byte. The CI is used to check that no packets have been missed out in case of poor signal quality. It is a modulo 256 number incremented for each new packet.

Following the CI and RI is a data length byte, the data and finally a two byte cyclic redundancy check (CRC). The CRC is calculated using feedback on bits 0, 4, 7, 9 and 16.

These provisions make Datacast suitable for financial and other numerical data where integrity is of utmost importance.

Full details of the Datacast service are available from the BBC. For professional consultancy on the use of Datacast in business readers are recommended to contact Logica.

Private Teletext

So far we have only considered the source of teletext to be the two broadcasting companies. It is also possible to gain the advantages of teletext in a private video network.

Hotels, chalet parks, large stores and even factories may have their own network broadcasting video to their guests, customers or workers. Such institutions can include teletext in their signal and add to their services the ability to distribute textual data. The advantage of teletext over simply using computer terminals are twofold.

- The network of cables already exists.
- The receiver (teletext TV set) is inexpensive.

It is possible to combine the signal from, say, the BBC with locally-added teletext so that a hotel guest, for example, can view the normal programs and also dial up the latest menu, lists of hotel facilities or local tour information. Using the newsflash facility a guest could keep informed about the opening of the restaurant. The hotel could incorporate a paging service too.

Building Teletext Generators

Level 1 teletext in its simplest form consists of largely ASCII text with the magazine and row number and the header added around it. At the hardware level it is merely a series of black and white dots at a particular frequency and in a particular position in the video field. A programmable graphics chip such as Motorola 6845 can be programmed to produce such a dot pattern (Fig. 9).

To use the 6845 as a teletext generator the crystal frequency must be changed to 6.97MHz and the device programmed to output on, say, line 18 only. The data on the line will be from an area of RAM and at these addresses bytes corresponding to clock run-in, framing code, magazine and row address and row or header bytes must be placed. Some care is required to ensure the timing is correct. The penultimate cycle of the clock run-in must be at 12µs from the falling edge of line sync (as in Fig. 4).

The software must generate complete pages of text in memory including the header and initial bytes making 45 bytes per row. By incrementing the starting address pointer of the 6845 it may be made to generate teletext from one row after another. It would be best to use interrupts to increment this pointer after each field sync but if this is not possible on your computer it does not matter as teletext rows may be transmitted more than once without harm.

Full Field Teletext

Normal teletext, more properly known as VBI teletext,

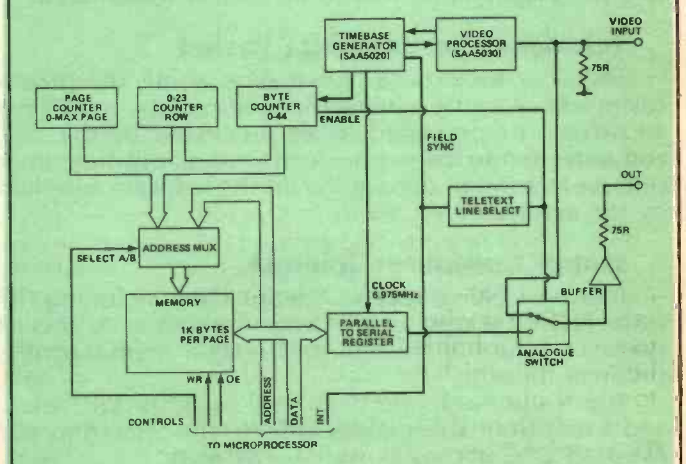


Fig. 9 Block diagram of a teletext transmission system.

uses no more than 16 lines of the video field. This limits the effective data rate to a maximum of 32K per second. If there is no requirement to have a TV picture at all then all 263 lines may be used giving a massive data rate of 526K per second.

With 300 pages in the cycle this would cut the access time from around nine seconds to 0.6s.

This method has been successfully applied in the Hong Kong Stock Exchange to provide very rapid access to stock information for some 600 terminals. With teletext the number of terminals is not important. If they had been standard computer terminals the computer servicing the requests would have had only 1ms to process the request for each terminal in order to guarantee the same performance.

The Future

To control the cost of teletext while allowing manufacturers to move with technology, a number of levels of teletext service have been defined by the DTI in their document 'The World System Teletext Technical Specification and an Introduction to Videotext'. Each level is intended to be brought into service as and when technology permits.

Level 1 and FLOF teletext pages look similar with their seven bright colours, limited character sets and crude mosaic type graphics. However, in the future we should be seeing lots of good things.

Levels 2 and 3 propose more colours for more subtle effects, lots more characters allowing foreign language and mathematical symbols to be mixed on a page. There are also double height and double width characters to make text displays more interesting (see Fig. 10). One of the outstanding new features is the possibility of redefinable characters. This means the bit-pattern for a character square may be sent to the decoder in advance of using the character so it can take any shape desired.

This can be used to produce high resolution graphic images by grouping a number of redefined characters together as a large bit-mapped area. Images such as the space shuttle in Fig.10 open the door to better presentation of title pages and advertisers' products.

The Mullard EUROM chip is a level 3 display controller. It provides for 32 different colours at a time chosen from a palette of 4096. It has redefinable characters on a 10-by-12 matrix which may be used to provide graphics with an effective resolution of 400 by 300 pixels or to give a very high quality text display. It has four built-in character tables which provide a wide variety of characters, foreign and English, symbols, and shapes for line drawing. The EUROM can be used to make a genuinely attractive display.

Further in the future are levels 4 and 5. Level 4 the so-called 'Alpha-Geometric' presentation level will expect the receiver to be able to produce many basic graphic elements from transmitted instructions. A number of drawing primitives such as ARC, VECTOR, AREA FILL will be used to produce ever better and more attractive images.

Level 5 is termed 'Alpha-Photographic' presentation. This level will require large amounts of memory and will produce full resolution still pictures. The enormous amounts of data required may limit this service to the cable networks where a full channel teletext service could use level 5 for home shopping for goods which need to be seen and which previously would have required a visit to the shop.

The high quality display system which will be in the TV set of the year 2000 will I'm sure also be used as the display for other parts of the home entertainment and communication system. All the settings of the TV brightness, volume, tuning, and so on, as well as those of the radio, amplifier and CD will be shown and altered using on-screen displays.

The video recorder will be programmed not by programme times but, through teletext, by names of the programmes and even actors and actresses. The home communication system will search the listings on teletext and automatically record all films starring, say, Peter Sellers or any program with the word 'gardening' in the title.

As storage devices become ever lower in cost we may have our entire library on-line. Teletext could be used to send us new editions and updates as they are ready. One could subscribe to the complete Oxford English Dictionary or Encyclopedia Britannica and have it constantly updated and available for instant computer access from your optical disk.

Teletext is really only just beginning. **ETI**

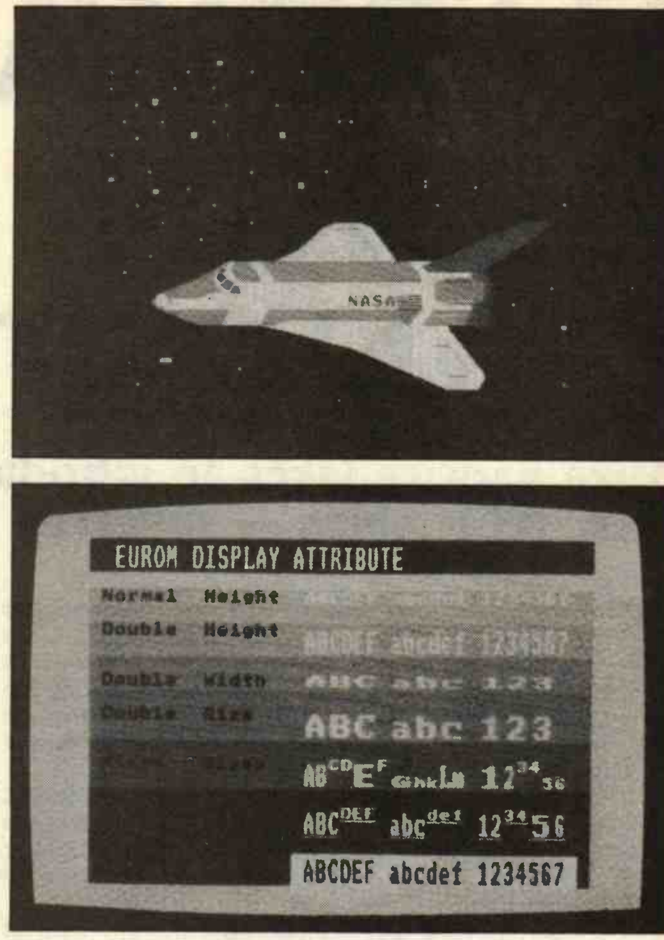


Fig. 10 Level 2 and 3 teletext screens.

Contact Addresses

BBC Designs Department
99 Great Portland Street
London, W1

Department of Trade and Industry
Information Technology Division
29 Bressendon Place
London, SW1

Logica Communications and Electronic Systems Limited
Attn. Gwyn Morgan
64 Newman Street
London, W1A 4SE

Morley Electronics
1 Morley Place
Shiremoor
Tyneside, NE27 0QS

Mullard Limited
Mullard House
Torrington Place
London, WC1E 7HD

Volex Electronics
Stowell Technical Park
Eccles New Road
Salford, M5 2XH

HARDWARE DESIGN CONCEPTS

Mike Barwise takes an introductory look at emitter coupled logic (ECL) chips — superfast but tricky with it.

The superfast logic family, ECL, of which super computers like Crays are made, has actually been around since the mid 1960's but has never caught on among amateurs. There are many myths about the difficulties of working with it but I don't think it poses any insuperable problems for the enthusiast except perhaps the cost of the requisite fast test gear.

The advantages of working with ECL are phenomenal speed, noise immunity and the ability to use a wide range of specialist components only made in this technology, such as flash analogue to digital converters and content addressable memory.

The main disadvantages compared with more familiar technologies (TTL and CMOS) are considerable power dissipation and heat generation. Circuits of more than about half a dozen packages should really be fan cooled. There is also a need for much more rigorous adherence to design rules and to some extent a lack of VLSI components, although this is rapidly being corrected as new devices appear at an amazing rate.

ECL was first introduced by Motorola in 1962 as MECL I, which, at a working speed of 30MHz, was by far the fastest logic family of its day. It has passed through several alterations up to the present set of three types or 'families'.

ECL is currently available in various types which differ in speed and use. Briefly, these are:

MECL10K (125-200MHz, introduced 1971-76)
MECL10KH (250MHz, 1981)
MECL III (500MHz, 1968)
(Motorola designations).

All of them work on the same basic principle but differ in internal layout and silicon technology. The faster types do get increasingly tricky to work with, so the one I recommend for experimentation is MECL10K. This is the slowest (a mere 150MHz!) and poses the least problem to the rule of thumb worker.

Saturated And Unsaturated

The now familiar CMOS and TTL logic families work by switching internal transistors *fully* on and *fully* off (driving them into *saturation* and *cut-off*). The collector-emitter current of a transistor varies according to the current applied to its base. However, there is a point beyond which additional base current cannot increase collector-emitter current and this is termed 'saturation'.

Similarly, with reducing base current, the transistor will always stop conducting before the base current reaches zero. The base current at which this happens is called 'cut-off'.

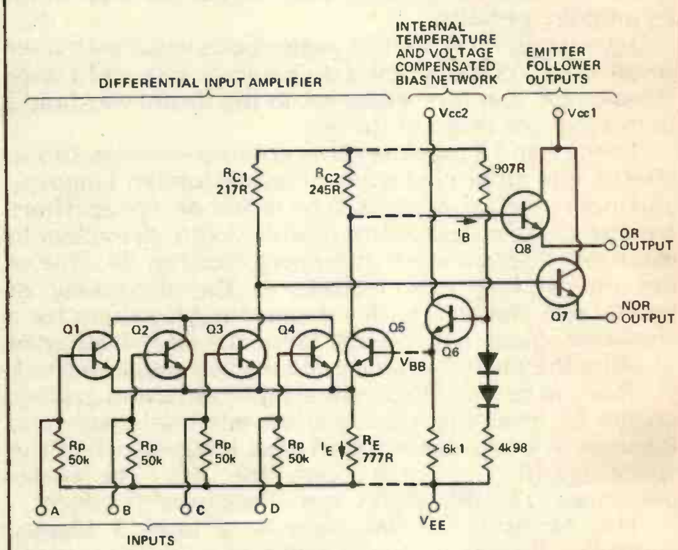


Fig.1 The Basic gate circuit for the MECL10K family.

The problem with switching between saturation and cut-off is that it slows you down. Crudely speaking, the capacitance of the transistor holds a charge when the transistor is in saturation and this dissipates relatively slowly, delaying the passing of the cut-off threshold.

ECL, unlike TTL, uses 'unsatured logic'. This means that the internal transistors are switched within their linear region, never cutting off or saturating. This is the main reason why ECL is inherently faster than TTL — 150MHz to 500MHz as opposed to the maximum of 90MHz available from F series TTL.

The ECL Circuit

TTL gate inputs use multiple-emitter transistors which are in effect a refinement of the simple diode gate. ECL works on an entirely different principle. Each input is the base of a separate transistor in a parallel connected bank which forms one half of an *emitter coupled* differential amplifier (Fig.1).

The other half of this differential amplifier is driven by a reference voltage, creating what amounts to a comparator. In passing, it is worth mentioning that the ECL input stage is reminiscent of the 'long tailed pair' of valve days (dates me doesn't it!).

Working With ECL

At first sight ECL looks rather odd to anyone familiar with solely TTL and CMOS saturated logic families. There are no AND gates in any ECL family, most gates have true and inverting outputs and the supply and logic levels are funny, being nominally −5.2V (yes, minus!) supply and −0.9/−1.8V logic high/low.

However, none of these points constitute any real problem to the user. They simply amount to a different convention. Such problems as ECL does pose are not unique to it. They are the general problems encountered when working at the high speeds of which ECL is capable.

At switching speeds in excess of about 100MHz, interconnections exhibit inductive and capacitative characteristics which must be carefully controlled to avoid serious degradation of the signals passing along them. The parasitic RC component of an interconnection creates a 'characteristic impedance' which must be matched to the input and output impedances of the devices connected to either end of the interconnection.

Interconnections with defined characteristic impedance are known as 'transmission lines' and their precise performance can be defined and predicted by mathematical means.

I do not intend to go into the calculations here, as they would put you off (and me too!). It is sufficient to say that without a lot of careful measurement and maths you cannot reliably use MECL III (500MHz). However, you can use the slower families (allowing 250MHz operation) as Motorola have been very crafty in the design of MECL10K and 10KH.

The two factors which affect overall logic system speed are risetime (the time the logic takes to make a nominal transition between high and low) and propagation delay (the time between a threshold transition at the input of a device and a resultant threshold transition at its output).

Of these two parameters, propagation delay is the worst offender in slowing down systems. The propagation delays of all cascaded logic stages add together, whereas the risetime of an overall system can be roughly considered as the slowest component risetime.

However, risetime is the factor which most significantly affects the requirements for transmission line impedance matching as the 'squarer' the waveform, the greater the range of high order harmonics present and so the greater the bandwidth of the system needs to be.

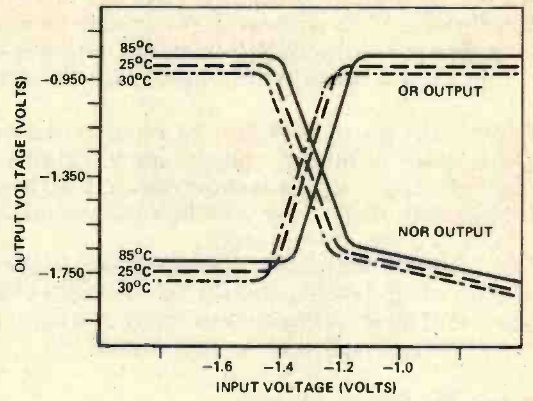


Fig.2 Typical transfer characteristic of the MECL10K family as a function of temperature.

MECL III has equal risetime and propagation delays of 1ns. This means the bandwidth of the device interconnections must be greater than 1GHz (1000MHz) by a factor of at least two. The craftiness in the case of MECL10K and 10KH is to make the risetime *slower* than the propagation delay.

So MECL10K has a risetime of 2½-3½ns and a propagation delay of 1½-2ns and 10KH a risetime of 1.8ns and propagation delay of 1ns. This means the interconnection bandwidth requirement is substantially relaxed even to the extent that wire wrapping techniques may be used (with care).

Design Rules For 10K And 10KH

The following rules are probably adequate for prototypes and experimentation.

- Use a proto board with a ground plane and copper power distribution. The board layout for my articles on the construction of the TTL pulse generator (Fig.3) would be a good starting point.
- All wiring should follow the shortest possible route. This is called 'point to point' wiring. It may look

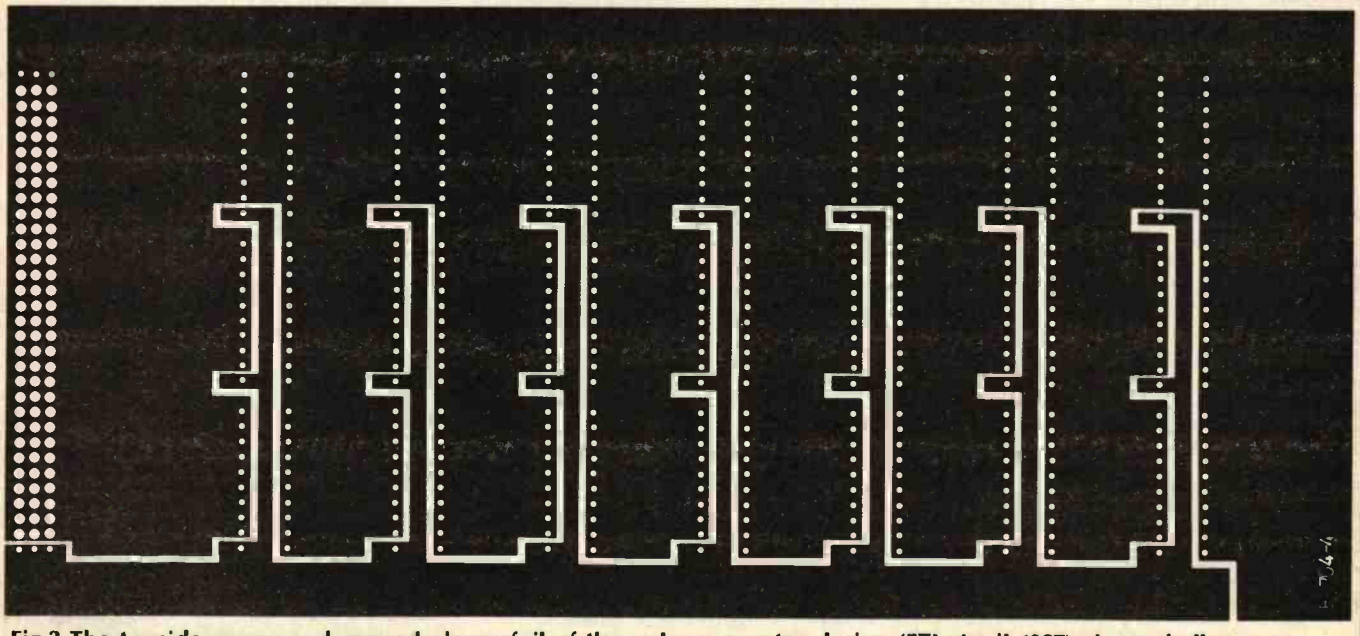


Fig.3 The topside power and ground planes foil of the pulse generator design (ETI, April 1987). A good all-purpose design for ECL experimentation and prototypes.

less tidy but it will dramatically improve performance.

- All wiring should be laid as close as possible to the ground plane. With wire wrap this means in contact with the underside of the PCB. If soldered wiring is used, it should be on the topside in contact with the ground plane.
- Great care must be taken to ensure the power supply rails meet optimum voltage specifications. Performance degradation in ECL is much worse than in other logic families with bad power supplies and will manifest itself as reduced noise immunity.
- ECL *must* be adquately cooled. It will blow up if it is not! Even proto boards should be mounted in some kind of case and have air blown over them by a fan if there are more than 5-10 packages in the circuit.

Where To From Here?

For further reading I strongly suggest the MECL Device Data manual and the MECL System Design Handbook, both available at about £5 each from Motorola distributors. The latter book goes into the maths required for MECL III (if you feel strong!). There is no substitute for the information in these books — they will be your ECL bible.

Two of the most interesting components, however, are the MC10H124 and MC10H125, which are quad TTL-ECL and ECL-TTL translators. Using these devices, the fastest flash ADC chips (working at about 50 million samples per second which TTL can handle) may be used. I will go into these in more detail very soon, as they open the doors to a host of really neat designs.

Next month I will take a look at new departures in analogue signal filtering, including both analogue and digital solutions.

FEATURE	MECL 10KH	MECL 10K			MECL III
		10100 10500	10200 10600	10800	
Year Introduced	1981	1971	1973	1976	1968
Bias Driver	VC*	10000	10000	VC*	10000
Output Pulldown Resistors	No	No	No	No	No
Input Pulldown Resistors	Yes	Yes	Yes	Yes	Yes
Maximum Input D.C. Loading Current	265μA	265μA	410μA	350μA	350μA
Specified Output Current	=22mA	=22mA	=22mA	=22mA	=22mA
Maximum Output Current	50mA	50mA	50mA	50mA	40mA
Transmission Line Drive	Yes	Yes	Yes	Yes	Yes
DC Loading Fanout	83	83	54	63	68
Input Capacitance	2.9pf	2.9pf	3.3pf	–	3.3pf
Output Impedance	7R	7R	7R	7R	5R
Gate Progration Delay (typical)	1.0ns	2ns	1.5ns	1-2.5ns	1ns
Gate Edge Speed (10 to 90%)	1.8ns	3.5ns	2.5ns	3.5ns	1ns
Flip-Flop Toggle Speed (min)	250MHz	125MHz	200MHz	N.A.	500MHz
Gate Power	25mW	25mW	25mW	2.3MW	60mW
Open Wire Length (Less than 100mV undershoot)	3in	6in	3in	6in	1in
Wire-wrap Capability	Yes	Yes	Yes	Yes	No
Use of Series Damping Resistors	Yes	Yes	Yes	Yes	Yes
Separate V_{CC} Inputs	Yes	Yes	Yes	Yes	Yes
Speed-Power Product	25pJ	50pJ	37pJ	4.6pJ	60pJ
Wire or Capability	Yes	Yes	Yes	Yes	Yes
*Voltage Compensated					

Table 1 MECL family comparison

ETI

CIRCUIT THEORY

Paul Chappell delves further into phasors and finds that capacitors can't predict the future after all.

Last month we saw how sine waves could be represented by rotating rods on a phasor diagram. In any linear network driven by a sine wave, every one of the resulting voltages and currents will also be a sine wave of the same frequency, so phasor diagrams come in handy for displaying the phase relationships between them. Better than that, they also give a lot of help in working out the voltages and currents in the first place, as we'll see in a moment.

First of all, let's take a look at individual components and see what happens when a sine wave voltage is applied. For a resistor the current at any instant is proportional to the voltage, so it comes as no surprise to find that the voltage sine wave gives rise to a current sine wave in phase with it (Fig. 1a).

How about a capacitor? The relationship between voltage and current is:

$$i = C\,dv/dt$$

For a general sine wave voltage of peak voltage V, $v = \sin(V\omega t + \theta)$ so the current will be:

$$i = V.C.\frac{d}{dt}\sin(\omega t + \theta)$$

$$= \omega.V.C.\cos(\omega t + \theta)$$

$$= \omega.V.C.(\sin\omega t + \theta + 90^\circ)$$

So the magnitude of the current will be ωC times the voltage and its phase will lead the voltage by 90° (Fig.1b).

The idea of the current leading the voltage that is producing it often causes confusion. It seems to suggest that capacitors have supernatural powers and can predict the future!

Let's put it to the test. We'll give the capacitor a sine wave voltage input until point A of Fig. 1c, at which point we'll let it level out. If the capacitor really does have precognition, it should level out the current at point B. Does it? Of course not! So much for psychic capacitors. Figure 1d shows what really happens.

The reason for the apparent supernatural power is that the voltage at any instant gives rise to a current proportional to its rate of change at any instant.

If the voltage is sinusoidal, it just happens that the current will also be a sine displaced by 90°. Leading and lagging is just a convenient way to talk about the phase relationship between the two.

With other waveforms, the current waveform will not even be the same shape as the voltage waveform (see Fig. 1e, for example) so any talk of leading and lagging is meaningless. Can you think of a voltage other than a sine wave that produces a current of the same shape? Don't spend more than five hours looking for one! (I'm not allowing exponentials — they don't repeat!)

After that digression, let's return to the business in hand. Since a sine wave voltage applied to a capacitor produces a sine wave current, if we only consider the magnitude of the two sine waves the capacitor seems to behave in a similar way to the resistor. The voltage produces a current ωt times as big, so the capacitor has a kind of 'resistance' to sine waves 1/ωC. This 'resistance' is not fixed — it varies with frequency. It's also different from ordinary resistance because it only works for sine waves and gives a shift in phase.

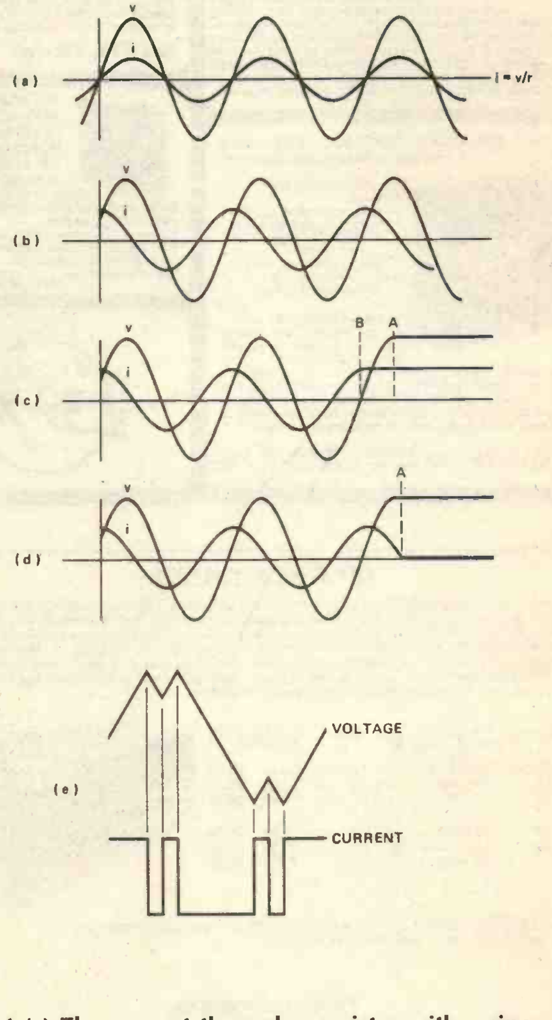


Fig. 1 (a) The current through a resistor with a sine wave voltage applied. (b) The current through a capacitor with a sine voltage. (c) Future prediction by a capacitor. (d) What really happens. (e) The current through a capacitor with a complex voltage wave.

An inductor has a similar sine wave voltage to current relationship, but this time the current lags the voltage by 90°. The 'resistance' of an inductor is ωL.

Do these 'resistances' behave in the same way as ordinary resistances? For instance, if a resistor R is wired in series with a capacitor C (Fig. 2a) can we just add the apparent resistances? Is the 'resistance' of the two components together R + 1/ωC? Let's use a phasor diagram to find out.

If you remember from last month, the process for making a phasor diagram is to arrange all the rods in the correct phase relationship to each other. To make the sine

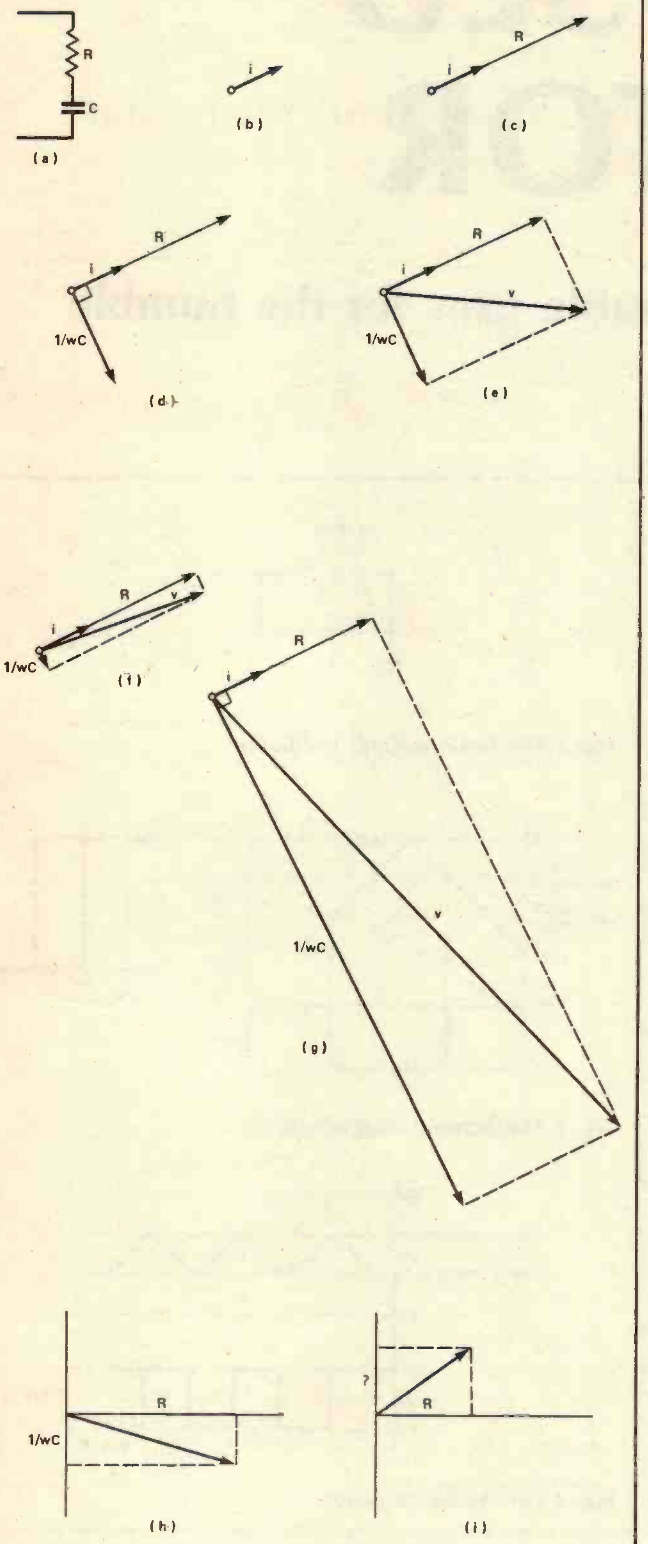


Fig. 2 Phasors to describe the voltage and current through a capacitor and resistor in series-(a). (b) The current phasor. (c) The phasor for the voltage across the resistor added. (d) The phasor for the voltage across the capacitor. (e) The phasor for the total voltage drop? (f)&(g) Differing overall voltage drops with different frequency. (h) Separating the 'resistance' of the resistor and capacitor. (i) Separate 'resistances' of a resistor and inductor.

waves, the machine is started up to spin all the rods around, still locked in the same angular relationship.

Since all the rods move in a complete circle for each cycle of the sine waves, we can put the first one in at any old angle. As long as the others are arranged at the correct angle to the first reference rod, the sine waves will all have the proper phase relationship.

Let's begin with the current phasor for Fig. 2a. Just to make the calculations easy, we'll give it a length of 1, making the current waveform peak at 1A. Quite a lot really but imaginary components don't burn so it should be OK. The current phasor is shown in Fig. 2b.

The voltage across the resistor is an easy phasor to add. It will be in phase with the current and R times as long (Fig. 2c).

The voltage across the capacitor will have an amplitude of $1/\omega C$ and will lag the current by 90° so let's put that one in next (Fig. 2d).

Finally, we can work out the voltage across the whole circuit. It will be the sum of the capacitor and resistor voltage phasors (Fig. 2e).

The amplitude of the voltage is $\sqrt{R^2+1/\omega C^2}$ and since the current has an amplitude of 1A, this is also the effective resistance of the circuit to sine waves. It's not quite the same as the R + $1/\omega C$ we were hoping for!

The current in the circuit as a whole leads the voltage by somewhere between the 90° lead for a capacitor and the zero phase shift for a resistor. The contribution the capacitor makes to the phase shift varies with frequency. If the frequency increases, $1/\omega C$ becomes smaller and the circuit looks more and more like a resistor to the driving circuit (Fig.2f). For low frequencies the opposite is true and the circuit looks more like a capacitor (Fig.2g).

There's another trick we can do with this diagram. If someone gave us the voltage and current phasors of the circuit for a particular frequency, we could deduce the values of R and C.

If the current phasor was of unit length and assumed to be along the positive x axis, all we'd need would be the voltage phasor. The resistor's resistance would be the 'shadow' on the horizontal axis and the capacitor's 'resistance' (from which we could work out its value) would be the shadow on the vertical axis (Fig.2h).

What would we make of the voltage phasor shown in Fig.2i? Obviously the circuit can't be a resistor and capacitor because the voltage is leading the current. A resistor and inductor would do the trick.

It's usual to split the apparent sine wave 'resistance' of a circuit into two parts. The part that gives a voltage in phase with the current (the shadow on the horizontal axis) is the *resistance*, the part that gives a 90° phase shift (the shadow on the vertical axis) is the *reactance*. The sum of the two is called the *impedance*. Resistance and reactance are both measured in ohms.

To distinguish between phase lead and phase lag, the capacitive type of reactance, where the voltage lags the current, is given a negative sign. The reactance of a capacitor (X_c) is $-1\omega C$. The inductive type of reactance (voltage leading current) is given a positive sign. The reactance of an inductor is ωL.

The impedance of any combination of resistors, capacitors and inductors can be split into reactive and resistive components and so they will appear to the driving circuit to be a resistor and an inductor or capacitor. In general the *driving point impedance* will change with frequency in a way that can't be matched by a pair of components, so the idea is not quite so useful as reducing a resistor network to a single resistor. Having said that, it is often useful to know how the driving point impedance changes with frequency, so we'll have a look at that next month.

ETI

THE UNUSED OSCILLATOR

Neville Croucher finds innumerable uses for the humble CMOS Schmitt trigger gate.

An oscillator is one of the most common building blocks in electronics. There are hundreds of different designs ranging from atomic references to simple RC circuits. Ever since the introduction of the 555 timer many years ago millions have been used, along with the newer generation of low power equivalent devices. However, there are another couple of ICs which offer a choice of either four gated or six free running oscillators. Combined with the extremely low power consumption and near perfect output characteristics these must be among the most underused devices available.

The devices in question are the CMOS 4093 quad NAND gate and the 40106 hex inverter. What makes these special is that the inputs use Schmitt trigger switching and while most designers are aware of the application of these as a waveform shaper it is not always known how easy it is to produce an oscillator out of just one of these gates as shown in Fig. 1.

To understand why the circuit works it is necessary to understand what happens in a Schmitt trigger circuit. Figure 2. illustrates the schmitt action.

When the input voltage rises above the upper threshold point, the output changes from a high to a low level. However, as the voltage falls below the upper threshold the output does not change until the lower threshold point is reached. This affect is called hysteresis and the symbol used to represent a Schmitt trigger is a representation of a hysteresis loop.

Once the action of the Schmitt is understood, it is easy to appreciate the operation of the oscillator. When the supply is first connected the capacitor will be discharged and so the input voltage will be zero (Fig. 3). This will cause the output to go high and so the capacitor will start to charge through the resistor. When the voltage on the capacitor reaches the upper threshold voltage at point 1, the output will then go low and the capacitor voltage will fall. When the capacitor voltage reaches the lower threshold voltage point 2, the output will go high and the action continues indefinitely.

It will be noticed that the time from start to point 1 is longer than that from 2 to 3 but this only occurs on the first cycle.

The frequency of the oscillator is dependent on the threshold voltages and the values of the timing components. Because the output voltage and the threshold voltages are *both* dependent on the supply, the actual frequency is difficult to predict as the threshold levels vary from one device to another although as a rough guide the complete time period is approximately equal to the time constant RC.

For a frequency of 1kHz a good starting value would

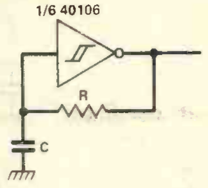


Fig. 1 The Basic Schmitt oscillator.

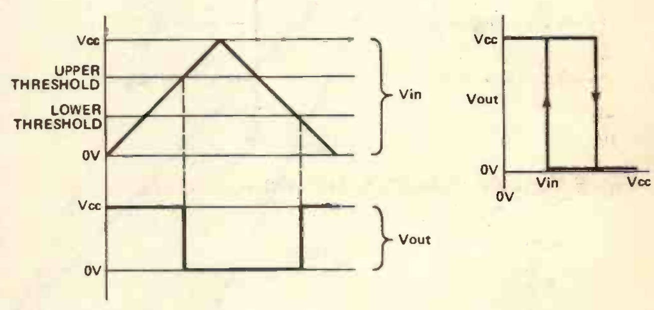


Fig. 2 The Schmitt trigger action.

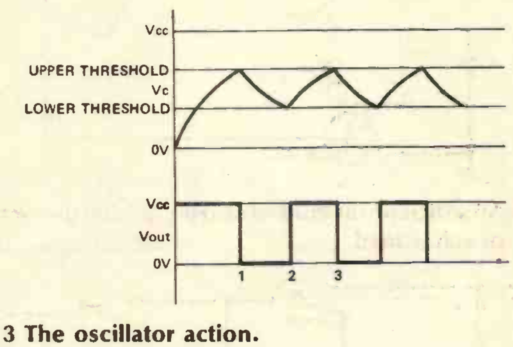


Fig. 3 The oscillator action.

be 100n and 10k. When choosing these values it is sensible to keep the resistor between 3k3 and 10M. The capacitor should ideally be chosen so that a resistor value between 10k and 100k can be used. If this is done there is plenty of tolerance in the resistor value to allow for fine adjustment if necessary.

If the oscillator is to be battery powered it is worth bearing in mind that the low power consumption available using CMOS is only an advantage if the rest of the circuitry is not going to take a lot of power. This will only be the case if quite high value resistors are used.

The pinout of the 40106 is shown in Fig. 4. This chip

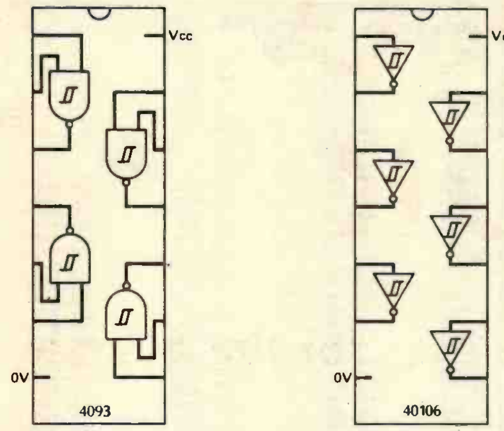


Fig. 4 Pinouts of the Schmitt trigger chips used.

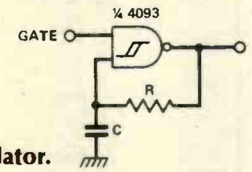


Fig. 5 A gated Schmitt oscillator.

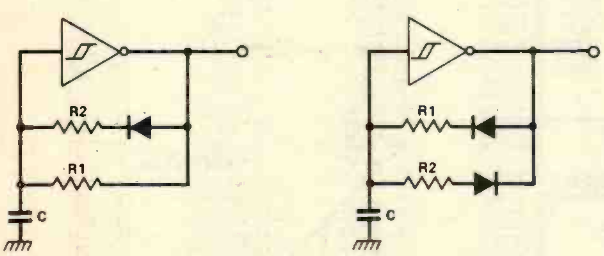


Fig. 6 Variable duty cycle Schmitt oscillators.

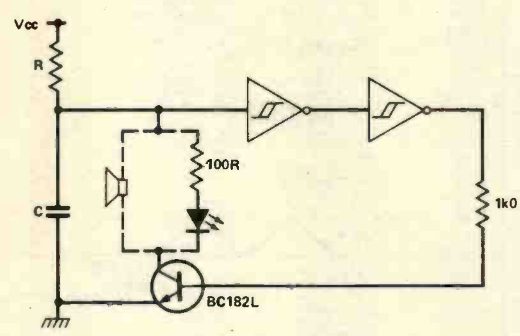


Fig. 7 An efficient method of driving a loudspeaker or other load.

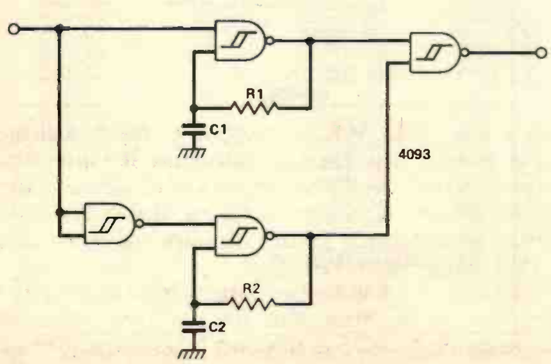


Fig. 8 A digitally selected two frequency oscillator.

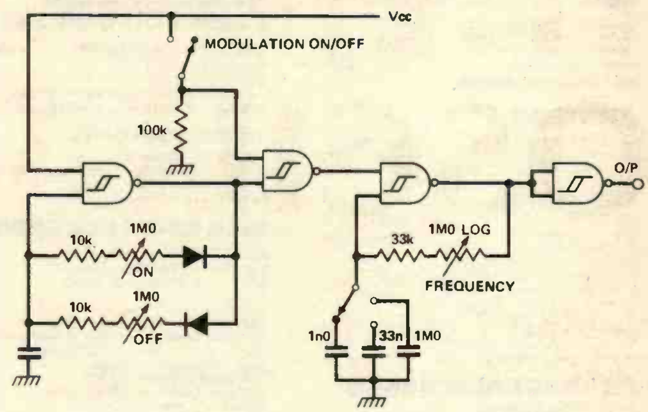


Fig. 9 A simple pulse generator built around a single chip.

contains six separate inverters and so six different oscillators can be made from one single chip. The 4093 is a quad NAND with Schmitt inputs which allows us to gate the oscillator very simply as shown in Fig. 5. When the gate input is connected to 0V the output of the gate is forced high and does not oscillate. When the gate input is taken high the oscillator is enabled. If the output is required to be low when the oscillator is off then the output should be inverted using one of the other gates in the package. As always with CMOS, unused inputs must be connected to either 0V or the supply.

With the oscillators shown so far the duty cycle is always 50%, allowing for tolerances within the device itself. If a different duty cycle is required this can be achieved in two ways as shown in Fig. 6.

In the first circuit, the capacitor is discharged only through R1. When the capacitor is charging the diode conducts and the resulting pulse width is dependent on R1 and R2 in parallel. If a short off period is required it is simply a case of turning the diode the other way.

In the second circuit the two time periods are each controlled by a separate resistor by use of the two diodes. R1 affects the high output and R2 affects the low output.

If the output is required to drive a loudspeaker or an LED it is possible to drive the output directly. If however a power efficient circuit is required, a useful technique is to use the stored energy in the capacitor to power the load. In Fig. 7 the capacitor charges from the supply through the resistor. When the upper threshold point is reached the transistor is turned on and the capacitor discharges through the speaker (or LED or whatever). In this way it is possible to build circuits for battery operation that consume a minimal amount of power.

Figure 8 shows a circuit which selects between two different output frequencies depending on whether the input is high or low. This is useful for applications requiring tone encoding for transmitting digital signals.

Finally, Fig. 9 shows a a simple but versatile pulse generator circuit. The output may be continuous or gated by the built-in modulator. The output frequency is in three ranges covering approx 1-33Hz, 33-1000Hz, and 1-33kHz. The modulation has separate on and off times, each variable between 10ms and 1s. The whole pulse generator uses just one chip!

With all of these circuits the aim is to show how simple to use and how versatile these devices are. They are intended as examples only but should give plenty of ideas for experimentation. **ETI**

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• 500K 40 T 48 TPI Cased with PSU & Leads	£105.00	£3.00
• 1MB 80 T 96 TPI Cased with PSU & Leads	£110.00	£3.00

3.50" FLOPPY DISC DRIVES		
1MB 135 TPI D/S Slimline	£75.00	£1.50
• 1MB 80 T 135 TPI Cased with PSU & Leads	£95.00	£3.00
• Twin 1MB 80 T 135 TPI Cased with PSU & Leads	£165.00	£5.00

DISC DRIVE ACCESSORIES

DISKETTES		
5.25" Double Sided/Double Density	£0.90	
3.50" Double Sided/Double Density	£2.00	
3" CF2	£3.99	
3" CF2DD	£5.00	
Regulated PSU (state 5.25" or 3.50")	£8.50	£1.50
5.25" Drive Case Takes 1 5.25" H/Height Drive	£9.00	£2.00
3.50" Drive Case Takes 2 3.50" Drives	£15.00	£2.00
Drive Interface Cable - Single	£5.00	£0.50
Drive Interface Cable - Double	£7.00	£0.50
5.25" Drive Case and PSU assembled - Takes 1 H/H Drive	£20.00	£3.00
3.50" Drive Case and PSU assembled - Takes 2 Drives	£24.00	£3.00

• Available In 110 & 220V Versions

MONO/COLOUR MONITORS

PHILIPS	Price (Ex VAT)
High-res Green screen monitor. Model No:BM7502	£72.50
High-res Amber screen monitor. Model No:BM7522	£77.50
IBM compatible (Green) with Leads. Model No:BM7513	£95.00
Dark glass, White screen monitor. Model No:BM7542	£77.50
MITSUBISHI - Colour	
Med. Res. BBC Compatible Model 1404	£232.00
Med. Res. IBM Compatible Model 1404E	£264.00
Med. Res. IBM Compatible + Colour Card Model 1404EC	£391.00
HANTAREX	
SPECIAL OFFER HX12 HI-RES MONO GREEN	£65.00
CT9000 MED RES 14" COLOUR RGB, RGB1	£179.95
MODEMS	
Nightingale plus Comstar software	£120.00
Answer call mini modem MD101, V21	£73.00
Miracle Technology WS2000 V21,V23	£95.00
Miracle Technology WS3000 V21,V23 AA AD	£275.00
Miracle Technology WS3000 V22,V21,V22 AA AD	£471.00
Miracle Technology WS3000 V22BIS,V22,V21,V23 AA AD	£595.00

NB: Please add £3.00 P and P per Single Drive, and £5.00 P and P per Dual Drive
Please add £7.00 delivery on Monitors, £3.00 on Modems

SPECIAL OFFER

5¼" 500K DS/DD MITSUBISHI DISC DRIVE	£75.00
5¼ IMB DS/DD MITSUBISHI DISC DRIVE	£80.00
PHILIPS 8833 COLOUR MONITOR with BBC lead	£225.00

D type CONNECTORS

PLUGS way	9	15	25	37
SOLDER	0.45	0.60	0.90	1.25
PCB	.65	.75	1.05	-
PCB R/A	.95	1.50	2.05	-
SOCKETS				
SOLDER	.65	90	1.25	2.00
PCB	.75	1.10	1.75	-
PCB R/A	1.30	1.90	2.60	-
COVERS	.60	.65	.68	.80
IDC PLUG	3.15	3.75	3.00	-
IDC SOCKET	3.40	3.90	3.00	-

RIBBON CABLE

per metre	Grey	Colour
10 way	0.40	0.70
16 way	0.65	1.10
20 way	0.80	1.30
26 way	1.00	1.70
34 way	1.35	2.30
40 way	1.65	2.60
50 way	1.95	3.30
64 way	2.80	4.20

CENTRONICS CONNECTORS
36w IDC Plug 2.95 Skt 4.10
36 way Plug Solder 3.00

IDC CONNECTORS

	SKT	PCB Plug	R/A Plug	EDGE Plug
10 way	0.61	0.65	0.65	
16 way	0.70	0.85	0.85	
20 way	0.88	1.10	1.10	
26 way	0.98	1.20	1.20	
34 way	1.12	1.50	1.50	3.20
40 way	1.35	1.65	1.65	
50 way	1.65	2.50	2.50	

PRINTER LEADS

Memotech	8.50	QL	6.85
Amstrad	8.80	Dragon	7.95
		BBC	7.40

MODULATORS
UM1286 2.00
UM1233 3.00

HEADER PLUGS
DIL IDC
14 PIN 0.72 28 PIN 1.43
16 PIN 0.80 40 PIN 1.95
24 PIN 1.10

DIL SWITCHES
4 way 0.68 8 way 0.80
6 way 0.75 10 way 0.95

74LS & 74F

		74LS175	0.50	74LS368	0.35	74F74	0.40
		74LS181	1.80	74LS37	0.18	74F85	1.95
74LS374	0.65	74LS182	2.00	74LS373	0.65	74F125	1.05
74LS00	0.17	74LS183	1.50	74LS378	0.75	74F138	1.05
74LS02	0.18	74LS190	0.55	74LS38	0.18	74F161	2.95
74LS03	0.18	74LS191	0.65	74LS390	0.50	More available	
74LS04	0.17	74LS192	0.65	74LS393	0.45		
74LS08	0.18	74LS193	0.65	74LS395A	0.90		
74LS09	0.18	74LS194A	0.65	74LS40	0.18		
74LS10	0.18	74LS196	0.55	74LS42	0.40		
74LS107	0.30	74LS197	0.65	74LS47	0.60		
74LS109	0.30	74LS20	0.65	74LS48	0.60		
74LS11	0.18	74LS21	0.18	74LS49	0.90		
74LS112	0.30	74LS22	0.18	74LS51	0.20		
74LS113	0.30	74LS240	0.70	74LS54	0.20		
74LS114	0.30	74LS241	0.70	74LS541	0.90		
74LS122	0.35	74LS242	0.70	74LS55	0.20		
74LS123	0.40	74LS245	0.70	74LS640	1.35		
74LS125	0.30	74LS244	0.60	74LS641	1.25		
74LS126	0.30	74LS247	0.60	74LS642	1.20		
74LS12	0.18	74LS248	0.90	74LS643	1.75		
74LS132	0.35	74LS249	0.90	74LS644	1.75		
74LS133	0.35	74LS251	0.45	74LS645	1.75		
74LS136	0.28	74LS253	0.50	74LS668	0.80		
74LS137	0.70	74LS256	0.80	74LS669	0.80		
74LS138	0.30	74LS257	0.45	74LS670	1.30		
74LS139	0.30	74LS258	0.45	74LS673	7.50		
74LS13	0.28	74LS259	0.80	74LS674	7.50		
74LS14	0.40	74LS26	0.18	74LS682	2.35		
74LS145	0.80	74LS260	0.60	74LS684	2.75		
74LS147	1.10	74LS266	0.22	74LS685	2.75		
74LS148	1.00	74LS27	0.18	74LS686	5.00		
74LS15	0.18	74LS273	0.65	74LS687	2.75		
74LS151	0.45	74LS279	0.50	74LS689	2.75		
74LS153	0.55	74LS280	1.60	74LS73	0.28		
74LS155	0.45	74LS283	0.60	74LS74AN	0.22		
74LS156	0.45	74LS290	0.70	74LS75	0.27		
74LS157	0.45	74LS293	0.70	74LS76	0.27		
74LS158	0.45	74LS295	1.10	74LS78	0.27		
74LS160	0.50	74LS298	0.95	74LS83	0.45		
74LS161	0.50	74LS299	2.00	74LS85	0.55		
74LS162	0.55	74LS30	0.18	74LS86	0.28		
74LS163	0.50	74LS32	0.18	74LS90	0.30		
74LS164	0.50	74LS322	3.00	74LS92	0.40		
74LS165	0.80	74LS323	2.75	74LS93	0.35		
74LS166	0.75	74LS33	0.22	74LS95B	0.50		
74LS168	1.20	74LS352	1.00	74LS96	0.75		
74LS169	0.75	74LS353	0.80	74F00	0.38		
74LS170	1.00	74LS365	0.35	74F02	0.38		
74LS173	0.60	74LS366	0.35	74F10	0.38		
74LS174	0.50	74LS367	0.35	74F14	0.75		

7430	0.30	7446	0.85	7486	0.60
74367	0.75	7448	1.40	7490A	0.50
7438	0.35	7450	0.25	7491	0.60
7440	0.30	7470	0.90	7492	0.30
7441	0.60	7474	0.36	7493	0.50
7442	0.62	7475	0.45	7494	0.85
7443	0.90	7476 + 7485	0.90	7496	0.60

TTL74

7400	0.22
7401	0.22
7402	0.22
7404	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.25
7410	0.30
74100	2.20
74114	0.20
7412	0.25
74121	1.75
74123	0.65
7413	0.35
7414	0.60
74141	0.70
74147	1.50
74153	0.65
74155	0.68
74157	0.99
74159	1.50
74160	0.80
74161	0.80
74163	0.85
74165	0.85
7417	0.40
74170	1.55
74173	0.99
74174	0.88
74180	0.85
74181	2.00
74182	0.80
74184	1.56
74188	2.10
74190	1.05
74191	2.00
74193	1.20
7420	0.30
7422	0.30
74251	1.10
74284	2.50

TRANSISTORS

AC128	0.30	BF200	0.35	MPSA55	0.25
AC142	0.33	BF244	0.35	MPSU05	0.50
AC176	0.25	BF256B	0.45	TIP29A	0.32
AC187/8	0.23	BF257/8	0.40	TIP29C	0.32
AD149	0.75	BF259	0.30	TIP2955	0.50
AD161	0.40	BF324	0.25	TIP30	0.32
AD162	0.40	BF336	0.30	TIP30C	0.36
AF124-127	0.55	BF337	0.35	TIP3055	0.50
AF139	0.38	BF421-423	0.22	TIP31A	0.45
AF239	0.50	BF469-472	0.40	TIP31C	0.40
BC107B-110	0.11	BF870-872	0.30	TIP32A	0.45
BC114	0.20	BFR41	0.22	TIP32C	0.40
BC140	0.30	BFR51	0.20	TIP33C	0.85
BC147-159B	0.12	BFR90	0.30	TIP34A	0.80
BC170	0.07	BFR91	0.75	TIP34C	0.90
BC182-239C	0.09	BFR94	0.88	TIP36	1.25
BC256A	0.30	BFX29	0.28	TIP41A	0.45
BC307B-338	0.20	BFX84	0.33	TIP41B	0.50
BC441/461	0.33	BFX85	0.45	TIP42A	0.50
BC477	0.20	BFX87/88	0.45	TIP42B	0.50
BC516/7	0.30	BFY17	0.30	TIP42C	0.50
BC547B-559	0.11	BFY41	0.30	TIS90	0.20
BD124P	0.85	BFY50	0.30	TIS91	0.30
BD131	0.50	BFY51	0.30	2N2219A	0.27
BD132	0.50	BFY52	0.33	2N2221A	0.27
BD133	0.48	BFY90	0.76	2N2368	0.24
BD135	0.45	BSX20/21	0.25	2N2369A	0.15
BD136-140	0.30	BSX26	0.30	2N2483	0.22
BD245B	0.55	BSX29	0.30	2N2646	0.55
BD517	0.70	BU104	1.70	2N2904A	0.25
BF115	0.40	BU105	1.50	2N2906/7	0.25
BF154	0.25	BSY95	0.35	2N2926	0.11
BF167	0.30	BUY69	2.10	2N3053	0.25
BF177	0.30	MJE2955	0.98	2N3054	0.55
BF178	0.35	MJE3055	1.60	2N3055	0.48
BF181	0.25	MJE340	0.38	2N3819	0.35
BF184	0.30	MJE370	0.95	2N3904	0.15
BF185	0.30	MJE520	0.45	2N3905/3906	0.15
BF196	0.13	MJ2955	0.50	3N128	0.99
BF197	0.18	MJSA05	0.35	MANY MORE	
BF198/9	0.16	MPSA12	0.35	AVAILABLE	

LINEAR ICs

AY-3-1014A	2.75
AY-3-1015D	2.75
AY-3-8470	2.00
AY-3-8475	3.00
AY-3-9710	3.15
AY-3-9725	4.00
CA3011	1.10
CA3018	0.75
CA3028A	1.00
CA3046	0.60
CA3052	1.90
CA3054	1.00
CA3065	2.00
CA3080A	2.00
CA3080E	0.55
CA3085	1.30
CA3088	0.50
CA3088E	2.00
CA3089Q	2.00
CA3090AQ	2.30
CA3100S	2.00
CA3130E	0.75
CA3140T	0.70
CA3161E	1.50
CA3162E	5.00
CA3189E	2.25
CA3193E	1.50
CA3240E	0.90
CA3260E	2.50
CA3290E	1.10
HA1366W	1.70
LA3300	1.90
LA4032P	2.45
LA4400	3.50
LA4420	2.25
LA4422	3.20
LA4461	3.50
LC7120	3.00
LC7130	3.00
LC7131	3.00
LM1889N	2.50
M51513L	2.00
M51515L	3.00
MB3712	1.80
MC1315P	2.90
MC1330P	1.90
MC1349P	1.50
MC1460G	2.90
MC1463R	4.80
MC1469R	3.00
MFC6040	0.90
ML237B	2.50
ML238B	4.50
NE535T	1.10
NE5501N	0.90
NE5534N	1.00
SAB3209	3.75
SN76008N	2.25
SN76110N	1.20
SN76115AN	1.60
SN76131N	1.25
SN76396N	1.65
SN76600P	1.30
SN76660N	0.80
SN76707N	2.10
SN76708N	1.30
TA7204P	1.30
TA7205AP	0.90
TA7208P	1.30
TA7222P	1.30
TA7310P	1.30
CA3020	2.00
HA1388	2.50
LM1357P	1.95
LM301AN	0.30
LM310N	2.40
LM311	0.45
LM319	1.50
LM324N	0.35
LM339N	0.35
LM348N	0.55
LM358N	0.45
LM380N-14	0.80
LM381	1.50
LM3900	0.45
LM558	1.60
LM710CN	0.90
LM711CN	0.90
LM741	0.50
LM747CN	0.80
MB3756	4.00
NE555	0.20
NE556	0.55
NE566	1.30
TBA120S	0.80
TBA920	1.75
TDA1011	2.00
TDA1022	4.00
TDA2006	3.10
TDA2190	2.40
TDA2591	2.75
TDA2670	1.50
TL071CP	0.38
TL072CP	0.60
TL074CN	1.00
TL081CP	0.30
TL082CP	0.50
TL084CN	0.90
TBA990Q	2.75
TC9100	7.50
TC9109P	7.50
TCA270SB	3.00
TCA650	3.50
TCA660B	3.50
TCA740	2.40
TCA900	1.90
TCA910	1.90
TDA1003A	1.90
TDA1035T	2.50
TDA2002	2.75
TDA2010	3.00
TDA2030	1.80
TDA2522	2.50
ZN425E8	3.40
ZN426E8	2.90
ZN427E	5.90
ZN428E8	4.40
ZN447E	8.75
ZN449E	2.90
ZN435E	5.00

COMPUTER ICs

1691	12.00
1770	20.00
1772	15.00
1793	15.00
2793	15.00
2797	15.00
6502A	4.25
6551A	5.50
6522A	4.00
6800	2.00
6802	2.60
6803	8.25
6808	5.00
6809E	6.50
6810	1.50
6818	3.90
6820	1.50
6821	1.50
6840	3.70
6845	5.50
6847	6.25
6850	1.10
6852	2.40
6854	6.25
68000	14.00
76489	2.50
8035	3.15
8080A	4.15
8085A	2.75
8088	9.75
8131	4.50
8155	3.50
8156	3.50
8212	1.50
8214	4.75
8216	1.50
8224	2.90
8226	2.90
8228	3.00
8243	2.80
8251A	3.25
8253	3.25
8255	3.50
8256A	11.00
8257-5	3.90
8259	3.90
8271	32.00
8272	12.00
8272A	14.00
8283	4.40
8284	5.25
8288	10.00
8T26A	0.90
8T27	1.45
8T28	1.75
8T31	3.45
8T95	0.85
8T97	0.85
8T98	1.40
8748	12.00
9216	12.00
MC1488	0.65
MC1489	0.65
MC3242	6.50
MC3446	2.25
MC3447	3.00
MC3486	2.15
MC3487	2.15
Z80ACPU	2.00
Z80BCPU	7.50
Z80ACTC	2.00
Z80ADART	7.00
Z80ADMA	8.25
Z80APIO	2.75
Z80ASIO	8.00
Z80ASIO-1	8.00
Z80ASIO-2	8.00
ULN2002	0.70
ULN2003	0.70
ULN2004	0.70
TMS9901	5.75
TMS9902	5.95
TMS9914	16.00
TMS9918	10.00
TMS9928	5.00
TMS9929	5.00

MEMORIES

62256P15	12.50
2114-2	2.75
2716-350N/S	4.25
2732-450N/S	4.25
2732A-200	5.00
3732-2 32K	1.25
2764-25	3.25
27C64-25	6.50
27128-200	4.00
27128-250	3.50
27256-25	4.25
4116-3	0.75
27512-25	19.00
4164P-15	1.85
41256-15	2.95
27512-25	9.00
50256-12	4.50
6116LP3 150N/S	2.00
6116P4 200N/S	2.00
HM6264LP12	4.00
HM6264LP15	3.00
TC5501P	4.00
TC5514AP3	2.95
TC5516APL2	2.90
TC5517BP	2.95
TC5565PL15	3.55
UPD41464C-15	8.00

DIODES

AA119	0.08
AA129	0.10
1N4001	0.04
1N4002	0.04
1N4003	0.05
1N4004	0.05
1N4005	0.05
1N4006	0.06
1N4007	0.06
1N4148	0.02
1N5401	0.10
1N5402	0.10
1N5404	0.12
1N5406	0.14
1N5408	0.17
OA47	0.14
OA90	0.10
OA91	0.13
1S941	0.07

XXX—AMSTRAD—XXX
20MB Hard Disc system to suit PC1512 series Micro
£475
price includes VAT and delivery
For further details contact Electro Mech Limited

79L05	0.33
79L08	0.40
79L12	0.33
79L15	0.40
79L24	0.80
7918	0.40
7924	0.40

74HC & 74HCT

HC00	0.28
HC02	0.28
HC03	0.28
HC04	0.28
HC08	0.28
HC107	0.35
HC109	0.40
HC10	0.28
HC112	0.40
HC113	0.40
HC11	0.28
HC125	0.40
HC126	0.40
HC132	0.70
HC133	0.70
HC137	0.70
HC138	0.70
HC139	0.70
HC14	0.70
HC153	0.70
HC158	0.50
HC160	0.80
HC161	0.80
HC162	0.80
HC165	0.85
HC173	0.80
HC174	0.80
HC175	0.80
HC194	0.80
HC195	0.80
HC240	1.00
HC241	1.00
HC242	1.00
HC244	1.00
HC245	1.00
HC257	0.80
HC266	0.70
HC273	1.00
HC32	0.35
HC390	1.00
HC393	1.00
HC42	0.50
HC51	0.28
HC534	1.00
HC540	2.00
HC541	2.00
HC74	0.50
HC75	0.50
HC85	1.00
HCT240	1.75
HCT241	1.75
HCT244	1.50
HCT245	2.20
HCT640	2.40

CRYSTALS

32.768 KHz	0.95
100.0 KHz	4.00
1 MHz	2.65
1.8432 MHz	1.90
2.0 MHz	2.00
2.4576 MHz	1.75
2.5 MHz	1.90
3.0 MHz	2.00
3.2768 MHz	1.30
3.579545 MHz	0.90
3.6864 MHz	1.70
4.00 MHz	1.20
4.194304 MHz	1.30
4.433619 MHz	0.90
4.9152 MHz	1.20
6.00 MHz	1.30
6.144 MHz	1.30
6.5536 MHz	1.30
7.159 MHz	1.30
7.3728 MHz	1.50
8.0 MHz	1.30
10.0 MHz	1.50
12.00 MHz	1.30
15.00 MHz	1.75
16.0 MHz	1.75
18.432 MHz	1.30
20.0 MHz	1.75
32.00 MHz	1.30
36.00 MHz	1.30
48.00 MHz	1.30

VOLTAGE REGS

7805	0.35
7808	0.35
7808CK	0.56
7812	0.35
7815	0.35
7815CK	0.56
7818	0.35
7824	0.38
78L05	0.30
78L08	0.45
78L12	0.30
78L15	0.30
78L24	0.65
7905	0.40
7908	0.40
7912	0.40
7915	0.40

CMOS

4000	0.18
4001	0.18
4002	0.18
4006	0.60
4007	0.18
4008	0.55
4009	0.35
40103	4.05
40104	1.10
40106	0.35
40105	0.50
40108	3.15
40109	0.90
4010	0.35
40110	2.15
40114	2.30
4011	0.18
4012	0.18
4013	0.25
4014	0.45
4015	0.38
40161	1.90
40163B	0.65
4016B	0.22
40174B	0.65
40175B	0.65
4017B	0.40
40181B	2.10
4018B	0.65
40192B	0.65
40193B	0.85
40194B	0.65
4019B	0.30
40106B	0.35
4020B	0.45
4021B	0.50
4022B	0.55
4023B	0.18
4024B	0.30
40257B	1.90
4025B	0.18
4026B	0.85
4027B	0.25
4028B	0.35
4029B	0.45
4030B	0.18
4031B	1.10
4033B	1.20
4034B	1.30
4035B	0.60
4038B	1.00
4040B	0.40
4043B	0.40
4044B	0.45
4045B	1.00
4046B	0.55
4047B	0.45
4048B	0.40
4049B	0.22
4050B	0.22
4051B	0.45
4052B	0.45
4053B	0.45
4054B	0.65
4055B	0.65
4056B	0.75
4060B	0.60
4063B	0.70
4066B	0.22
4067B	2.10
4068B	0.18
4069B	0.18
4071B	0.18
4072B	0.18
4073B	0.18
4075B	0.22
4076B	0.50
4077B	0.22
4078B	0.50
40813	0.18
4082B	0.18
4086B	0.55
4089B	1.10
4093B	0.22
4094B	0.65
4095B	0.65
4096B	0.95
4097B	2.50
4099B	1.00
4502B	0.45
4503B	0.40
4506B	1.05
4510B	0.45
4511B	0.45
4512B	0.45
4514B	1.05
4515B	1.05
4516B	0.45
4517B	2.60
4518B	0.45
4520B	0.45
4522B	1.10
4526B	0.65
4527B	0.55
4532B	0.60
4536B	2.25
4538B	0.65
4543B	0.60
4555B	0.40
4556B	0.40
4584B	0.35
4585B	0.60

DIL SOCKETS

TP Turned Pin LP Low Profile	LP	TP
8 PIN I.C. SOCKET	0.05	0.20
14 PIN I.C. SOCKET	0.07	0.35
16 PIN I.C. SOCKET	0.08	0.38
18 PIN I.C. SOCKET	0.09	0.43
20 PIN I.C. SOCKET	0.10	0.48
24 PIN I.C. SOCKET	0.13	0.52
28 PIN I.C. SOCKET	0.14	0.55
40 PIN I.C. SOCKET	0.18	0.85
24 PIN ZIF	4.16	
28 PIN ZIF	4.87	
40 PIN ZIF	7.02	

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DESIGNING FOR EFFICIENCY

Switching on a switch mode power supply isn't as easy as it sounds. Les Sage explains why.

The operating principles and the various waveforms found in modern switch mode power supplies (SMPS) were described in last month's article. A number of design problems were highlighted, and we will now see how modern thinking has managed to overcome these problems to produce SMPS offering very high efficiencies and high reliability.

Switch On

Now that the normal running operation is understood it is necessary to look at what happens at switchon. As we know, very little dissipation occurs in the transistor when it switches on provided there is zero energy (a small step in the collector waveform) in the transformer. The collector current begins to ramp upwards linearly at the rate of $I = tV/L$ (where I is in amps, t in seconds, V in volts and L in Henrys). As this forward phase is storing energy in the core no output voltage will occur. The feedback loop detects this and treats it as a heavy output load requiring more input energy, so the control signal to the drive circuit continues to increase the on-time still further.

The point is that there will never be any output whilst the chopper transistor is conducting because energy is only transferred to the output when the transistor switches off. The feedback loop is in fact holding off the output energy so long as it senses low or zero output volts. The net result is that the collector current continues to rise until the core saturates. With a saturated core the inductance disappears, the transistor comes out of saturation and exceeds its safe operating area (SOAR) turning into a now useless piece of scrap metal. The feedback loop essential for normal correct operation has in fact destroyed the transistor at switch on. This also happens should the output be short-circuited or if the mains input level falls dramatically (brownout), all resulting in long on-times destroying the chopper transistor.

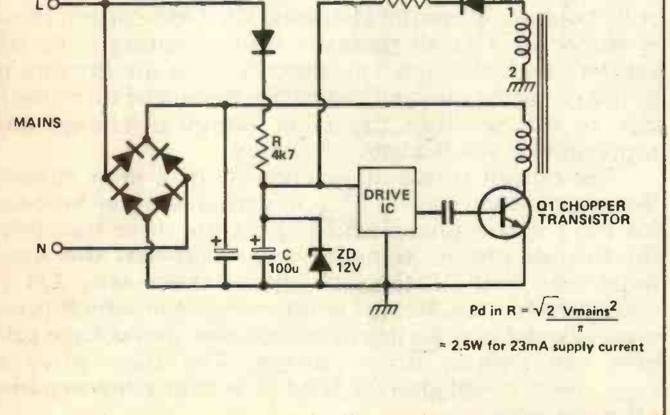


Fig.1 Start-up power for the SMPS is derived from the mains via R, C and ZD. Once normal operation is established, the power can be taken from winding on the transformer (1, 2).

There are two important points to get right regarding these problems. The first is that the drive circuit must be free-running (ie. self oscillating) with a frequency sufficiently low to ensure that the free running period is greater than the maximum on-time plus the off-time required under worst case conditions, this occurring at maximum output power and minimum mains voltage.

The second point is that at first switch on, only short, low repetition rate pulses should be available. These are not under loop control and serve to establish a small output potential. If this potential does not appear the logic circuitry detects this and provides the PSU with a very short, safe, pulse width which can be maintained indefinitely. This is the short circuit protection mode.

If the small output potential does appear, then the pulse width is gradually increased until at a threshold point a flipflop switches control over to the normal feedback loop. Normal regulatory operation is now resumed, although circuitry is normally included to continuously monitor the input mains and the output DC. If the mains falls below a predetermined level (undervoltage lockout) then the protection cycle is re-entered.

This type of circuitry is not normally built in discrete component form although some manufacturers have tried. There are several modern integrated circuits which perform all the functions required, although a lot of ICs are only basic types which lack some or all of the features discussed. Throughout this article I will at times refer to discrete circuitry in an attempt to give a fuller and more easily understandable explanation.

A Supply For A Supply

Drive circuitry can be quite complex, including linear and logic circuits, and all this circuitry will need its own power supply at, say, 12V.

It would be silly to include a separate 50Hz mains transformer to supply 12V for the drive circuitry. It would be nice if the drive and control circuit could be driven off the mains direct via a dropper resistor and zener.

The problem is that although modern technology allows us to build all sorts of logic and linear circuitry with a total consumption of only several milliamps, the switching transistor itself requires much higher base currents. As an example, a typical 150W switcher operating at 30kHz would have a transistor collector peak current of

$$I_c = 2.P_o/V_s.T_{on}.f = 3.6 \text{ amps max.}$$

High voltage, high frequency chopper transistors with low Vsat characteristics are notoriously very low gain. A BU208A for instance has a current gain of just 3 at 3.6 amps, requiring over 1A base current to remain in

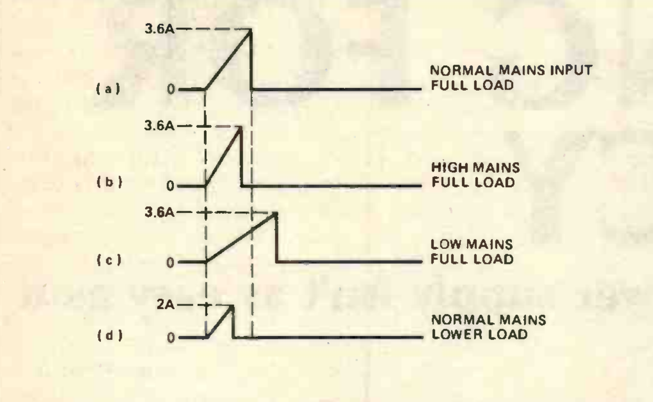


Fig.2 The collector current ramp varies with input voltage and load, and the base drive must closely match the height and angle of this ramp.

saturation. To supply 1A base current direct from the mains is clearly impractical.

Earlier it was stated that the initial turn on phase uses very short pulses to establish correct operation. Figure 1 shows that power for this can be obtained initially from the mains via a dropper resistor storing charge on a decoupling capacitor. This capacitor then supplies the required short high current ouput drive pulses required by the transistor's base. As soon as the PSU has established an output voltage, this output voltage itself can supply the power required to fully drive the chopper transistor under normal conditions. This scheme is almost universally adopted.

Collector Current Proportionality

It has been stated a few times that the key to modern SMPS design lies in the base drive. We haven't quite finished with drive yet as there is one more very neat trick used to give quite a substantial increase in overall efficiency. This is called collector current proportionality and is achieved in a surprisingly simple way.

The normal DC power supply for most ICs is 12V. Much less than this and the control loop comparator will have insufficient headroom for complete control. However we have already seen that the chopper transistor requires around 1A base current to fully saturate in a typical application. Even though this current is supplied by the SMPS transformer itself, 1A at 12V is 12W wasted as heat, and this is almost 10% of the maximum output.

Worse still, if the IC is to drive the chopper transistor direct (for low parts count) all this 12W drive power is dissipated within the IC, requiring an expensive 'power package' device. Figure 2 shows that the collector current rises linearly with time, starting from zero and reaching a maximum of 3.6A at the turn off point. It follows that it's not necessary to supply the full 1A base current all the time. 1A is required only at the end of the conduction on-time phase. If the base current is therefore made to rise linearly as well as the collector current, with just enough current to maintain the transistor in saturation, a considerable saving in drive power and IC dissipation will result.

A typical value would be around 1.5W compared to 12W, allowing a low-cost copper leadframe-type DIL IC to be used.

Collector Current Simulation

The base current must ramp upwards exactly in line with the collector current, otherwise the transistor may never saturate resulting in very high chopper dissipation. The problem is that the collector current varies from condition to condition. Figures 2a-c show the collector current for various loads and mains input voltages.

It is therefore necessary to vary the base current ramp in proportion to the collector current. The collector current cannot itself be monitored very easily since the collector is busy swinging up and down from 0 to +800V. The emitter current is not a reliable means of collector current monitoring since it includes the base current and this is not constant since hFE varies with current and saturation level.

A simple piece of circuitry designed to simulate the collector current is used. Since the collector load is almost a pure inductor the collector current is proportional to the supply voltage Vs with respect to time. It is only necessary to monitor the supply voltage and to integrate this over a time period to determine the actual collector current at any given moment. This can then be impressed upon the base current drive, giving a base current proportional to the actual collector current which will increase or decrease with supply variations,

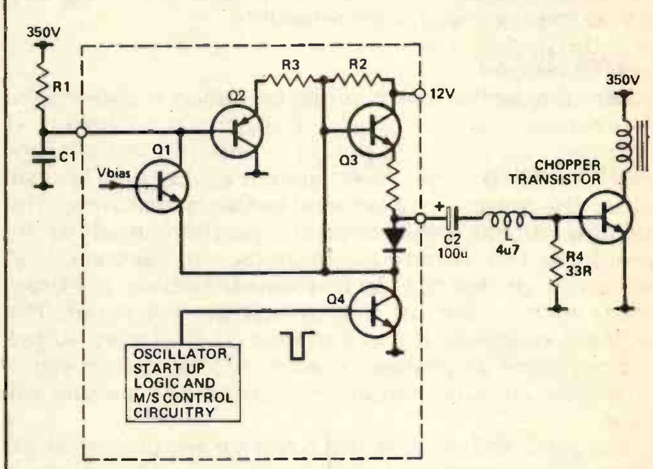


Fig.3 Basic elements of a drive circuit incorporating collector current simulation. R1, C1, Q1 and Q2 monitor and integrate the supply voltage while R2 and R3 shift the DC level before feeding it to the totempole output stage, Q3/Q4. Output coupling capacity C2 provides a negative off-drive signal and R4 is included to increase the Vceo to Vcer. The circuitry within the dotted lines would normally be contained within an IC.

and load on-time variations exactly following the collector current variations.

A discrete circuit block achieving this for those intrigued is shown in Fig. 3 while Fig. 4 indicates the collector/base current waveforms. The base current ramp is stood on a small pedestal thus ensuring collector saturation at all times. The short spike at the beginning of the collector current just as the transistor turns on is due to the snubber capacitor energy discharge and represents a small waste of energy.

The output driver stage consists of a high current 'Totempole'style stage (Q2) acting as an emitter follower for the forward phase whilst Q3 is the drive transistor for the off phase. Remember we said that the most important time is the off phase: that's why Q3 is configured as a common emitter amplifier which turns on very quickly since it provides current and voltage gain over the control drive current. The base drive is capacitively coupled to the base so as to give the required off drive potential.

The on phase, controlled by Q2, is actually very slow compared to collector current, so Q2 acting as an emitter follower will follow the signal at its base without adding voltage gain. The output stage then satisfies the earlier

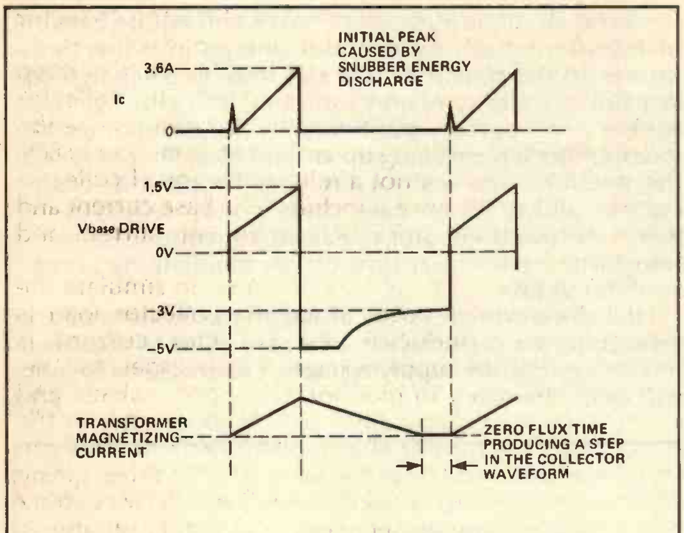


Fig.4 Typical waveforms in a proportionality SMPS.

exacting requirements. Also shown in Fig. 4 for the first time is the transformer's magnetizing current and as can be seen it returns to zero on each phase creating the now familiar step in the collector waveform.

Zero Energy Switching

The ideas put forward so far have enabled the development of a very efficient, low cost and very reliable SMPS of the type most common nowadays. There's one more significant and quite recent development which can

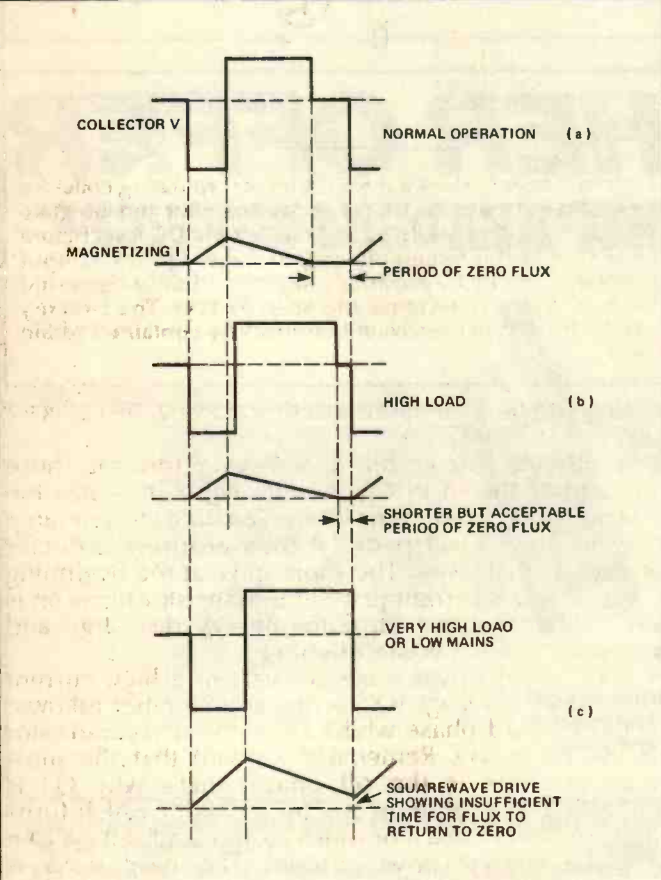


Fig.5 A comparison of collector voltage and magnetising current waveforms for various load conditions.

further improve the efficiency and reliability. Fig. 5a shows the now familiar collector waveform with a small step time and also the transformer's magnetizing current. It soon occured to designers that this step time was actually wasted time, time in which nothing at all is happening.

Unfortunately it is required for regulation in a fixed frequency SMPS and varies inversely with load/line variations. Figures 5 b,c show the variation of this time, and the effect on magnetizing current for changes in load. Note particularly Fig. 5c which shows a squarewave collector voltage without step time and indicates the result. The effect is that the magnetizing current has not returned to zero, and you will recall that this straightforward squarewave drive leads to unreliability.

However, if the maximum load occurs where the step time and the flux just tend to zero, maximum switching efficiency occurs. The reason for this is twofold. First, at all times action is occuring, so time is not wasted by concentrating the switching into a shorter time period than necessary. Secondly, at the step corner there is zero energy, so switching on at this moment could in theory result in zero switching dissipation.

If the circuit is still to be capable of regulation it is necessary to have circuitry which detects this zero energy point (termed zero crossing on the voltage waveform). A signal must be sent to the control circuit telling it, regardless of what it thinks, that it's now time to switch on the chopper transistor. The result will be a shorter overall time period (ie, higher frequency operation) but successive cycles will shorten the on-time to maintain the correct output energy. As the load varies the overall period/frequency varies to maintain regulation and, ensure that switch on always occurs at the zero energy point.

Since the on and off times are now no longer fixed, the frequency varies with load and line variations. The SMPS cannot, as in fixed frequency units, be synchronised to an external clock, so it is termed non-synchronous. In practice we find that for varying output loads the mark-to-space ratio remains virtually constant whilst the frequency varies inversely with load level (ie., high loads = low frequency). For mains line input variations we find that the frequency remains fairly constant but the mark-to-space ratio varies in proportion to the input volts. This continuous, complex variation of both mark-to-space and frequency ratio whilst maintaining continuous core magnetizaton is termed 'Mesh' operation.

These ideal waveforms do not occur in practice so we have to turn our attention back to the real switching waveform. At switch off it was stated that the snubber capacitor slows down the Vce dv/dt, improving transistor power dissipation in the all important off phase. This dissipation is traded for dissipation during the on phase since all the energy stored in the snubber has to be removed by the transistor prior to the following off phase.

Figure 6 shows the mesh waveform in more detail with the now familiar ringing due to transformer inductance and snubber/stray capacitance. The capacitor's stored charge is dissipated at the point of transistor turn on, but looking at the entire ringing waveform shows that it is a resonant circuit with the Tx inductance. In a resonant circuit energy is repeatedly cycled back and forth from the inductor to the capacitor. Looking at the first quarter cycle, point x is where all the capacitor's charge has been transferred to the transformer. If the transistor is driven on at this point there will be no energy in the capacitor to dissipate since it's stored in the transformer. Therefore it will be added to the following on-time energy storage phase. The resulting efficiency is extremely high due to the transistor switching on and off at the moment of zero energy.

The delay required between zero magnetic energy and zero snubber energy is normally quite small and fairly constant regardless of the load/line conditions. Therefore a simple short delay in the zero-crossing detector will allow for this.

To prove the validity of this technique it is quite simple to wire up a standard power supply with a fixed load and to vary the frequency via the sync input terminal whilst monitoring the collector waveform on a scope and also monitoring the mains input power. As the frequency is varied so that the switch on cycle occurs anywhere either side of point x (Fig. 6) for a given output load the input power will increase. Switching on early before zero core flux is reached causes large increases in input power and increased transistor temperature.

As no circuit is ideal, most SMPS will not be capable of transferring all the snubber energy into the transformer so the transistor will still have to discharge the remaining snubber energy indicated by x,y, in Fig. 13. To further improve transistor reliability the snubber usually incorporates a paralleled resistor and diode in series with the snubber. The resistor limiting the peak discharge current allows lower base drive power requirements whilst the diode ensures the capacitor conducts the full transformer current at turn off, so maintaining correct snubber action.

It is obviously necessary to design the inductance and total collector capacitance with care so as to maximise this energy transfer/switching cycle. Otherwise its benefits will easily be lost. **ETI**

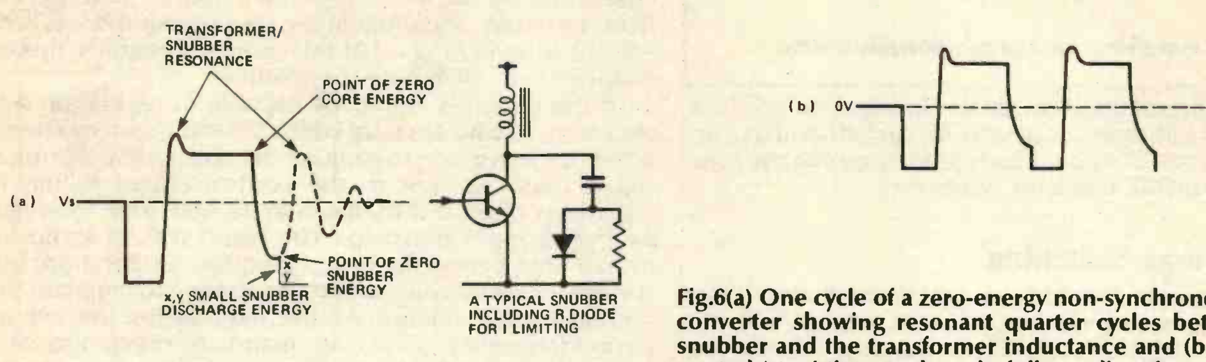


Fig.6(a) One cycle of a zero-energy non-synchronous mesh-converter showing resonant quarter cycles between the snubber and the transformer inductance and (b), without wasted 'step' time each cycle follows directly on from the preceding one and the frequency is thus under loop control.

THE DREAM MACHINE

Paul Chappell looks into the complexities of sleep and finds it can do with an electronic helping hand. This is such stuff as dreams are made of.

Free gift time has come around again and this year we've got something rather special for you — a dream machine! You will already have found the printed circuit board on this month's cover and next month there will be the components too.

Imagine this: you are in the middle of a particularly exciting adventure when you suddenly recognise it for what it is — a dream. Since it's a dream, you have the power to do anything you choose. You can go anywhere, do anything, break the laws of physics, defy social conventions — you have supreme authority! What will you do?

If you've ever had this experience, you may be interested to know it's not uncommon. In the psychology trade these are known as 'lucid dreams'. They often occur spontaneously during nightmares — suddenly you realise that nothing in real life could be quite so bad, so you must be dreaming. Having turned your enemies to toads, you can get on with conjuring up more pleasant scenes for yourself! You may have had a recurring dream that becomes so familiar that you recognise it.

Often, lucid dreams are brought about just by reading about them — knowing that it's possible — so who can tell what might happen to you tonight?

When lucid dreams happen spontaneously you usually lose control after a while and slip back into a normal dream. With a little practice they can be sustained and become ever more frequent and powerful. With the Dream Machine by your bedside, some very strange experiences are waiting for you. This is not a project for the faint hearted!

Dreams are such personal things that they are not really

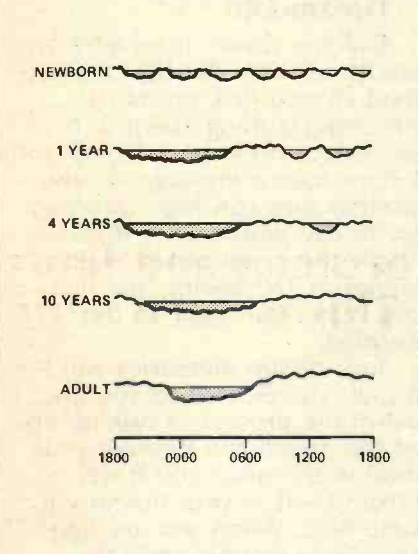


Fig.1 Our sleep pattern changes with age but we always require sleep.

amenable to the methods of scientific investigations. Most people have trouble recalling their own dreams with any accuracy, so the difficulties in trying to make sense of second hand accounts are almost insurmountable.

Much has been written about dreams with apparent authority, which on closer investigation turns out to be little more than opinion and prejudice. Some claim that dreams can be prophetic or didactic, others that they are composed of fragments from the day's activities put together in a bizarre way. Others still would claim that they are merely rubbish churned up as the brain sorts out its internal filing system during the night.

Coleridge claimed to have heard the poem 'Kublai Khan' word for word in a dream. Jung saw dreams as a 'hidden door' to the secret recesses of the mind. Joseph saved Egypt from famine after interpreting Pharoh's dream. Was Coleridge a liar? Was Jung and all the present psychiatrists who borrow from his techniques merely misguided? Was Joseph's shrewd intervention in the Egyptian economy a lucky accident?

Any theory put forward to explain the purpose of dreaming has a great variety of factors to take into account!

Sleep (Perchance To Dream)

The reason for sleep is still something of a mystery. The problem is that the obvious explanation (that the body and mind need rest to recover from the day's activities) just doesn't hold up under close scrutiny.

Any period of inactivity (sitting in an armchair in front of the TV will do) is quite enough to give the skeletal muscles all the relaxation they need. As far as the mind is concerned, the electrical activity certainly changes during sleep, but far from decreasing it becomes considerably greater!

In the search for an alternative explanation, scientists spent a great deal of time and energy searching for substances known as 'hypnotoxins'. The idea was that these toxins (poisons) would build up during the day until they reached a certain preset level

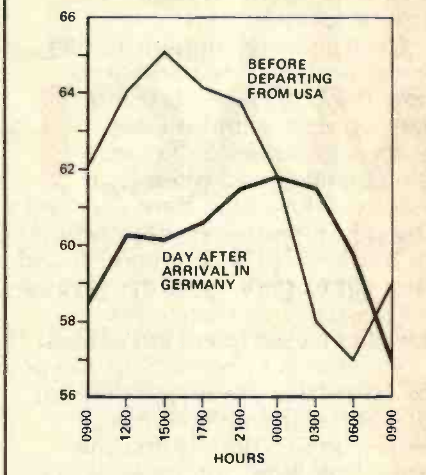
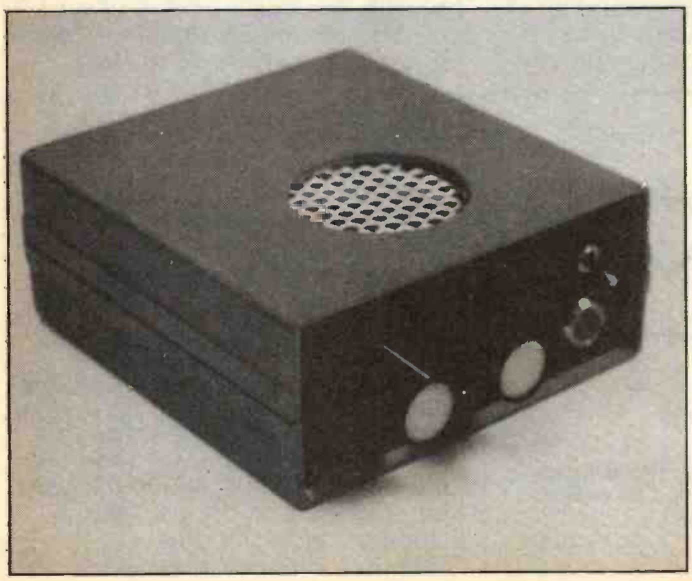


Fig.2 Even with a short time displacement (jet lag from travel to a new time zone) efficiency is severely impared by the change in sleep pattern.

which would trigger the sleep mechanism. During sleep, no more poisons would build up and those accumulated during the day would be gradually eliminated until they reached a lower threshold which would signal 'time to get up'.

This attractively simple idea was spoiled by the complete failure to find any sign of substances that would fit the description of hypnotoxins and so now it's been largely abandoned.

Perhaps sleep is not necessary at all? Maybe an occasional period of physical inactivity would be just as good? This doesn't work either (Fig.2). The evidence that sleep is



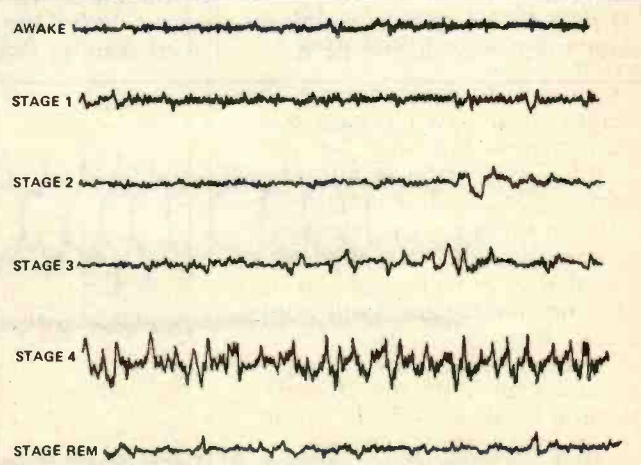


Fig.3 The different levels of sleep as demonstrated by EEG recordings.

absolutely vital to survival comes mainly from circumstances where sleep deprivation is used as a form of torture.

Destructive testing of human beings under these conditions show they can rarely last more than ten days without sleep. Death is preceded by intense hallucinations and often by insanity. Those who have survived long periods of sleep deprivation are not keen to recommend it and often suffer periods of depression and mental disturbance for months or even years afterwards.

So what *is* known about sleep? The hard facts are interesting but not particularly enlightening. Sleep is arbitrarily divided into levels, mainly on the basis of EEG recordings. The normal sleeping pattern is to sink through the various levels of sleep to reach the deepest level within about 45 minutes. This deep sleep is broken roughly every hour and a half by paradoxical sleep, so called because the brain waves take on a pattern that would normally be associated with alert wakefulness (Fig.3).

As the night progresses, the trend is for sleep to become lighter and the periods of paradoxical sleep to become longer, from about ten minutes early in the night to half an hour or so later on.

Paradoxical sleep is also known as rapid eye movement (REM) sleep. In the early 1950's it was discovered that this phase is accompanied by bursts of eye movement behind the closed lids.

As this is clearly visible, particularly in babies (where it was first noticed) it's astonishing that it took so long for anyone to discover it!

Dreams seem to occur with far greater frequency during REM sleep than at any other time. This was discovered by the simple expedient of waking people up during REM and non-REM phases and asking if they'd just been dreaming. Those woken from REM sleep almost invariably reported having a dream, whereas those in the non-REM stage rarely did.

In several experiments sleepers have been denied the opportunity for dreaming by being woken at the onset of each REM phase. They were allowed to sleep again immediately but would be woken at the first sign of any eye movement. The total sleep period allowed was the same as usual but it was a broken and dreamless sleep.

One result was that sleepers were so keen to enter the REM phase that it would begin almost as soon as their heads touched the pillow. The second was that the sleep period just didn't seem to refresh the subjects. After a few days they would show similar disturbances to those who were deprived of sleep altogether. Other groups of sleepers woken just as often (but always during the non-REM phase) showed hardly any effect at all.

It is tempting to draw the conclusion that sleep deprivation is really dream deprivation — that the whole purpose of sleep is to allow dreaming. Some have said just this. Others would claim that dreams are an incidental product of some essential activity which takes place during REM sleep.

Whatever the truth of the matter — whether dreams are the essential ingredient or a manifestation of some other vital process — it seems likely that the study of dreams can make a valuable contribution to the understanding of sleep. Very little seems to be forthcoming from other sources!

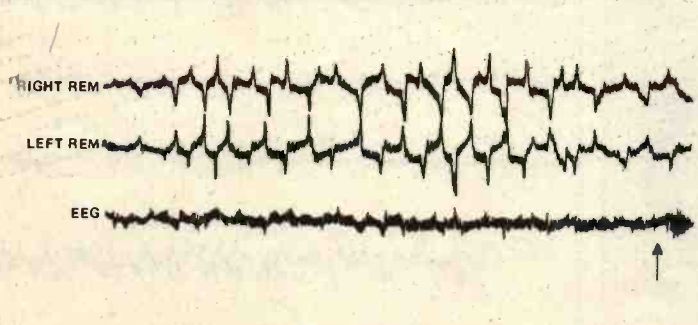


Fig.4 Correspondence between REM and dream imagery. The subject showed a regular series of left then right eye movements. On waking (arrowed) he reported dreaming of a table tennis match.

Improving Your Dream Life

Did you dream last night? You almost certainly did but there's a good chance that you don't remember a thing about it. If you're keen to know whether your dreams have a message for you, whether they can help with your day to day problems or if they're simply the result of last night's supper or TV viewing, the first step is to recall them in the morning.

Your dream memories will be at their sharpest when you are just in the process of waking up. Let the dream run through your mind in this state and it will remain fixed in your memory for some time. When you are fully awake, you can jot down the details if you like.

Fig.5 Noise — it's hard to imagine this could be beneficial!

After that comes the fun of trying to analyse the results. A single dream is not much to go on but if you keep a 'dream diary' you may see all kinds of patterns emerging.

Many people have claimed to be able to decide on the subject of their dreams by thinking about it just as they drift off to sleep. Some claim to be able to return night after night to a favourite dream to watch the next episode unfold.

A strange effect is the ability of dreams to weave external events into their own fabric. An interesting experiment (it can hardly be dignified by calling it 'research') was carried out by a certain Major Wellesley Tudor Pole who hit upon the charming idea of waking people from sleep by firing a pistol close to their ears. In every case where a dream was reported, the pistol shot was somehow built into the story as the natural culmination of the dream. Whether the good Major's friends ever spoke to him again afterwards is not recorded.

The Dream Machine

The Dream Machine was conceived as a project that everybody can have fun building and experimenting with and one which can also serve a useful purpose. One of its functions is to bring about a state of relaxed drowsiness conducive to having a good night's sleep. Being something of an insomniac myself, I had a definite personal interest in its success!

We tend to think of sleep as a time of relaxation but most people spend the night in such a state of tension that the experience is nowhere near as refreshing as it ought to be. I want to bounce out of bed in the morning feeling totally renewed and full of energy, not groggy and bleary eyed. So, you see, the project was really made for me, but I'll share it with you!

The principle of the Dream Machine is this: it produces pink noise. The sound of pink noise is similar to the sound of surf on the beach, wind in the trees or light rain. Quite poetic, really. Although noise 'looks' pretty angry (Fig.5) it's a very relaxing sound to listen to.

Some extravagant claims have been made for the effects of pink noise. I remember reading some years ago that people became so hypnotised by prolonged exposure to it that they could have their teeth pulled out without anaesthetics! Just the thing to amuse you on a rainy afternoon.

Noise

In most circuits the aim is to keep noise to a minimum but for this project we want to increase it! Luckily, we don't have far to look for sources of electrical noise. All kinds of things produce it — resistors, transistors, wastepaper baskets, ashtrays. . .everything on earth produces thermal noise voltages (Fig.6).

Thermal, or Johnson, noise is produced, as its name suggests, by heat. Heat agitates the electrons in any substance and causes minute voltage fluctuations across it. The actual voltage produced depends on the temperature, the resistance of the substance and the bandwidth. It is given by:

$$V_n = \sqrt{4kTRB}$$

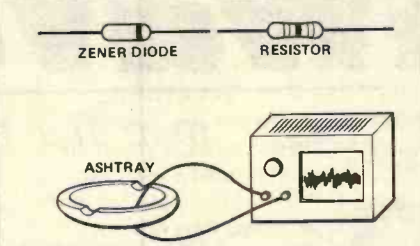


Fig.6 Any electronic device — even an ashtray — will produce thermal noise.

k is a constant very popular with physicists. It's Boltzman's constant and its value is 1.38×10^{-23}.

The bandwidth (B) is a tricky one. If we have a resistor on the bench it's clear that it must be band limited in some way, otherwise it would be producing light frequencies (in considerable quantity too, if you work it out) and would glow in the dark! But it's not clear just what the bandwidth is. For the purposes of the project we are only interested in noise voltages produced within the audio band — anything beyond that we won't hear anyway — so we'll use a generous value of 2×10^4 (20kHz).

The temperature, T, is the absolute temperature — based on zero being the point where all thermal processes come to a halt. At absolute zero there's no thermal noise at all. Absolute zero is so cold that even the toughest brass monkeys stay indoors! On the Centigrade scale it works out to be about −273°C!

Assuming a room temperature of 20°C, the absolute temperature would be 293°C. (Absolute degrees are the same size as Centigrade degrees. They just start earlier. Have you ever wondered why slow drivers are at the *front* of every traffic queue and not at the back? They start earlier too).

To work out the voltage produced by (say) a 1M0 resistor at room temperature, all we need now is a calculator:

$$V_n\ (RMS) = \sqrt{4\times1.38\times10^{-23}\times293\times10^6\times2\times10^4}$$

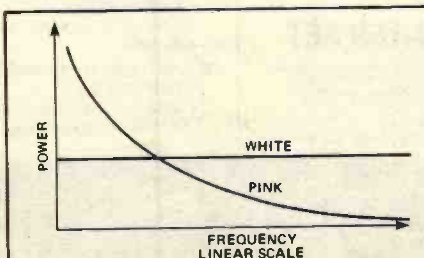


Fig.7 Power/frequency characteristics of white and pink noise.

This works out to near as damn 18μV. This is usable (and quite enough to cause problems in hi-fi amplifiers and brainwave monitors) but not much of a start for the Dream Machine. The noise from a 10,000M ceramic ashtray would be better. 100 times as good, in fact. But the currents would be much too small.

Luckily for us, thermal noise is not the only source of noise in electronic components (though it is for most ashtrays). Ask a resistor to do some work like passing a bit of current and up goes the noise (for most types, anyway). The Johnson noise is the lowest possible noise, sometimes called the noise floor. On top of that comes 1/f noise (the noise carpet?). In semiconductors there are other odds and ends too — mostly shot noise with a touch of partition noise (a bad habit picked up from valves).

How these noise mechanisms work (and how to put them out of action) is something I have in mind for a future *Circuit Theory* article. For the moment we'll just give thanks that they exist.

Other components can be even noisier. A zener diode on the point of conduction will produce enough noise to wake the neighbours and it is this I have chosen as the generator for the project.

Thermal noise has a spectrum with the same power in a given bandwidth no matter what the centre frequency may be. Between 50Hz and 100Hz there's just the same amount as between 1,000,000Hz and 1,000,050Hz, all things being equal (which they never are). It is called white noise by analogy with white light (which has an entirely different distribution — It's not really a very good name).

If the power varies inversely with frequency, the noise contains more of the low (red) frequencies and is called pink noise (Fig.7). In semiconductor devices, 1/f (pink) noise tends to predominate up to about 1kHz. Above that, the spectrum is fairly flat (on a linear frequency scale).

The noise from a zener diode is already tinged with pink, so judicious use of a capacitor and pot can vary it from pale pink to almost red (close enough for our purposes, anyway).

Next month you'll be getting the components and I'll start on the construction details. In the meantime, sweet dreams!

ETI

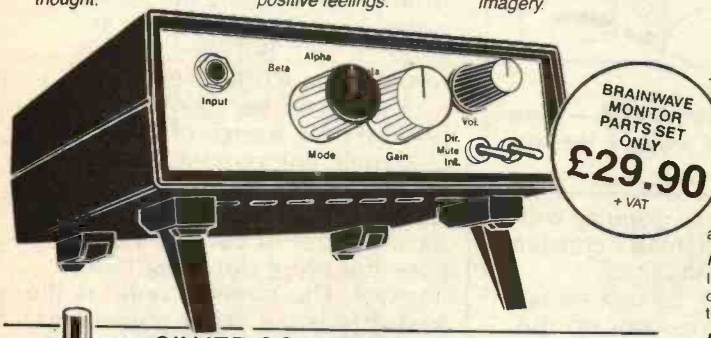
Are we about to create a race of Supermen?

Brainwave monitor

β BETA – *Concentration, problem solving, active thought.*

α ALPHA – *Relaxation, pleasure, tranquility, positive feelings.*

θ THETA – *Imagination, creativity, hynagogic imagery.*



BRAINWAVE MONITOR PARTS SET ONLY £29.90 + VAT

The ETI Brainwave Monitor must be the most astonishing project ever to appear in the pages of an electronics magazine. It will allow you to hear your brainwaves and judge the relative levels of various types. It will also help you to control your mind more effectively, to be at peak performance in all situations.

Doesn't my mind work perfectly well when left to its own devices?
If you've ever been confused, unsure of yourself, shy, unable to pass exams or to impress people at interviews, you know perfectly well that it doesn't. Your mind (and everybody else's) is full of bad habits, inappropriate responses, feelings of inadequacy . . . all pulling you down. Why should you put up with it?

Mind training sounds like hard work!
It can be. If you want to do it the hard way, go and study under a Zen master for fifty years or so. You'll get there in the end! With the brainwave monitor it takes no effort at all. Just the opposite in fact – **trying** is the one thing you mustn't do!

How do I start?
At first you use the monitor's internal indicator to exercise your mind. In direct mode you improve the time percentage; in integrate you concentrate on the amplitude. After that, the choice of direction is yours. With the Alpha Plan you can reach the core of your personality to root out the weakness and replace it with inner strength. Otherwise you can just enjoy the feelings of pleasure and clear headedness that alpha training brings, or the creativity and imagery of the theta state.

A friend told me I can use brain power to control lights and things. I can't believe it!
As a matter of fact, you can do more than that! The interface sockets on the monitor allow you to turn lights on and off, control toys and electrical gadgets, play computer games . . . all with your mind! Are we about to create a race of Supermen? Only time will tell.

The Brainwave Monitor is featured in the September, October and November 1987 issues of ETI. The approved parts set contains: two PCBs, all components including three PMI precision amplifiers, shielded box for screening the bio-amplifier, attractive instrument case with tilting feet, controls, switches, knobs, plugs and sockets, leads and materials for electrodes, full instructions for assembly and use.

Parts are available separately. We also have a range of accessories, professional electrodes, books, etc. Please send a stamped, self-addressed envelope if you just want the lists. Otherwise, an SAE + £2 will bring you lists, construction details and further information.

SILVER SOLUTION

This powerful silver plating compound must be the greatest revolution in electronics since the IC! Just wipe on with a cloth to plate PCB tracks, connectors, wire, component leads, etc. with a layer of pure silver!
Essential for:
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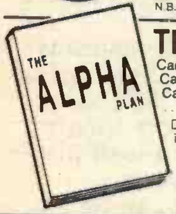
N.B. The solution will take to brass, copper, etc. but not to steel or pre-plated components.



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Can you really train your brain to think more effectively?
Can you really achieve peak performance in things you're 'no good at'?
Can you really overcome fear, shyness, uncertainty?
. . . And can you do it all without really trying?

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Dr. Lewis's book 'The Alpha Plan' is yours for only £2.50 (no VAT).
Your future is waiting.

Complete Parts Sets for ETI Projects

POWERFUL AIR IONISER

FEATURED IN ETI, JULY 1986

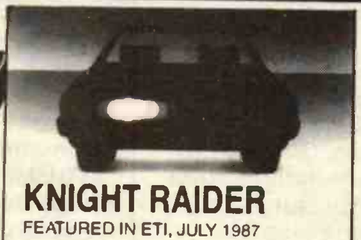
Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner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

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

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

DIRECT ION PARTS SET
WITH BLACK CASE £9.50 + VAT
WITH WHITE CASE £9.80 + VAT

Instructions are included



KNIGHT RAIDER

FEATURED IN ETI, JULY 1987

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

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

The control box parts set consists of case, switches, LEDs, PCB, components, hardware and instructions. The sequence board includes PCB, ICs, power FETs, components, hardware and instructions.

KNIGHT RAIDER CONTROL BOX ONLY
£6.90 + VAT!
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BUILD YOUR DREAM MACHINE IN STYLE

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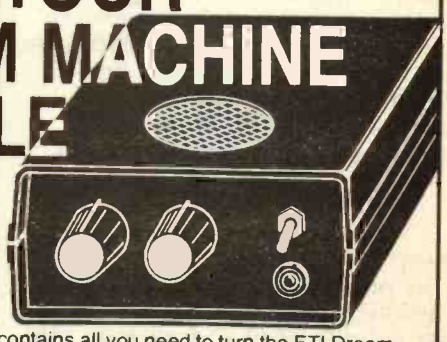

Our expansion parts set contains all you need to turn the ETI Dream Machine into a very special project.

The parts set contains:
- PRESTIGE CASE
- MAINS POWER SUPPLY COMPONENTS (transformer, rectifiers, capacitors, regulator.)
- HIGH QUALITY EXPANSION COMPONENTS (TBA820 IC, resistors, capacitors, preset transistor, loudspeaker)
- ALL CONTROLS AND ACCESSORIES (pots, switches, knobs, neon lamps, fuse holder, fuse, mains cable, etc.)
- FULL INSTRUCTIONS

(You will need the free components and PCB from the November and December issues of ETI to complete the project).

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Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 Experimenter Set £5.80 + VAT

Prices shown are exclusive of VAT, so please add 15% to the order total. UK postage is 60p on any order. Carriage and insurance for overseas orders £1.50. Please allow up to 14 days for delivery.

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ETI CONCEPT

Robert Stevenson continues his description of the ultimate mains controller.

The construction of the Concept controller was covered last month. In this issue the calibration and operation of the controller will be described.

The Concept's operating system software is held in EPROM on the CPU board (IC3). The EPROM used can be either a 2764 (8K) chip or a 27128 (16K) chip depending on availability. Only just over 7K of the EPROM is used and the hex dump of the used portions is given in Listing 1.

Alternatively, pre-programmed EPROMs and the source and object code on a BBC micro disk are available from the author. See last month's Buylines for details.

Calibration

When the Concept is fully assembled and all the wiring checked carefully, plug in and switch on.

All the display LEDs should light for a second and then the Concept should go into time display mode. As this is the first power-up this should show *00.00*. The centre decimal point should flash at 1Hz and the top left LED should light to indicate time mode.

Press the mode (MDE) key and the Concept should go into cost mode and display *000.0*. Another press puts it into power mode. The display may show a figure now. This is meaningless until the unit is calibrated.

Switch off and connect the 'normal' link on the power board. Switch on again and allow at least a half hour for the unit to 'warm up'. Press the MDE key twice to enter power mode.

With an insulated trimmer tool and some care adjust RV1 to give a reading of *0005* on the display. Now press SET and MDE to initiate the auto-zero routine which takes about ten seconds. The offset value calculated is stored in the battery backed RAM and so this procedure should not need repeating.

Switch off again and change the link to 'calibrate'. After switch-on and warm up, the multi-turn preset RV2 should be adjusted to give a reading of *2450*. The last digit may fluctuate but this is quite normal.

Switch off and return the link connection to the 'normal' position. The Concept is now calibrated and ready for use.

In use, slight drift of the power measurement circuitry can cause a reading of 1W when nothing is even connected to the Concept. This is quite normal and although it can create a cumulative cost error, this is unlikely to exceed ½p a day. If a permanent drift is experienced, the calibration procedure should be repeated.

Certain types of appliance may give unexpectedly low power readings. This is particularly true of TVs and computers which use switch mode power supplies. The Concept measures the in-phase power that the domestic electricity meter counts on. The cost displayed is therefore the cost you pay.

Problems?

If the Concept fails to work first time, try switching it off and then on. If that doesn't solve the problem make another check on the orientation of all the ICs and for broken and shorted tracks on the PCBs.

Using an oscilloscope or logic probe check for address and data bus activity. If this is okay, monitor the 6502 IRQ line (IC1, pin4) for a low pulse every 5ms with a longer pulse every second.

If the CPU appears to be working, check that the relays can be switched on manually. If they cannot, examine the driving circuitry.

If the battery is not fully charged, the RAM can become corrupted causing occasional strange functioning of the Concept. The best cure for this is to switch off and short out the RAM, erasing it totally. Short across pins 12 and 24 of IC10.

Operation

In general, the Concept is programmed with the sequence SET-function-data-SET. Pressing CE/C will cancel data entry or a selected function. The status LEDs light when a function is operating and flash when data entry is expected.

The time is set by pressing SET and then key 5 (HR). This blanks the hours digits and flashes the hour LED. Type in two digits for the hours in 24 hour format. A further press of SET stores the setting.

The minutes and day are set in the same way using keys 6 (MIN) and 4 (DAY). The day required is entered using the numbers 1 to 7 (Sunday to Saturday).

The mains outputs are turned on manually using the MAN key followed by keys 1 to 4. This toggles the output from its

```
0000  4C 50 E0 20 2A 2A 2A 2A 2A 2A 20 43 4F 4E 43 45
0010  50 54 20 2A 2A 2A 2A 2A 2A 2A 20 53 6F 66 74 77
0020  61 72 65 20 56 65 72 73 69 6F 6E 20 31 2E 33 31
0030  20 20 62 79 20 52 6F 62 65 72 74 20 53 74 65 76
0040  65 6E 73 6F 6E 20 31 39 38 37 20 20 20 20 20 20
0050  A0 FF A2 FF A9 00 9D 00 80 9D 00 60 CA D0 F5 88
0060  D0 F2 A9 00 85 9B 78 A5 0E C9 55 D0 0C A5 0F C9
0070  AA D0 06 20 10 E1 4C 80 E0 A9 00 A2 FF 95 00 9D
0080  00 02 9D 00 03 9D 00 04 CA D0 F2 85 00 8D 00 04
0090  8D 00 03 A2 01 86 93 A9 14 85 F9 A9 55 85 0E A9
00A0  AA 85 0F A5 1B 09 02 85 1B A9 FF 85 96 20 10 E1
00B0  A9 14 85 75 20 AF E6 A9 FE 85 85 A9 01 85 84 A9
00C0  00 8D 88 02 85 94 85 98 85 88 85 B5 85 C1 20 BB
00D0  E6 A9 01 85 B7 85 7C A9 03 8D 78 FA A9 33 85 9C
00E0  A9 E7 85 9D A9 00 85 AC 85 AE A9 03 85 AD 85 AF
00F0  58 A9 00 A8 85 95 85 96 85 97 85 98 85 99 85 9A
0100  A2 58 A0 02 20 9E E3 20 AF E6 20 BB E6 4C 32 E3
0110  A9 F0 8D 03 20 A9 00 8D 01 20 8D 0F 20 A9 00 8D
0120  02 20 A9 00 8D 0C 20 A9 63 8D 0B 20 A9 13 8D 07
0130  20 A9 8B 8D 06 20 A9 88 8D 04 20 A9 13 8D 05 20
0140  A9 FF 8D 08 20 8D 09 20 A9 C0 8D 0E 20 60 48 48
0150  8A 48 98 48 AD 04 20 E6 8D A9 00 A6 94 9D 00 60
0160  E8 E0 06 D0 02 A2 00 86 94 A9 01 9D 00 60 85 95
0170  A4 8D C0 64 B0 02 55 18 8D 00 40 A5 4F F0 15 A5
0180  4D 38 E9 01 85 4D 80 02 C6 4E A5 4D 05 4E D0 04
0190  A2 00 86 4F E6 70 A5 8D C9 C8 F0 3E C9 01 F0 12
01A0  C9 02 F0 18 C9 03 F0 1E C9 04 F0 24 20 34 FA 4C
01B0  2B E3 A5 8E D0 F9 20 78 FA 4C 2B E3 A5 8E D0 EF
01C0  20 78 FA 4C 2B E3 A5 8E D0 E5 20 78 FA 4C 2B E3
01D0  A5 8E D0 DB 20 78 FA 4C 2B E3 A0 00 84 8D E6 8E
01E0  A9 FF AC 09 20 AE 08 20 8D 08 20 8D 09 20 86 29
01F0  84 2A 38 E5 29 85 2B A9 FF E5 2A 85 2C A9 0A 85
0200  2F A9 00 85 2D 85 2E 85 30 A2 10 06 2B 26 2C 2A
0210  A8 26 2D C5 2F A5 2D E5 30 90 0C 98 E5 2F A8 A5
0220  2D E5 30 85 2D E6 2B 98 CA D0 E0 85 2E A5 2B 38
0230  E5 F9 85 2B B0 06 A5 2C E9 01 85 2C A5 2C C9 0C
0240  90 06 A9 00 85 2B 85 2C A9 00 A2 09 95 30 CA D0
0250  FB A5 2B 85 31 A5 2C 85 32 A5 1F 85 35 A5 20 85
0260  36 20 D1 E4 A5 98 F0 25 A5 31 18 65 CB 85 CB A5
0270  32 65 CC 85 CC A5 33 65 CD 85 CD A5 34 65 CE 85
0280  CE A9 00 65 CF 85 CF A9 00 65 D0 85 D0 AD 7C 02
0290  F0 1C A5 F7 38 E9 01 85 F7 B0 02 C6 F8 A5 F7 05
02A0  F8 D0 08 A9 00 8D 7C 02 A5 9B 86 85 9B A5 8E
02B0  C9 3C F0 18 C9 1E D0 11 A6 C7 F0 0D 18 65 C3 85
02C0  8E A5 C4 85 8D A9 00 85 C7 4C 28 E3 A2 00 86 8E
02D0  E6 90 D0 02 E6 91 E6 8F A6 C1 E0 7A D0 04 A2 00
02E0  86 C1 A5 2B 9D 00 04 E8 A5 2C 9D 00 04 E6 C1 E6
02F0  C1 A5 8F C9 3E F0 03 4C 2B E3 A2 00 86 8F A5 C3
0300  05 C4 F0 04 A9 FF 85 C7 E6 92 A5 92 C9 18 F0 03
0310  4C 2B E3 A2 00 86 92 E6 93 A5 93 C9 0B F0 03 4C
0320  2B E3 A2 01 86 93 CA 86 90 86 91 68 A8 68 AA 68
0330  28 40 6C 9C 00 A5 70 C9 03 D0 03 20 1B F5 20 1A
0340  E5 8D 79 02 AD 7B 02 F0 06 20 1E F7 4C 32 E3 AD
0350  78 02 F0 0E AD 79 02 20 CC E6 90 D6 20 50 F6 4C
0360  32 E3 AD 79 02 F0 28 C9 03 F0 20 C9 0C F0 17 C9
0370  08 F0 0D C9 04 F0 03 4C 32 E3 20 EA E6 4C 32 E3
0380  20 80 E6 4C 32 E3 20 80 E7 20 F6 E9 4C 32 E3 20
0390  D4 F0 20 F6 E9 4C 32 E3 20 22 F8 4C 32 E3 48 78
03A0  84 4E 86 4D 58 A2 01 86 4F A6 4F D0 FC 68 60 48
03B0  8A 48 98 48 A5 50 C9 0F D0 01 18 A5 51 E9 27 90
03C0  03 4C 15 E4 A9 00 85 54 85 55 85 56 85 57 A5 53
03D0  10 03 20 05 E4 A2 00 A0 20 A9 00 06 50 26 51 26
03E0  52 26 53 2A C9 0A 90 04 E9 0A E6 50 88 D0 EC 48
03F0  E8 A5 50 05 51 05 52 05 53 D0 DC 68 CA 95 54 8A
0400  D0 F9 4C 15 E4 A0 04 A2 00 38 A9 00 F5 50 95 50
0410  E8 88 D0 F6 A0 A9 00 85 50 85 51 85 52 85 53 68
0420  A8 68 AA 68 60 48 8A 48 98 48 A9 00 85 52 85 53
0430  85 5F 85 60 A2 10 46 5A 66 59 90 0D A5 5F 18 65
0440  5B 85 5F A5 60 65 5C 85 60 66 60 66 5F 66 5E 66
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0460  EB 85 5B A9 03 85 5C A5 64 85 59 A9 00 85 5A 20
0470  25 E4 A5 5D 85 65 A5 5E 85 66 A5 63 85 59 A9 00
0480  85 5A 85 5C A9 64 85 5B 20 25 E4 A5 5D 85 67 A5
0490  5E 85 68 A5 65 18 65 67 85 65 A5 66 65 68 85 66
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04C0  A5 65 18 65 61 85 65 90 02 E6 66 68 A8 68 AA 68
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04F0  18 A6 39 76 42 CA D0 FB A4 39 B1 3D 6A 91 3D 88
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0510  00 C8 CA D0 F4 C6 41 D0 D8 60 8A 48 98 48 A9 00
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0540  E5 A0 00 A9 01 85 73 38 26 71 A5 71 C9 FF F0 03
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0570  0C FF 85 72 8A 48 98 48 A6 72 E0 FF D0 05 86 72
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05C0  85 75 4C 80 E5 C5 75 D0 0A A2 05 A0 00 20 9E E3
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0620  77 2A A8 26 7A C5 78 A5 7A E5 79 90 0C 98 E5 78
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0640  78 A6 2B A4 2C 58 86 50 84 51 A9 00 85 52 85 53
0650  20 AF E3 A5 54 20 72 E5 85 9A A5 55 20 72 E5 85
0660  99 A5 56 20 72 E5 85 98 A5 57 20 72 E5 85 97 A5
0670  95 29 7F 09 03 85 95 A0 00 A2 F0 01 60 AC 35 E3
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0690  0F 85 D8 78 A5 9B 45 D8 85 9B 58 20 BB E6 20 F6
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06B0  20 A2 E6 A9 FF 85 95 85 96 68 60 48 A9 00 85 95
06C0  85 19 85 1A 85 1B 85 1C 85 1D 68 60 F0 1A C9 01
06D0  F0 16 C9 02 F0 12 C9 08 F0 0E C9 04 F0 0A C9 03
06E0  F0 06 C9 FF F0 02 38 60 18 60 20 F6 E9 20 A6 E5
06F0  95 09 83 85 95 A5 7C C9 04 A9 00 85 7C 4C [illegible]
0700  EA E6 C9 02 D0 0B A9 73 85 9C A9 E7 85 9D 4C 28
0710  E7 C9 01 D0 08 A9 33 85 9C A9 E7 85 9D 4C 28 E7
0720  A9 40 85 9C A9 E6 85 9D A2 0A A0 00 20 9E E3 20
0730  F6 E9 60 A5 8F 85 50 A9 00 85 51 85 52 85 53 20
0740  AF E3 A5 54 20 72 E5 85 9A A5 55 20 72 E5 85 99
0750  A5 92 85 50 A9 00 85 51 85 52 85 53 20 AF E3 A5
0760  54 20 72 E5 29 FD 85 98 A5 18 09 02 85 18 A5 95
0770  29 FE 09 82 85 95 A5 55 20 72 E5 85 97 4C 35 E3
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0790  E5 85 9A A9 05 20 72 E5 85 97 A9 02 20 72 E5 85
07A0  98 A9 10 20 72 E5 85 99 A2 02 A0 00 20 9E E3 20
07B0  F6 E9 20 AC E5 C9 0C D0 06 20 DC E5 4C 37 E8 C9
07C0  0B D0 06 20 D6 E5 4C 37 E8 C9 0A D0 06 20 93 EA
07D0  4C 37 E8 C9 09 D0 06 20 75 E8 4C 37 E8 C9 0E D0
07E0  06 20 A4 F5 4C 37 E8 C9 0F D0 06 20 67 F9 4C 37
07F0  E8 C9 03 D0 06 20 8C E8 4C 37 E8 C9 06 D0 06 20
0800  59 EC 4C 37 E8 C9 04 D0 06 20 4F ED 4C 37 E8 C9
0810  01 D0 03 4C 37 E8 C9 02 D0 06 20 F4 EC 4C 37 E8
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1A40  9B 25 B7 A4 B9 F0 02 25 BA C9 00 F0 08 A9 01 9D
1A50  00 80 4C 5A FA A9 00 9D 00 80 E6 B8 06 B7 A5 B8
1A60  C9 04 D0 07 A2 00 86 B8 E8 86 B7 60 A5 B9 49 FF
1A70  85 B9 60 00 20 40 60 FF 38 26 B5 06 B4 E6 BB A6
1A80  BB BD 73 FA 10 11 A9 00 85 AE 85 BB A9 01 85 B4
1A90  A9 FE 85 B5 4C 99 FA 85 AE A9 FF 85 1E A2 00 A0
1AA0  01 B1 AE 29 40 D0 03 4C D5 FA 84 B3 8A A8 B1 AE
1AB0  A4 B3 C5 90 F0 03 4C D5 FA B1 AE 29 3F C5 91 F0
1AC0  03 4C D5 FA B1 AE 29 80 F0 07 A9 01 85 1E 4C D5
1AD0  FA A9 00 85 1E C8 C8 E8 E8 C0 1D F0 03 4C A1 FA
1AE0  A5 1E C9 01 D0 09 A5 9B 05 B4 85 9B 4C FC FA A5
1AF0  1E F0 03 4C FC FA A5 9B 25 B5 85 9B 60 AA CA BD
1B00  03 FB 60 00 20 40 60 20 A2 E6 A9 40 85 19 A9 00
1B10  85 1B 20 AC E5 C9 01 D0 07 A9 FF A0 00 4C BD FB
1B20  20 CC E6 90 ED 20 3B E8 C9 01 D0 0B A8 AA 20 72
1B30  E5 85 97 8A 4C BD FB C9 02 D0 0B A8 AA 20 72 E5
1B40  85 98 8A 4C BD FB C9 03 D0 0C A0 00 AA 20 72 E5
1B50  85 99 8A 4C BD FB C9 04 D0 0C A0 00 AA 20 72 E5
1B60  85 9A 8A 4C BD FB C9 07 F0 03 4C 12 FB A0 0F AA
1B70  A9 01 20 72 E5 85 97 A9 02 20 72 E5 85 98 A9 03
1B80  20 72 E5 85 99 A9 04 20 72 E5 85 9A 20 BB E6
1B90  [illegible]
1BA0  [illegible]
1BB0  [illegible]
1BC0  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1BD0  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1BE0  [illegible]
1BF0  [illegible]
1C00  [illegible]
1C10  [illegible]
1C20  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1C30  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1C40  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1C50  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1C60  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
1C70  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
1C80  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
1C90  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
1FF0  FF FF FF FF FF FF FF FF FF FF FF FF 00 E0 4E E1
```

Listing 1 The used sections of the 2764 EPROM (IC3 on the CPU board).

previous state. All four outputs can be toggled using the key 7 (ALL).

The countdown timer is started with SET—1 (CDN) followed by one of the keys 1 to 4 or 7 to select the output channel. Then enter the delay required (up to 99) followed by SET again to start the countdown.

At the end of the timed period the selected output is toggled. The countdown may be cancelled at anytime by pressing SET—CDN again.

The timer is programmed using the PRG key. Each channel can be programmed with seven separate on/off time program pairs. Select channel one (key 1) and the display will show either *P.1 1* or *u.1. 1*. The letter indicates if that on/off time has been programmed. The first number indicates the channel and the second the on/off time program number (1 to 7). The seven time programs can be selected by further presses of the PRG key. A seventh press exits the programming routine.

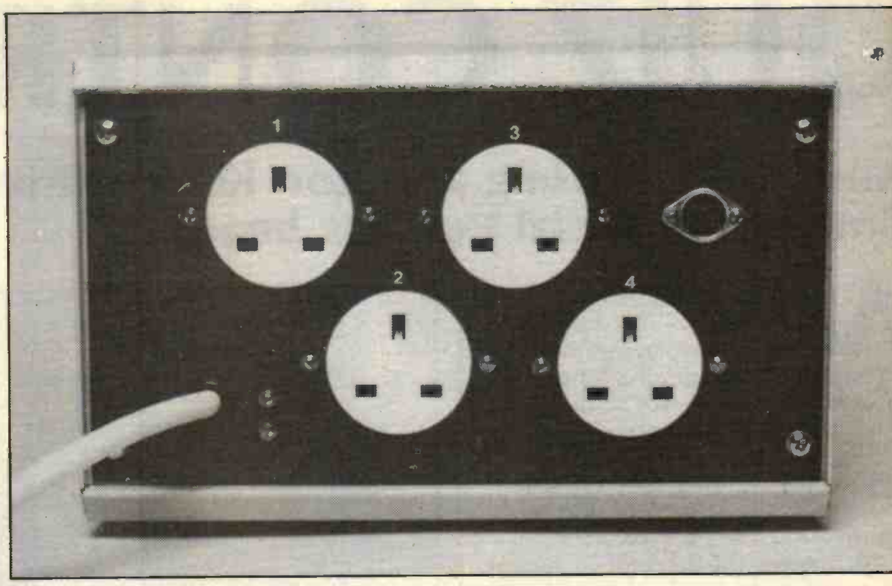
When the required program is selected, SET allows the on/off time to be programmed. The display shows the previously set on time (*00.00* if unprogrammed). A four digit number (hours then minutes) should be entered SET pressed and then the day number followed by SET to store this time. The off time day is then entered in the same way. The display will now show *P.1. 1.* If you are not programming another on/off time you must exit the routine by successive pressing of the SET key and not by using CE/C.

Needless to say, the other channels can be programmed by selecting the relevant channel number at the start of the procedure.

To set the same on/off time for each day of the week, program the first time program with the required times (the day is unimportant), exit the routine in the normal way and enter SET—0 (ED) followed by the channel number. This copies the set times into each time program for each day of the week.

Entering SET—9 (CAP) and then a channel number clears all the time programs assigned to that channel.

The output channels can also be turned off by external trigger signals applied to the DIN socket. The signal should be from a TTL type circuit with open collector



outputs. A logic low on the inputs will turn off an output and prevent it from coming on if a programmed on-time occurs.

The external controls are ignored by default and should be enabled first by entering SET—MAN (C-SW). The C.SW LED lights when the conditional switching is enabled.

The Concept's real time clock will run slightly slow. This can be compensated for by the software. The trim factor is entered after pressing SET—3 (TRM). The number entered should be between 0 and 999 and represents the number of $\frac{1}{100}$s to add every hour.

By carefully monitoring the Concept's timekeeping and adjusting the trim factor accordingly, an accuracy of better than five seconds a week can be achieved.

Cost Power

The Concept can display both the instantaneous power drawn by the outputs and the cumulative cost. Pressing the MDE key switches the display between the three modes of time, power and cost.

The cumulative cost is zeroed by entering SET—MDE (RST) when the display is showing the cost.

The rate at which the power is 'charged' is set by entering SET—8 (RTE). The cost in pence per kWhr is then entered as three digits up to a maximum of 99.9p.

The projected cost per day or per week can also be displayed. Entering PROJ.COST—4 and PROJ.COST—2 displays the cost per day and week, respectively, based on the instantaneous power consumption. PROJ.COST—3 and PROJ.COST—1 display the daily and weekly cost based on the power consumed during the past hour. PROJ.COST—7 displays the average power over the past hour.

The last function of the Concept is the software lock. The keypad of the Concept can be disabled to prevent unauthorised use. When locked, the MAN, PRG, MDE and PROJ.COST keys cannot then be used. Press SET—2 (LCK), enter a four digit number and remember it! The SET key should then be pressed and held for four seconds until the display shows Loc. The lock can be used in any of the three modes — time, power or cost.

To unlock the Concept simply enter the four digits and press SET. After three failed attempts at entering the code, the Concept displays *STOP* and totally locks up for five minutes. If the power is removed during this period, the lock-up period starts again on power-up.

The Concept software also includes extensive error coding. If an invalid input is entered the display shows *Err.* followed by a number identifying the error. The error display can be cleared by pressing C/CE. The error codes are as follows:

0 time minutes>59
1 time hours>23
2 timer hours>23
3 timer minutes>59
4 countdown=0
5 CAP with all channels selected
6 PRG with all channels selected
7 ED with all channels selected
8 overflow on projected cost
9 overflow on compensation (requires re-adjustment)

ETI

QUIZ CONTROLLER

Andrew Armstrong and Ron Keeley strive for peace in our time at the Trivial Pursuits board.

A quiz has an endless fascination. Is this because we enjoy displaying our knowledge? For the challenge? Is it some kind of masochistic holdover from our schooldays when quizzes were more of a torture than a pleasure? Or is it the sheer satisfaction of getting it right?

Whatever the reason, in recent years the quiz has become almost a way of life. In the week this article is being written, there are no less than ten quiz games of one kind or another appearing on our TV screens, two of them running every night of the week.

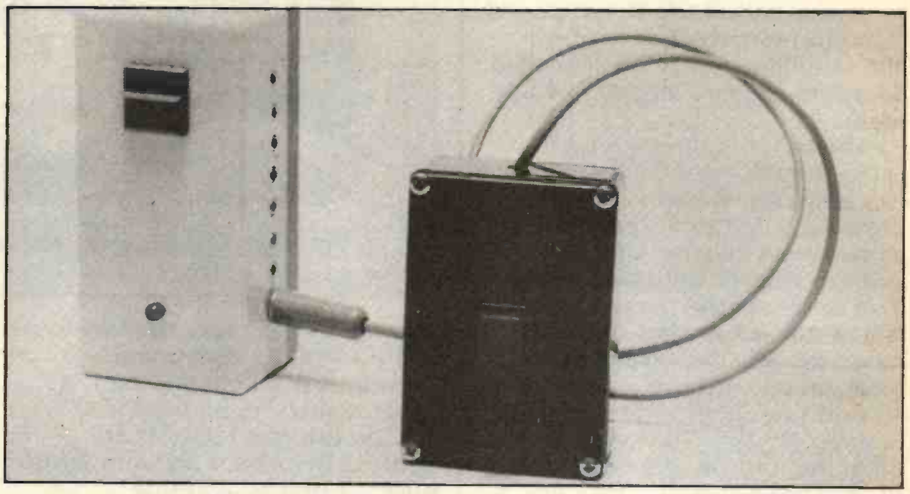
All over the country this weekend, people will be sitting down to play Trivial Pursuit, Quizwrangle or one of the look-alike quiz board games.

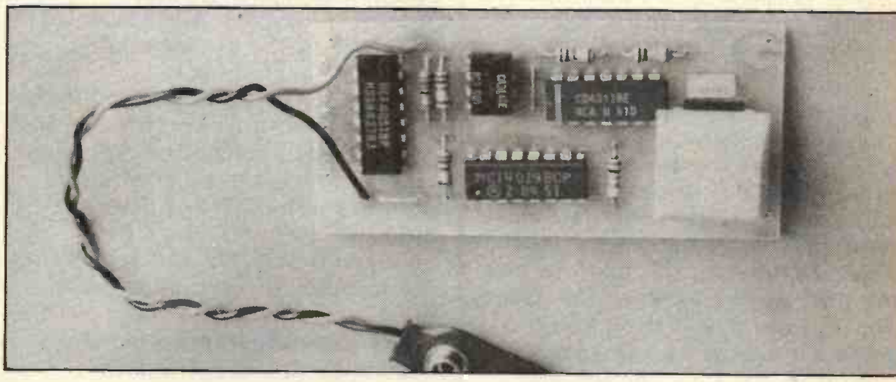
Even our most treasured leisure hours down at the Three Ferrets are now threatened by an invasion of electronic quiz machines (they are best played in teams, if you want to win!).

Many of the most popular games on TV pit teams or individuals against each other, with the first person to indicate that they know the answer being given the opportunity to reply to the $64m question.

Usually a system of buttons, buzzers and flashing lights is used, with a function which locks out all other buttons after one has been pressed. The advantage of this, of course, is that the quizmaster avoids contentious decisions concerning who pressed which button first!

Many such designs have been published in various places and there is nothing new about the principle. However this design is probably the most neat and compact quiz controller ever, with an easy wiring system that eliminates the most tedious difficulty with these things, that of connecting the players to the central control unit (we don't all have expensive stage sets to mask the wiring runs!). Up to eight players can participate in the quiz, with a further person acting as quizmaster.





HOW IT WORKS

Figure 1 show the circuit diagram. A pair of NAND gates (IC3c,d) are configured as a simple clock producing a square wave output at around 2kHz. The clock signal drives IC4, a 4029 4-bit binary/BCD up/down counter. This has both pin 10 (U/D) and pin 9 (BIN/DEC) tied to the +9V rail, which sets up the IC to count up in binary. It is permanently enabled by the C/E terminal, pin 5, tied to 0V. The lower three bits of the counter output are used to sequence the channels of a 4051 eight-channel analogue switch.

This has eight independent analogue switches with eight independent input/outputs, Y0 - Y7, and a common input/output, Z, on pin 3. The outputs are connected via individual jack plugs and two wires to an LED and a push-button switch wired in parallel. Each switch is selected in turn as the binary counter clocks the address pins 9, 10 11 and in turn each LED is connected to the 9V rail via pin 3 and resistor, R1. At this stage the LEDs will be dimly illuminated as each is on for just ⅛ of the time.

However if one of the push-buttons is selected, the Z input on pin 3 immediately goes to 0V, triggering IC2, a BIFET op-amp wired as a comparator. With the inverting input biased at just under 2V, the output on pin 6 will go low, tripping the latch configured from IC3a,b which in turn locks up the clock.

The 4051 remains switched to the channel on which the button was pressed and when the button is released, the corresponding LED comes on at full brightness. Until a switch is pressed, the forward drop of the LEDs is greater than the voltage on the inverting input of the comparator, so its output is normally high.

The latch is reset by a master switch, SW9, in the hands of the quiz master. This releases the clock and re-starts the sequencing of the quiz stations by IC1.

Although the voltage on the comparator input is momentarily dropping below the comparator threshold due to charging up the capacitance of the wiring, it does not stay low long enough to trigger the comparator.

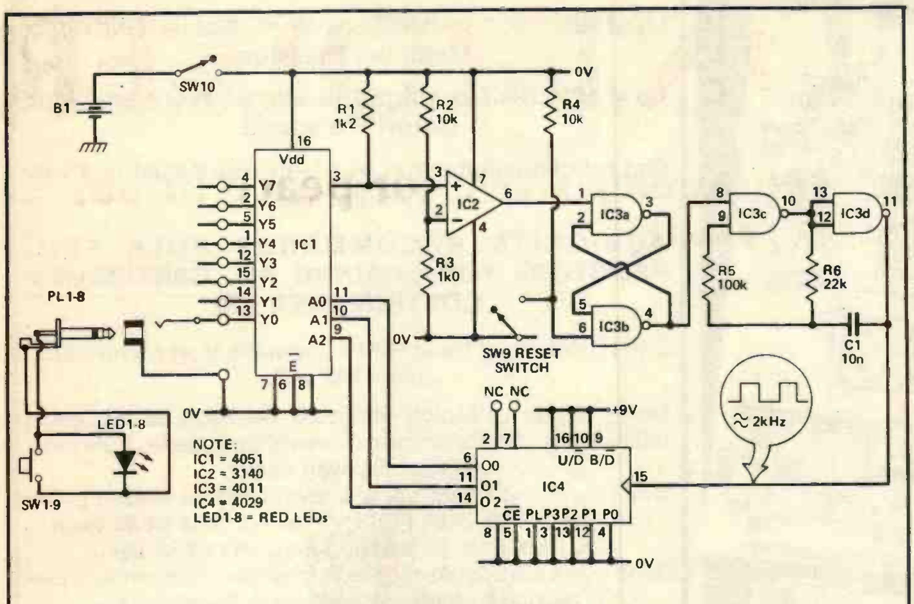


Fig. 1 The circuit diagram of the quiz controller.

PARTS LIST

RESISTORS (all ¼W 5%)

R1	1k2
R2	10k
R3,4	1k0
R5	100k
R6	22k

CAPACITORS

C1	10n polyester

SEMICONDUCTORS

IC1	4051
IC2	3140
IC3	4011
IC4	4029

LED 1-8 5mm LEDs, any colour, preferably high efficiency.

MISCELLANEOUS

B1	9V PP3 battery and connector
PL1-8	2.5mm jack plug
SK1-8	2.5mm jack socket
SW1-8	SPST push-to-make
SW9	Push-to-make rocker switch
SW10	SPST toggle switch

PCB; cases; connecting wire.

BUYLINES

The components are all readily available from a variety of sources. None are critical except, perhaps, SW9 as the PCB is laid out to accept an RS switch which is available from Electromail (part 337-368). Suitable boxes for the controller and the quiz stations are available from Cirkit. The PCB is available as ever from our own PCB Service.

Construction

The PCB measures just 75x35mm and can be built into any convenient sized case, but be sure it has a surface wide enough to take the eight 2.5mm sockets leading to the quiz stations.

Begin construction with the resistors (all six of them), the single capacitor and the two wire links (see Fig. 2). The master reset switch SW9 should be soldered in too, along with the leads for the PP3 battery connector.

You could, at this stage, also solder in short lengths of wire from the IC1 switch outputs and one short lead from the 0V rail, ready to hook up to the eight 2.5mm jack sockets.

The ICs can be soldered in (there are only four of them) observing the usual precautions when handling the CMOS types. Wire a switch and LED across one of the quiz station outputs, fit a PP3 battery to its connector and the board should be operational.

The LED should be glowing dimly until the reset button is pressed at which point it should come on at full brightness. Press SW9 on the PCB and the LED should revert to the dimly lit state. If you fail to achieve these results check the board for the usual misconnections, solder bridges across tracks, dry joints and so on. The circuit and construction are so simple that very little can go wrong!

The enclosure will need a cutout on the top through which SW9 can protrude and eight holes drilled for the 2.5mm sockets. The prototype did not include a power switch, but a miniature toggle can easily be installed and wired in series with the +9V battery lead as shown in Fig. 1. Alternatively another 2.5mm socket could be fitted and a shorted jack plug used to switch the +9V lead.

Finish off the construction by wiring up the jack sockets. The board can be mounted on top of the PP3 battery with a small square of double-sided tape, using sufficient to lift SW9 through the top cut-out. Another piece of tape will keep the battery firmly fixed to the bottom of the box.

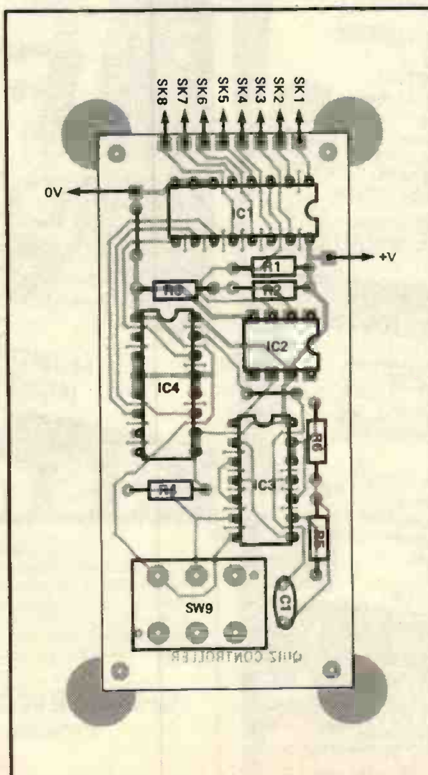


Fig. 2 The component overlay.

The individual quiz stations are connected to the controller via 2.5mm jacks and twisted pair cable of required length. Another option is to use one pair of a length of two-pair telephone cable.

All that remains is to set up your quiz game. Fingers on your buttons please; you have two minutes starting from ... NOW. Football has been banned in England on at least four separate occasions. When was the first such occasion?

I've started so I'll finish ...

In 1314 by Edward II, who proclaimed 'forsooth as there is a great noise in the city caused by hustling over large balls, from which many evils arise, may God forbid, we command and forbid, on pain of imprisonment, such a game to be used in the city in future.

Source: The Oxford Companion to Sports and Games, by John Arlott, Paladin, 1976.

ETI

MULTI-STANDARD PRINTER BUFFER

Leycester Whewell's micro is quick off the mark thanks to this 256K printer buffer with Centronics and RS232 interfaces.

A most irritating feature of many printers is their data acceptance rate. Many have sufficient capacity to hold only a single line of text, although some can store 2K, 4K or 8K of data. So, when listing a program or document of any reasonable size, the computer is effectively slowed down to the speed of the printer.

A printer buffer appears as a very fast printer to the computer, storing its output so that the operator can get on with the next task without an enforced coffee break. Meanwhile, the buffer outputs data to the printer at its normal speed.

Features

Although the idea of a printer buffer is not a new one (and designs have appeared in ETI before) this device has an ample memory capacity of either 64K or 256K — approximately 20 or 80 pages of A4 text respectively.

The buffer also allows parallel-parallel, serial-parallel, parallel-serial and serial-serial data transfers with a serial data rate of either 1200 or 9600 baud. This should accommodate just about any combination of printer and micro.

The unit is driven by an 8-bit microprocessor, the 6803 (see Fig. 1). This is a 6800 with the added features of 128 bytes of zero page RAM, a timer, a serial communications interface, parallel I/O and some additional instructions.

Since the 6803 has only one serial interface, with I/O handshaking, one half is used to receive data and the other to transmit data. This combination prevents the use of XON and XOFF handshaking as an alternative to RTS and CTS. The same clock source drives both the receiver and transmitter, so serial-serial transfers must be at the same baud rate.

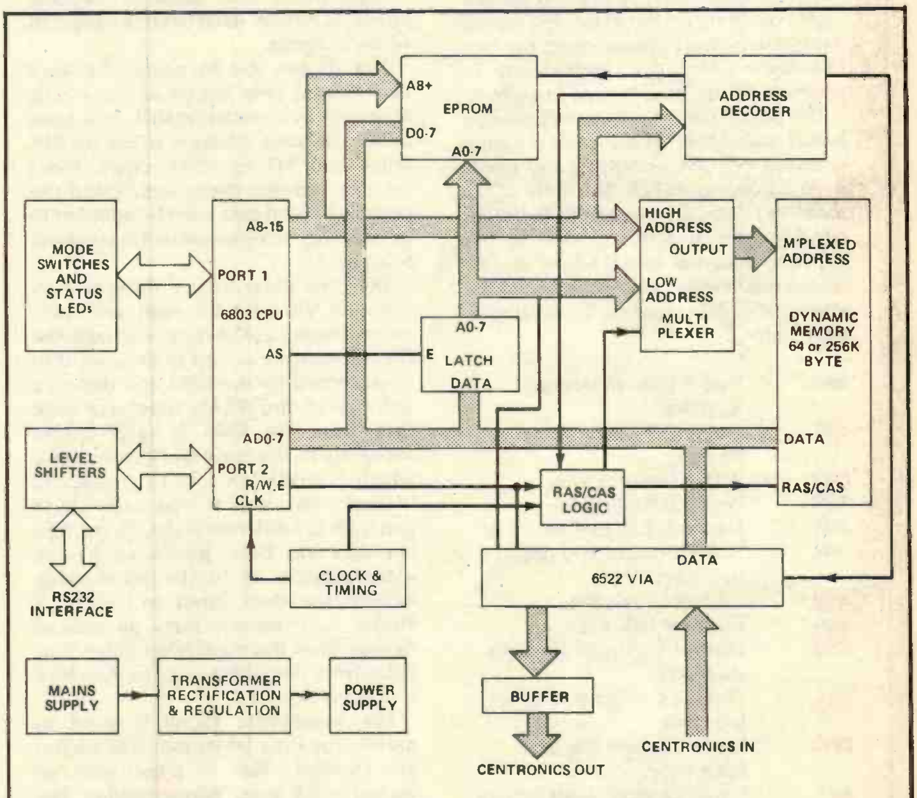


Fig. 1 Block digram of the printer buffer.

A rotary switch selects the desired transfer combination with an eighth position reserved for a self test mode. This checks the memory and the parallel and serial interfaces. The status of each is indicated by flashing the LEDs on the front of the unit.

A PAUSE switch halts the output to the printer although data is still accepted from the host micro and the RESET switch resets the entire unit, clears any data present and allows a new operating mode to be selected.

Four LEDs indicate when the pause is active, when the buffer unit is empty of data and when the unit is full and the fourth flashes at about 1Hz with a duty cycle proportional to the fullness of the buffer memory.

The software checks the state of the interfaces in turn in a continuous loop. Whenever a data transfer has been acknowledged then the next character is processed. This allows the asynchronous supply of data and retrieval of data from the buffer.

At the end of each loop the status LEDs are updated. A regular timed interrupt is used to initiate a software refresh of the DRAM and test whether the PAUSE switch is pressed or not.

Construction

A soldering iron with a fine tip is needed to prevent solder bridges between the fine tracks of the PCB. Solder all the through pins first.

Unless you are an experienced constructor and have a temperature controlled iron, it is recommended that sockets are

HOW IT WORKS

Whenever a microprocessor has to address more memory than it was originally intended for, there is always the problem of how to split it up. The buffer RAM is divided into 32K blocks — two for the 64K version and eight for the 256K version.

Three of the I/O lines on the 6803 (PI/O-2) act as extra address lines. The main difference between the 64K and 256K DRAM chips is that pin 1 is used for refreshing on the former and address line A8 on the latter. To prevent refresh cycles occuring on the 64K chips during a normal memory access cycle, the two I/O lines which are multiplexed to produce A8 are always kept at logic 1.

The paged DRAM is located between &4000 and &BFFF in the memory map with the EPROM occupying the space from &C000 to &FFFF. The only other memory mapped component, the 6522, is addressed at &100 to &10F in the partially decoded space below &4000. All the 6803's internal RAM, timer, serial and parallel data registers are located in page zero:

&00	Port 1 Data Direction Register
&01	Port 2 Data Direction Register
&02	Port 1 Data Register
&03	Port 2 Data Register
&04–07	Unused, External Memory
&08	Timer Control and Status Register
&09	Counter High Byte
&0A	Counter Low Byte
&0B	Output Compare Register High Byte
&0C	Output Compare Register Low Byte
&0D	Input Capture Register High Byte
&0E	Input Capture Register Low Byte
&0F	Unused, Exernal Memory
&10	Rate and Mode Control Register
&11	Transmit/Receive Control and Status Register
&12	Receive Serial Data Register
&10	Transmit Serial Data Register
&14	RAM Control Register
&15–1F	Reserved
&20–7F	Unused, External Memory
&80–FF	Internal RAM

In order to fit I/O lines onto the 6803 CPU without departing from a 40 pin package, the low order address bus and data bus have been multiplexed. As a consequence each memory access cycle is split in two. During the first half, when the Data Strobe (E) is low, the low order address is placed on the multiplexed bus. The falling edge of the Address Strobe (AS) is provided to latch the data into a transparent latch (ICI8).

The non-multiplexed upper address lines and signals such as Read/Write are also stable by this time. The data to be read or written is transferred during the second part of the cycle, when E is high. It is important that the data buffers in peripheral devices are not activated until E is asserted otherwise bus contention will occur.

To keep the DRAM chips as small and cheap as possible, their address lines are multiplexed. Two strobes, Row Address Strobe (RAS) and Column Address Strobe (CAS) are used to latch each half of the address.

The strobes are so named because each DRAM chip has its memory cells arranged as a square matrix of n rows and n columns, where n is 256 for 64K chips and 512 for 256K chips. Strict timings between these signals and the periods of valid data must be adhered to in order to achieve correct operation. See Fig. 3.

The time delay from E rising to RAS falling is different for read and write cycles. During a read cycle, data from the DRAM must be set up in time for it to be accepted by the 6803 and during a write cycle, the DRAM must wait until data from the 6803 is valid before accepting it. The input clock to the 6803, which is divided by four to produce E, is used with a dual D type latch K16 to generate the different RAS/CAS timings. No data has been published by the manufacturers as to the relationship betwen the clock input and the data strobe E. However, tests on several devices show that there is typically a 50ns delay from the falling edge of the clock to a transition of E.

The Read/Write signal is used to modify the time when the IC16 latches are clocked. This is done with an exclusive-OR gate. When reading, the RAS signal is sent low on the first clock transition after E is high — this is the low to high edge. The low half of the address is latched into the DRAM at this point. Two logic gate delays provide the interval between RAS going low and the select signal of the 74LS257 multiplexers changing, so that the other half of the address is ready for when CAS goes low.

On the next clock transition of the same phase, if the correct address is decoded then CAS is sent low. Sufficient time is allowed for the data to be read by the CPU — which latches it on the falling edge of E. RAS and CAS are sent high again when E goes low and thus completes the read cycle.

During the write cycle, the same process as above occurs, but the Read/Write line now makes IC16 clock on the high to low edge of the input clock. This delays the production of RAS and CAS by half a clock period (about 100ns), ensuring the data from the CPU is valid by the time that it is latched into the DRAM by the falling edge of CAS. Since the period of E is fixed, the active part of a DRAM write cycle is 100ns shorter than for a read cycle.

Each time that the DRAM is accessed, all the locations in the column of the row that is addressed are refreshed. To refresh the whole chip, every row must be accessed at intervals of not more than 4ms.

A background program accesses every row once in 4ms. Timed interrupts trigger a program that runs through 256 consecutive bytes of EPROM. By arranging the low order address to be latched by RAS and strobing RAS on every memory access cycle even if the DRAM is not being accessed, the program in EPROM will keep the memory refreshed. A loss of just 5% processing speed results.

Interfaces

The centronics interfaces are connected to a 6522 Versatile Interface Adaptor IC20. Port B is used for parallel data output and Port A for parallel data input. Each centronics interface has three handshake lines. When the data has been set up and is stable, the sending unit pulses the STORE line low for a minimum of 0.5μs. The BUSY line is then sent high by the receiving device until it is ready to accept more.

At this point the ACKNOWLEDGE line is given a low pulse by the receiving unit to indicate that the current transfer is complete. The 6522's handshake lines are set to act as STROBE and ACKNOWLEDGE signals for each port although an additional RS flip-flop is required to generate the BUSY signal.

Parallel output data is buffered by a K21 and the handshake lines are buffered using spare gates from ICI. This enables long cables (over 3m) to be used.

The 6803's Serial Communications Interface is programmed to operate in the standard mark/space format with one start bit, one stop bit and no parity. The clock source is derived from the processor clock. A 4.9152MHz crystal must be used to generate the common baud rates of 1200 and 9600.

Consequently, the processor clock is 1.23MHz which requires a 1.25MHz version of the 6803, or better, and a 1.5MHz version of the 6522. It is unlikely a 1MHz 6803 and 6522 will fail to operate under these conditions.

The RTS and CTS handshaking lines are used with no facility for XON/XOFF handshaking. So, a full duplex interface can be split in two, one half to receive data only from the computer and the other to send data only to the printer. This enables serial-serial data transfers to take place concurrently without plug changing. If serial-serial transfers will never be used in a particular application, there is little point in using two D-type connectors.

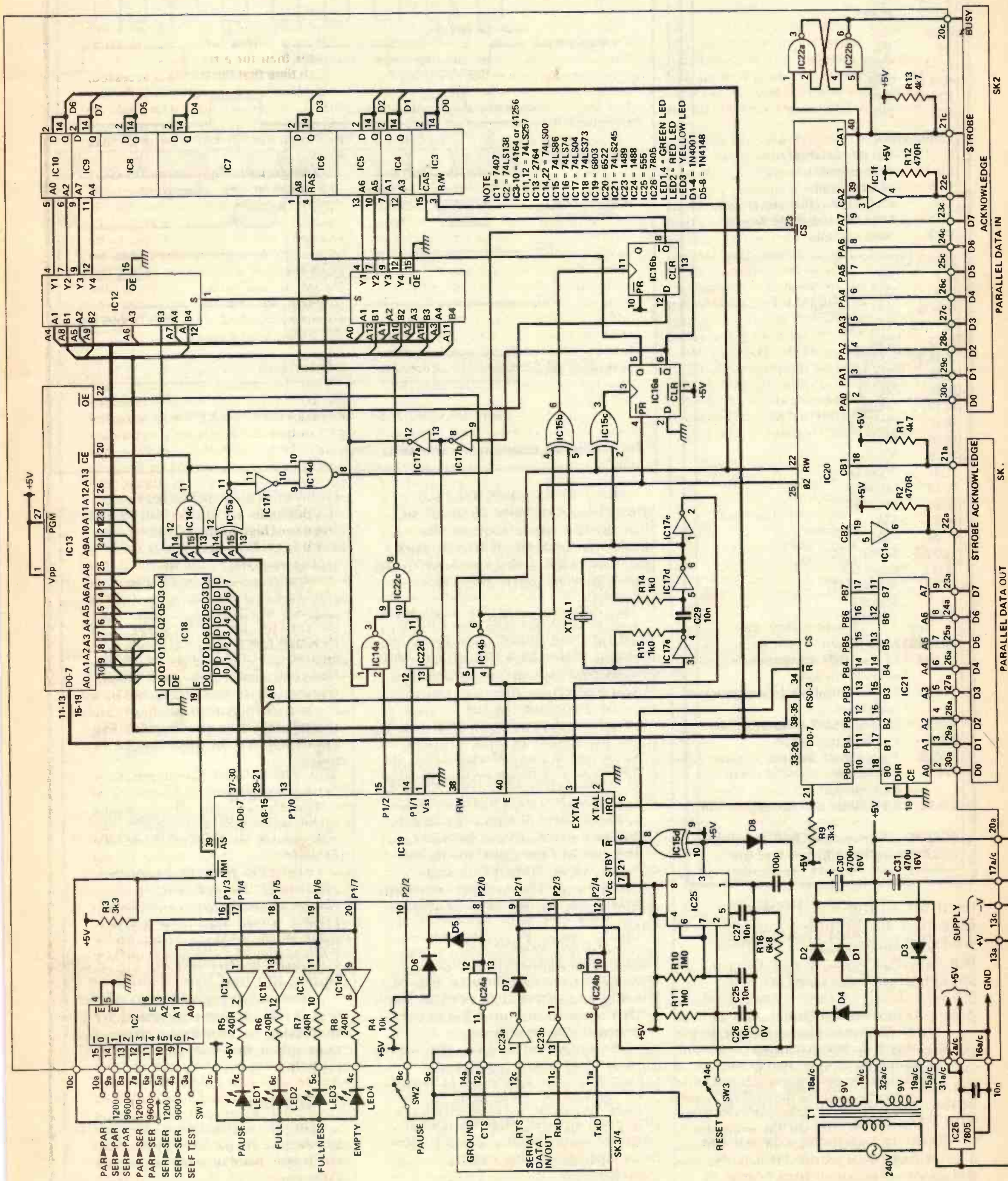


Fig. 2 The circuit diagram of the printer buffer.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,13	4k7
R2,12	470R
R3,9	3k3
R4	10k
R5-8	240R
R10,11	1M0
R14,15	1k0
R16	6k8
CAPACITORS	
C1,2	47μ 6V tantalum
C3-28	100n ceramic
C29	10n ceramic
C30	4700μ 16V radial electrolytic
C31	470μ 16V radial electrolytic
C32	100p ceramic
SEMICONDUCTORS	
IC1	7407
IC2	75LS138
IC3-10	4164 or 41256
IC11,12	74LS257
IC13	2764
IC14,22	74LS00
IC15	74LS86
IC16	74LS74
IC17	74LS04
IC18	74LS373
IC19	6803
IC20	6522
IC21	74LS245
IC23	MC1489
IC24	MC1488
IC25	555
IC26	7805
LED1,4	Green LED
LED2	Red LED
LED3	Yellow LED
D1-4	1N4001
D5-8	1N4148
MISCELLANEOUS	
CON1	64 way DIN 41612 plug & socket
SK1,2	36 way Amphenol Centronics socket
SK3,4	25 way RS232 D socket
SW1	1 pole 8 way rotary
SW2,3	1 pole push button
T1	9-0-9V 30VA toroidal mains transformer
XTAL1	4.9152MHz crystal

PCB; IC sockets; case; PCB standoffs; TO220 mounting kit; nuts and bolts.

used for all the ICs. However, note that all the holes must be soldered both sides to connect the two PCB foils. In any case a socket should be used for the EPROM (IC13) in case a modified program is ever required.

Figure 5 shows the component overlay for the PCB. Before soldering in the DIN 41612 connector, it should be properly seated on the PCB and then fixed to it with 2.5x10mm bolts.

To ensure that the case of the crystal does not short circuit the tracks on the component side of the board, a piece of insulating material should be fixed to the downward facing side.

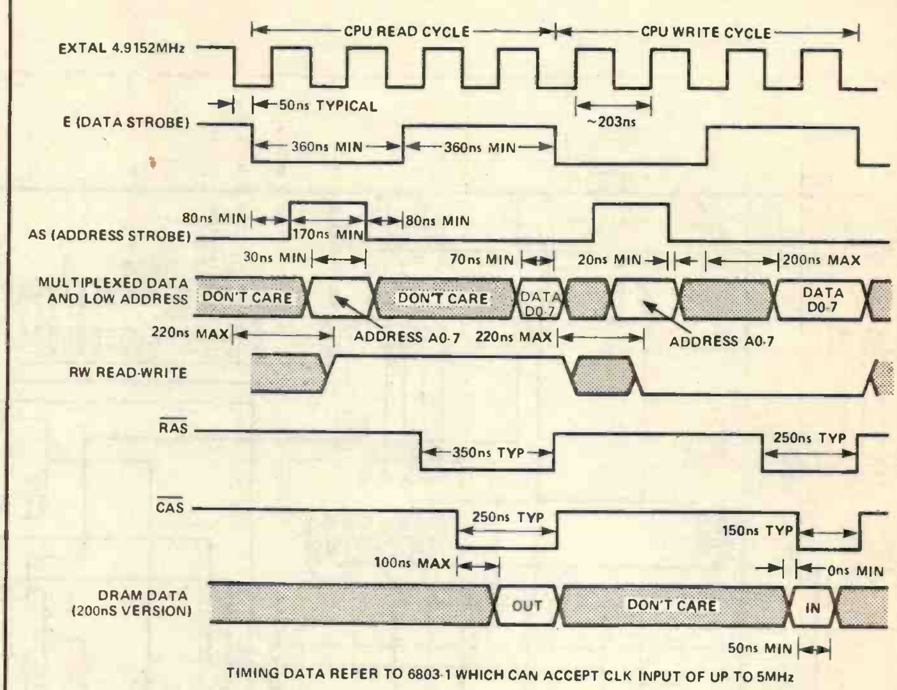


Fig. 3 Timing diagram for the 6803 CPU.

The freshly soldered PCB should be carefully cleaned of flux on the underside of the board using a small brush and paraffin, with a finer solvent used afterwards to wash away the paraffin.

Finally, insert the ICs. Avoid wearing man-made clothes so as to keep static to a minimum and always rest ICs on a conducting surface such as the non-painted side of a biscuit tin lid.

Either 4164 or 41256 ICs may be used for IC3-10 to give a buffer size of 64K or 256K. The correct first byte of the EPROM software for the buffer size must be used.

The printer buffer has been designed to fit into a pressed sheet metal box approximately 160mm wide, 80mm tall and 200mm long. The voltage regulator (IC26) bolts to the side of the case.

In the prototype the Centronics connectors are mounted on each side of the box, the RS232 connectors on the back with the switches and LEDs on the front. All connections to off-board components are made via a 64 way DIN 41612 connector located at one end (Fig. 6). Three support locations have been provided on the PCB so that it can be fixed to the base of the box, straddling the mains transformer.

Before drilling any holes, satisfy yourself that the components will all fit together in their intended positions. Remember to allow enough space for the DIN connector to be removed from the PCB with all the wires attached to it.

For greatest safety, the earth of the mains cable should be bolted directly to the base of the case using a spade terminal. If the signal ground potential of any of the units likely to be connected to the buffer is not floating or Earth, then the 7805 regulator must be insulated from the case using standard TO220 insulating washers.

Software

Finally, a programmed EPROM should be plugged into position as IC13.

The EPROM can be either a 2764 or 27128 type and it should be programmed according to Listing 1. For use with a 64K buffer the first byte should contain the number 06. For a 256K buffer the first byte should be 00.

This arrangement also allows a 64K buffer to be upgraded to 256K by replacing the RAM chips and over-programming the first byte with 00.

Testing

Before using the unit a series of checks must be made. Run through the connections to the DIN plug and make sure that all are correct. Take particular care with the supply wires from the transformer. Turn the unit on

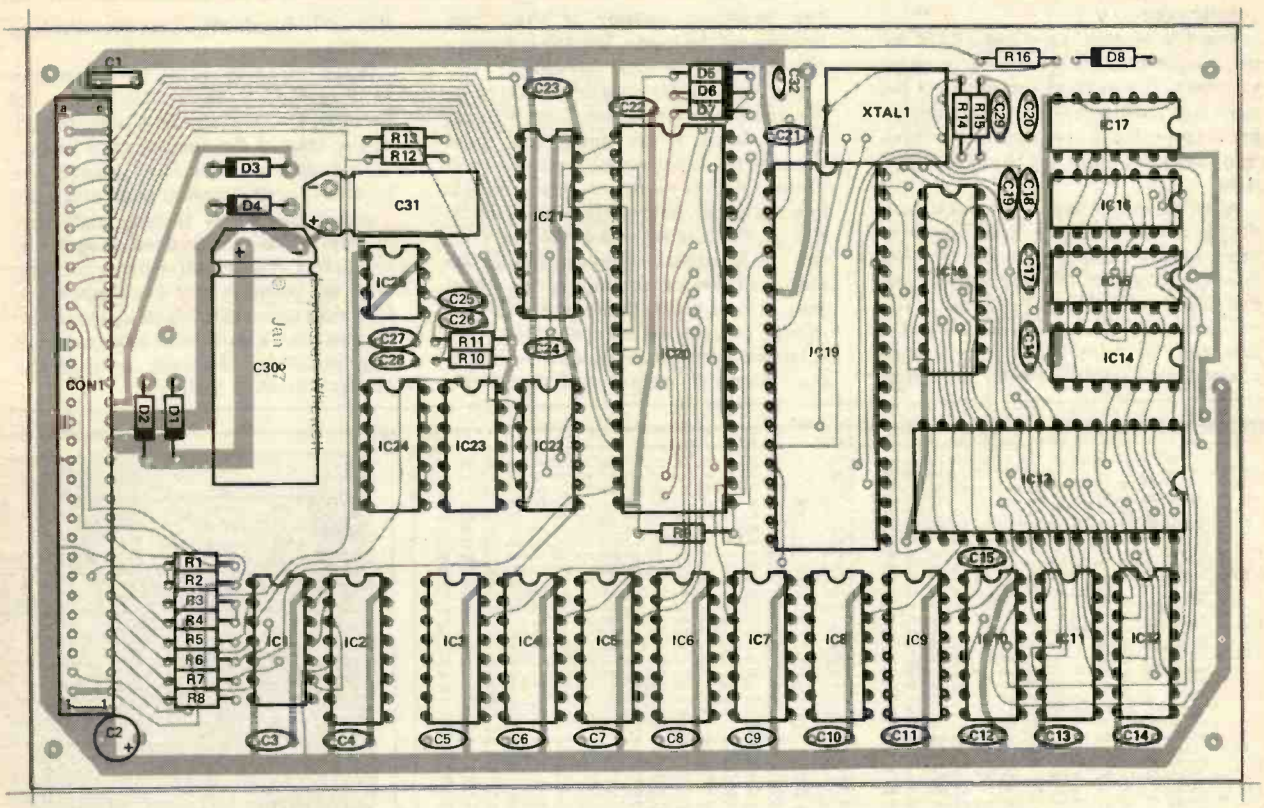


Fig. 4 The component overlay for the printer buffer board.

Pin	Row a	Row b
Pin	**Row a**	**Row b**
1	ground	ground
2	+5V	+5V
3	mode 7 select	LED anodes
4	mode 6 select	EMPTY LED cathode
5	mode 5 select	FULLNESS LED cathode
6	mode 4 select	FULL LED cathode
7	mode 3 select	PAUSE LED cathode
8	mode 2 select	PAUSE switch
9	mode 1 select	PAUSE/RESET common
10	mode 0 select	mode select return
11	TxD	RxD
12	CTS	RTS
13	IC24 +V	IC24 –V
14	RS232 ground	RESET switch
15	+V rectified output	+V rectified output
16	7805 regulator ground	7805 regulator ground
17	–V rectified output	–V rectified output
18	T1 secondary I	T1 secondary I
19	T1 secondary II	T1 secondary II
20	Centronics data ground	BUSY (IN)
21	ACKNOWLEDGE (OUT)	ACKNOWLEDGE (IN)
22	STROBE (OUT)	STROBE (IN)
23	D7 (OUT)	D7 (IN)
24	D6 (OUT)	D6 (IN)
25	D5 (OUT)	D5 (IN)
26	D4 (OUT)	D4 (IN)
27	D3 (OUT)	D3 (IN)
28	D2 (OUT)	D2 (IN)
29	D1 (OUT)	D1 (IN)
30	DO (OUT)	DO (IN)
31	+5V	+5V
32	transformer ground	transformer ground

Table 1 DIN 41612 connector pin-out.

Pin	Function
1	Strobe
2	D0
3	D1
4	D2
5	D3
6	D4
7	D5
8	D6
9	D7
10	Acknowledge
11	Busy
12-18	Not connected
19-28	Ground
29-36	Not connected

Table 2 Centronics interface connections.

Pin	Function
2	TxD
3	RxD
4	RTS
5	CTS
7	Ground

Table 3 RS232 interface connections.

Software

The 128 bytes of zero page RAM are used both for the stack and program variables. The main requirement of the stack is to store registers during a refresh interrupt — using seven bytes at a time. This leaves the entire DRAM free to hold data.

After the buffer has been reset it must decide which operating mode it is in. In order to save components, the CPU I/O lines connected to the LED outputs also drive the mode select decoder (IC2). The decoder is enabled and each output is selected in turn until the return connection causes an NMI interrupt. The selected output at that time determines the mode. The I/O lines then revert to their normal operation.

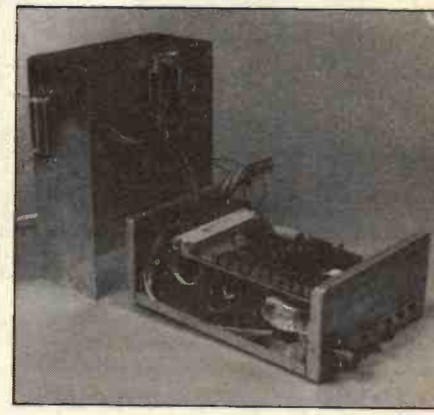
The main buffer program selected by the mode switch consists of a never ending loop. If the buffer has spare capacity, the input source is checked and if more data is ready it is read and put into the buffer. In the case of serial input, if there are less than 64 bytes free then the CTS handshake line is negated. The loop then checks the status of the output port. If there is data in the buffer and the printer is ready to accept it (either by acknowledging the previous byte sent to the Centronics output or asserting the RTS serial handshake line) the next byte is sent.

Again, for serial inputs, the CTS output is asserted if there are over 128 bytes free in the buffer. A branch back to the start of the loop is then made.

This alternate sampling ensures the printer is kept supplied with data even if the computer is sending data very rapidly. When receiving serial input, any characters that result from a framing error are ignored. It is less annoying to find a character missing in a pice of text than to have a corrupted character ruin a printout by changing one of the printer's internal settings.

```
0000    3B 3B 3B 3B 3B 96 02 84 F7 97 02 96 8A 8A 80
0010 97 8A 3B 86 FF 4C 81 08 27 13 97 8A 16 58 58 58
0020 58 58 CA 08 D7 02 01 01 7D 00 8A 2A E8 96 8A 84
0030 07 97 8A 39 86 FF B7 01 02 4F B7 01 00 B7 01 03
0040 86 41 B7 01 0B 86 AC B7 01 0C 86 AA B7 01 0C 7F
0050 01 04 86 09 B7 01 05 86 FF B7 01 0D 86 C0 B7 01
0060 0E 7F 00 89 39 0F 8E 00 FF BD E0 34 86 FF 97 00
0070 86 76 97 02 86 01 97 01 97 03 B6 E0 00 97 82 97
0080 83 97 86 CE 40 00 DF 84 DF 87 7F 00 8B 7F 00 8C
0090 7F 00 BD 7F 00 8E 7F 00 8F 0E BD E0 13 86 76 97
00A0 02 D6 8A 26 03 7E E1 F8 C1 07 27 19 5A 86 06 54
00B0 24 02 86 05 97 10 58 CE E0 BF 3A EE 00 6E 00 E2
00C0 A7 E3 96 E4 56 BD E0 E8 26 06 96 02 88 B0 97 02
00D0 BD E1 83 26 06 96 02 88 40 97 02 BD E1 CC 26 E5
00E0 96 02 88 20 97 02 20 DD BD E0 F4 CE 06 DB 09 26
00F0 FD 7E E1 33 D6 02 C4 F0 DA 82 D7 02 86 EA C6 08
0100 CE 40 00 4C A7 00 8B 2D A7 01 8B 2D A7 02 8B 2D
0110 A7 03 8B 2D A7 04 8B 2D A7 05 8B 2D A7 06 8B 2D
0120 A7 07 8B 2D 3A 8C C0 00 26 D9 4C 7C 00 02 D5 02
0130 27 CE 39 D6 02 C4 F0 DA 82 D7 02 86 EA C6 08 CE
0140 40 00 4C A1 00 26 3B 8B 2D A1 01 26 35 8B 2D A1
0150 02 26 2F 8B 2D A1 03 26 29 8B 2D A1 04 26 23 8B
0160 2D A1 05 26 1D 8B 2D A1 06 26 17 8B 2D A1 07 26
0170 11 8B 2D 3A 8C C0 00 26 C9 4C 7C 00 02 D5 02 27
0180 BE 4F 39 C6 06 8D 04 26 F9 C6 05 D7 10 C6 0A D7
0190 11 96 03 8A 01 97 03 C6 02 D5 03 27 2C 96 03 84
01A0 FE 97 03 D5 03 26 22 7D 00 11 7D 00 12 4F C6 20
01B0 D5 11 27 FC 97 13 D6 11 C4 C0 27 FA C4 40 26 09
01C0 D6 12 11 26 04 4C 26 E6 39 86 FF 39 C6 3F F7 01
01D0 0E B7 01 0D 4F 87 01 00 01 01 C6 02 F5 01 0D 27
01E0 14 F6 01 01 11 26 0E C6 10 F5 01 0D 27 07 F7 01
01F0 0D 4C 26 E1 39 C6 FF 39 86 02 B5 01 0D 27 FB B6
0200 01 01 B7 01 00 D6 86 DE 87 08 8C C0 00 26 0A CE
0210 40 00 5C C1 08 26 02 D6 82 9C 84 26 0C D1 83 26
0220 08 96 02 84 DF 97 02 20 32 B6 01 0D 84 02 27 2B
0230 B6 01 01 D6 02 C4 FB DA 86 D7 02 DE 87 A7 00 D6
0240 86 08 8C C0 00 26 0A CE 40 00 5C C1 08 26 02 D6
0250 82 DF 87 D7 86 96 02 8A 80 97 02 B6 01 0D 84 10
0260 27 A3 D6 83 DE 84 9C 87 26 0C D1 86 26 08 96 02
0270 84 7F 97 02 20 B3 7D 00 8F 2B 8A D6 02 C4 F8 DA
0280 83 D7 02 A6 00 B7 01 00 D6 83 08 8C C0 00 26 0A
0290 CE 40 00 5C C1 08 26 02 D6 82 DF 84 D7 83 96 02
02A0 8A 20 97 02 7E E2 05 86 08 97 11 96 03 84 FE 97
02B0 03 96 11 84 C0 27 FA 2B 04 96 12 20 F4 96 12 B7
02C0 01 00 DC 87 C3 00 40 37 D6 86 81 C0 26 09 80 80
02D0 5C C1 08 26 02 D6 82 36 38 9C 84 26 12 D1 83 26
02E0 0E 96 02 84 DF 97 02 96 03 8A 01 97 03 20 36 96
02F0 11 84 C0 27 30 2B 04 96 12 20 2A 96 12 D6 02 C4
0300 FB DA 86 D7 02 DE B7 A7 00 D6 86 08 8C C0 00 26
0310 0A CE 40 00 5C C1 08 26 02 D6 82 DF 87 D7 86 96
0320 02 BA 80 97 02 B6 01 0D 84 10 27 96 D6 83 DE 84
0330 9C 87 26 0C D1 86 26 08 96 02 84 7F 97 02 20 AF
0340 7D 00 8F 2B 4E D6 02 C4 FB DA 83 D7 02 A6 00 B7
0350 01 00 D6 83 08 8C C0 00 26 0A CE 40 00 5C C1 08
0360 26 02 D6 82 DF 84 D7 83 96 02 8A 20 97 02 DC 87
0370 C3 00 80 37 D6 B6 81 C0 26 09 80 80 5C C1 08 26
0380 02 D6 82 36 38 9C B4 26 0A D1 83 26 06 96 03 84
0390 FE 97 03 7E E2 C2 86 02 97 11 B5 01 0D 27 FB 86
03A0 20 95 11 27 FC 86 02 95 03 26 FC B6 01 01 97 13
03B0 D6 86 DE 87 08 8C C0 00 26 0A CE 40 00 5C C1 08
03C0 26 02 D6 82 9C 84 26 0C D1 83 26 08 96 02 84 DF
03D0 97 02 20 32 B6 01 0D 84 02 27 2B B6 01 01 D6 02
03E0 C4 FB DA 86 D7 02 DE 87 A7 00 D6 86 08 8C C0 00
03F0 26 0A CE 40 00 5C C1 08 26 02 D6 82 DF 87 D7 86
0400 96 02 8A 80 97 02 86 02 95 03 26 A4 86 20 95 11
0410 27 9E D6 83 DE 84 9C 87 26 0C D1 B6 26 08 96 02
0420 84 7F 97 02 20 AE 7D 00 8F 2B 85 D6 02 C4 FB DA
0430 83 D7 02 A6 00 97 13 D6 83 08 8C C0 00 26 0A CE
0440 40 00 5C C1 08 26 02 D6 82 DF 84 D7 83 96 02 8A
0450 20 97 02 7E E3 B0 86 0A 97 11 96 03 84 FE 97 03
0460 DC 87 C3 00 40 37 D6 86 81 C0 26 09 80 80 5C C1
0470 08 26 02 D6 82 36 38 9C 84 26 12 D1 83 26 0E 96
0480 02 84 DF 97 02 96 03 8A 01 97 03 20 36 96 11 84
0490 C0 27 FA 2B 04 96 12 20 2A 96 12 D6 02 C4 FB DA
04A0 86 D7 02 DE 87 A7 00 D6 86 08 8C C0 00 26 0A CE
04B0 40 00 5C C1 08 26 02 D6 82 DF 87 D7 86 96 02 8A
04C0 B0 97 02 86 02 95 03 26 97 86 20 95 11 27 91 D6
04D0 83 DE 84 9C 87 26 0C D1 86 26 08 96 02 84 7F 97
04E0 02 20 AA 7D 00 8F 2B 4D D6 02 C4 FB DA 83 D7 02
04F0 A6 00 97 13 D6 83 08 8C C0 00 26 0A CE 40 00 5C
0500 C1 08 26 02 D6 82 DF 84 D7 83 96 02 8A 20 97 02
0510 DC 87 C3 00 80 37 D6 86 81 C0 26 09 B0 80 5C C1
0520 08 26 02 D6 82 36 38 9C 84 26 0A D1 83 26 06 96
0530 03 84 FE 97 03 7E E4 60 B6 01 0D B4 01 0E 85 40
0540 27 45 C6 40 F7 01 0D 8D 70 8D 3D 96 8A B1 07 27
0550 36 DE 8B 9C 8D 26 06 D6 02 CA 40 D7 02 08 DF 8B
0560 8C 02 00 26 22 7F 00 8B DC 87 93 84 16 07 58 06
0570 96 B6 92 83 7D E0 00 26 02 04 04 84 01 DD 8D 27
0580 06 96 02 84 BF 97 02 3B 86 04 95 03 26 24 86 08
0590 95 8F 26 1D 7C 00 BF 95 8F 27 16 D6 8F 17 C4 80
05A0 54 54 54 D7 90 88 80 97 8F D6 02 C4 EF DA 90 D7
05B0 02 39 96 BF 84 80 97 8F 39 73 00 89 2B 7F CE 00
05C0 00 CE 00 01 CE 00 02 CE 00 03 CE 00 04 CE 00 05
05D0 CE 00 06 CE 00 07 CE 00 08 CE 00 09 CE 00 0A CE
05E0 00 0B CE 00 0C CE 00 0D CE 00 0E CE 00 0F CE 00
05F0 10 CE 00 11 CE 00 12 CE 00 13 CE 00 14 CE 00 15
0600 CE 00 16 CE 00 17 CE 00 18 CE 00 19 CE 00 1A CE
0610 00 1B CE 00 1C CE 00 1D CE 00 1E CE 00 1F CE 00
0620 20 CE 00 21 CE 00 22 CE 00 23 CE 00 24 CE 00 25
0630 CE 00 26 CE 00 27 CE 00 28 CE 00 29 39 CE 00 00
0640 CE 00 01 CE 00 02 CE 00 03 CE 00 04 CE 00 05 CE
0650 00 06 CE 00 07 CE 00 08 CE 00 09 CE 00 0A CE 00
0660 0B CE 00 0C CE 00 0D CE 00 0E CE 00 0F CE 00 10
0670 CE 00 11 CE 00 12 CE 00 13 CE 00 14 CE 00 15 CE
0680 00 16 CE 00 17 CE 00 18 CE 00 19 CE 00 1A CE 00
0690 1B CE 00 1C CE 00 1D CE 00 1E CE 00 1F CE 00 20
06A0 CE 00 21 CE 00 22 CE 00 23 CE 00 24 CE 00 25 CE
06B0 00 26 CE 00 27 CE 00 28 39 00 00 00 00 00 00 00
1F00 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A
1F10 50 72 69 6E 74 65 72 20 42 75 66 66 65 72 20 20
1F20 68 61 72 64 77 61 72 65 2C 20 20 20 20 20 20 20
1F30 73 6F 66 74 77 61 72 65 20 61 6E 64 20 20 20 20
1F40 50 43 42 20 64 65 73 69 67 6E 20 62 79 20 20 20
1F50 4C 65 79 63 65 73 74 65 72 20 20 20 20 20 20 20
1F60 57 68 65 77 65 6C 6C 20 20 20 20 20 20 20 20 20
1F70 33 72 64 20 4D 61 72 63 68 20 31 39 38 37 20 20
1F80 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A 2A
1FF0 E0 01 E0 02 E0 03 E0 04 E5 38 E0 05 E0 06 E0 65
```

Listing 1 Hex dump of the used sections of the EPROM (see text for first byte).



without the PCB plugged in and check that each of the supply inputs read 9V relative to ground and that they are at 18V relative to each other.

Plug in the PCB and run the unit in the self test mode. The memory test involves writing to every byte of RAM, waiting 10ms to check the refresh system and then verifying that data. If successful, the EMPTY LED is toggled and next time the process is repeated with a different arrangement of data. A full check on 256K of RAM takes a couple of seconds.

To check the parallel ports, a lead with a Centronics connector at each end is required. By connecting the output to the input, a check is made on the transfer of 256 bytes of data. When the data is verified and separate tests on the handshake lines are satisfactory then the FULL LED is toggled.

The serial interface is checked in a similar way — by connecting the data lines and the handshake lines together. Tests are performed at 1200 and 9600 baud and if successful, the FULLNESS LED is toggled. If all is well, the buffer is now ready to earn its keep. **ETI**

THE ETI EEG MONITOR

Paul Chappell describes how to connect up your computer and your train set to the brainwave monitor.

I got so carried away on the subject of electrodes and biofeedback last month, I had no space to tell you about the output sockets. I'll put that right in this final article.

The circuits I have suggested later on are in the nature of Tech Tips — ideas for you to experiment with and adapt for your own use. Half the fun of electronics is in getting your own circuit designs up and running and since the interface requirements of the monitor are quite straightforward (and the outputs pretty indestructible unless you try really hard) it's the ideal place to start.

Before starting on the circuits I should say a few words about safety. In the earlier articles the monitor has been used as a stand alone, battery powered instrument and as such can't do you any harm. The outputs have been designed to allow the connection of mains powered equipment without undue risk but there are a few precautions to be aware of.

Safety

Electronic equipment can and does go wrong. If this happens with a bio-medical device where your body forms part of the circuit, the consequences could be unpleasant and possibly fatal.

The current necessary to harm you depends very much on where the electrodes are placed. From two electrodes on the same hand, for instance, you could take a considerable current without lasting effect. With electrodes on opposite hands, allowing a current path through the heart, a few tens of milliamps may be enough to put you out of action for good.

A rough guide is that 1mA will produce a tingling sensation (like a 9V battery touched to your tongue), 20mA will cause muscle contractions which may mean that you are unable to let go of the conductor, 50mA and above may interrupt the heart rhythm or stop it altogether, cause tissue damage and stop you from breathing.

For safety, the EEG monitor is powered from batteries and all connections to external circuitry are optically isolated. A few simple rules *must* be observed for your own protection:

- The monitor must *not* be operated from a mains power supply or 'battery eliminator'.
- The case of the monitor or any part of the circuit or electrodes must *not* be connected directly or indirectly to earth.
- An indirect connection to mains earth might happen if external equipment is plugged into the monitor's outputs and connection is made to the shell of the plug. *Only the pins* of the plug should be connected. If you use screened wire, the screen should be connected to the ground pin and not to the plug shell.
- The monitor should *not* be probed with mains powered equipment (an oscilloscope, for instance) while you are wearing the electrodes.

Household earthing systems are not always as good as they might be, particularly in older properties. Connecting the monitor to mains earth could put you at risk if a fault develops in an appliance anywhere in the house. There is also the possibility that the earth wire may become disconnected and allow leakage currents from (say) a capacitive mains filter to flow through you if you happen to touch a grounded metal object (a central heating radiator, perhaps).

Household safety regulations are made on the assumption that any contact with faulty equipment will be casual and through dry skin. Strapping electrodes to your head and reducing your skin resistance,to a low value with saline solution is a different matter altogether!

Please take care. We don't want to lose any readers!

The Switching Output

The output from SK3 switches at a level set by R45 and R46. If you set the monitor to *alpha*, this outut will be high when you are producing a small amount of alpha and low when you produce a lot. It can be connected directly to a home computer in place of the usual fire button on the joystick. Figure 1a shows how. The other joystick controls can be left connected in the usual way.

You'll have to be a pretty agile alpha producer to play ordinary computer games like this but don't let me discourage you from having a go. Otherwise, you can write programs for yourself which run at a slower pace.

If you saw the BBC's QED program on alpha a few months ago, you may remember Dr. Lewis had his trainees connected to an electric train set. When they produced alpha the train would go, when they didn't it would stop. The easiest way to do this is shown in Fig. 1b.

To select the 'on' speed of the train, short across pins 2 and 3 of the monitor's output socket and set the transformer control to give the speed you want. A small heatsink will be needed for the power FET.

Switching of other low voltage circuits can be achieved in a similar way (Fig. 1c). The capacitor C1 of Fig. 1b will not usually be necessary. It is included in the train controller because train set transformers usually have little or no smoothing.

The 1N4001 rectifier can also be left out. It is included to prevent damage to the circuit if the train set control is reversed. The only components necessary are the FET and a resistor!

The supply voltage for Fig. 1c can be anywhere between 9V and 40V — whatever the load requires. The specified FET will switch currents up to 4A, which should be enough for most purposes! A heat sink will be needed for currents above about 1A. You can use the circuit to give a practical demonstration of mind power by turning a light bulb or radio set on and off!

The switching threshold can be roughly set by varying the monitor's gain control but if you intend to make frequent use of this output, you may like to consider wiring a 47k log pot in place of R46. This will give more direct control over the switching point. The track of the pot is connected across the R46 position and the slider goes to IC6 pin 2. You may have trouble finding room for the extra control on the front panel!

The Analogue Output

The analogue output from SK2 gives a much finer control over

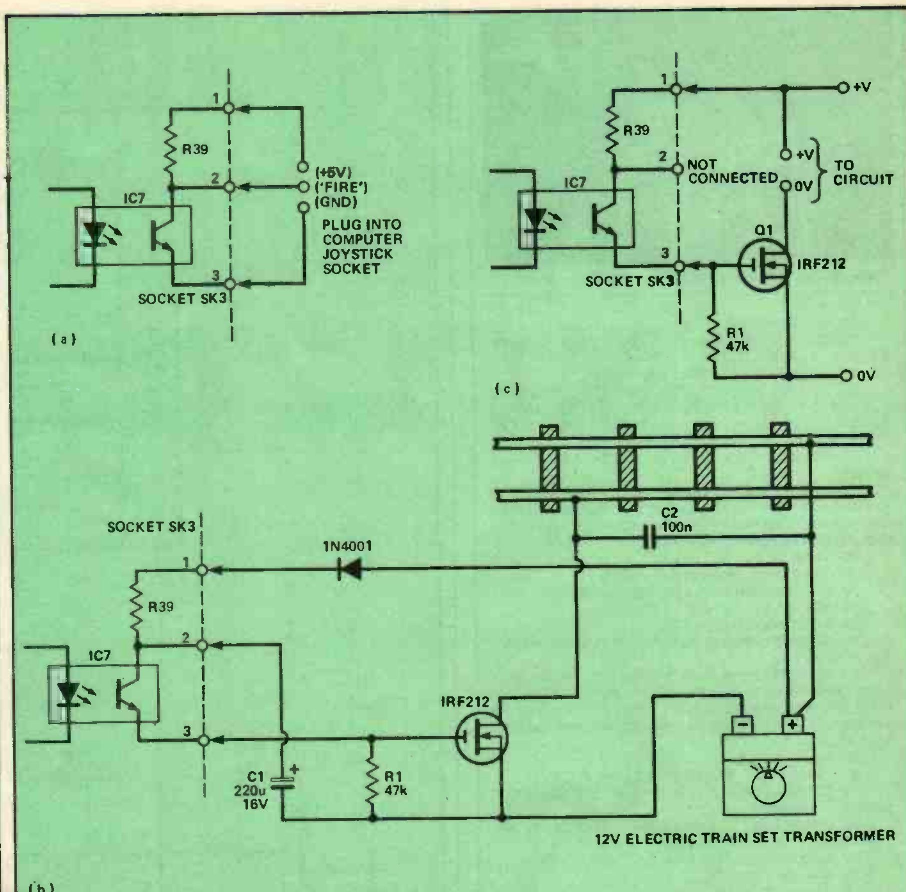


Fig. 1 Interfacing with the switched output. (a) Connecting the monitor to a micro's joystick fire input. (b) Controlling a model train set. (c) The circuit for general switched control.

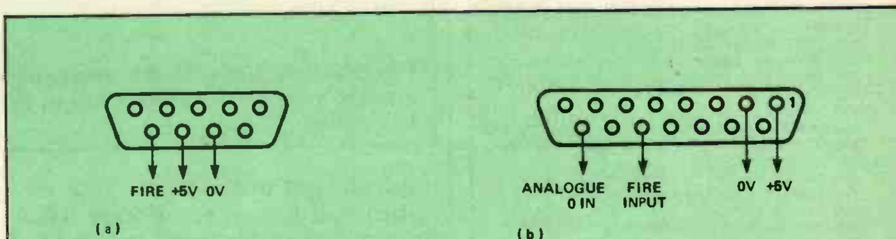


Fig. 2 Joystick pinouts for (a) Atari/Commodore standard (switch joysticks, also found on many Spectrum interfaces) and (b) the BBC micro pinout.

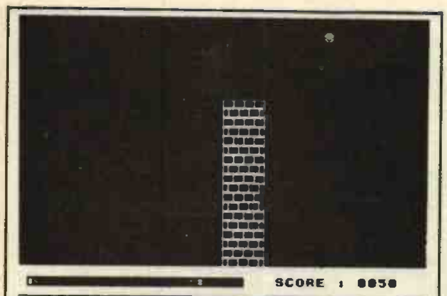
computer games than the switching output. A general purpose monitor-to-computer interface circuit is shown in Fig. 3a. The circuit will work with almost any computer with an analogue input port (either built in or as an add-on).

The interface circuit adjusts the output voltage range of the monitor to one which suits the computer. The LM358 was chosen for this circuit because it will operate from the low voltage supply, it takes very little current (less than 2mA) and has an output which will go all the way down to 0V (with the help of R7!)

RV3 sets the gain of the circuit so that a given increase in alpha can make a small or a large difference to the output voltage. RV1 and RV2 set the lower limit of the output voltage. It's useful to have RV2 as a pot rather than a preset — it can then be used as a kind of Y-shift control for the computer screen.

Setting the pots is best explained with reference to an actual game, and by a strange coincidence we've got one for you in Listing 1. The game runs on the BBC micro and will stretch your mental powers to the limit!

Your player starts at the left of the screen with the same aim as the chicken when it crossed the




```
   10 MODE1
   20 ON ERROR RUN
   30 DATA 1,15, 1,10, 1,5, 2,4,15, 3,4,11,17, 4,3,8,13,17
   40 VDU19,0,4;0;23,1,0;0;0;0;
   50 VDU23,240,254,254,254,254,254,254,0,0,23,241,239,239,239,239,239,239,0,0,23,255,0,-1,-1,-1,-1,-1,-1,0,23,254,0,127,127,127,127,127,127,0
   60 VDU23,242,60,126,219,255,189,219,102,60
   70 B$=STRING$(9,CHR$240+CHR$240+CHR$240+CHR$240+CHR$8+CHR$8+CHR$8+CHR$8+CHR$10+CHR$241+CHR$241+CHR$241+CHR$241+CHR$8+CHR$8+CHR$8+CHR$8+CHR$10)
   80 inc%=2
   90 SC=0:FOR screen%=0 TO 5
  100 COLOUR130:CLS:COLOUR1:GCOL0,2
  110 VDU24,8;104;1271;1016;16
  120 READN%:FORI%=1TON%
  130 READA%:PRINTTAB(A%*2,11*((screen%+I%)MOD2))B$;
  140 MOVEA%*64-4,448-352*((screen%+I%)MOD2):DRAWA%*64-4,1020-352*((screen%+I%)MOD2):DRAWA%*64+124,1020-352*((screen%+I%)MOD2):DRAWA%*64+124,448-352*((screen%+I%)MOD2)
  150 NEXT I%
  160 COLOUR128:PRINTTAB(1,30)SPC(21)
  170 COLOUR130:COLOUR0:PRINTTAB(25,30)"SCORE : 0000"
  180 PRINTTAB(37-LEN(STR$(INT(SC))),30);INT(SC)
  190 GCOL3,3:F%=FALSE
  200 X%=-32:Y%=500
  210 I%=INKEY(50)
  220 REPEAT
  230 SOUND2,-5,100+screen%*10,1
  240 I%=INKEY(5)
  250 OX%=X%:X%=X%+inc%:OY%=Y%
  260 Y%=ADVAL(1)/73+128
  270 VDU4,23,1,0;0;0;0;
  280 COLOUR1:COLOUR128
  290 PRINTTAB(1,30)CHR$254;STRING$(Y%/51-1,CHR$255);SPC(21-Y%/51)
  300 COLOUR130:COLOUR0
  310 SC=SC+0.125
  320 PRINTTAB(37-LEN(STR$(INT(SC))),30);INT(SC)
  330 VDU5
  340 VDU25,4,OX%;OY%;242,25,4,X%;Y%;242
  350 IF POINT(X%+32,Y%)>0 OR POINT(X%+32,Y%-32)>0 PROCBOOM
  360 UNTIL F% OR X%>1279
  370 VDU4,23,1,0;0;0;0;
  380 IF F% GOTO430
  390 FORN%=0TO50:I%=INKEY(4)
  400 SOUND1,-10,200+N%,1:SC=SC+1
  410 PRINTTAB(37-LEN(STR$(INT(SC))),30);INT(SC)
  420 NEXT N%
  430 I%=INKEY(80)
  440 NEXT screen%
  450 COLOUR130:CLS
  460 VDU24,8;8;1271;1016;16
  470 COLOUR128:COLOUR3
  480 PRINTTAB(14,10)"SCORE : ";INT(SC)
  490 T%=TIME:REPEAT UNTIL TIME>T%+100 OR INKEY(0)=32
  500 inc%=inc%*2:RESTORE:GOTO 90
  510 END
  520 DEF PROCBOOM
  530 F%=TRUE
  540 SOUND1,-10,5,20:SOUND0,-15,6,20
  550 I%=INKEY(100)
  560 ENDPROC
```

Listing 1. The BBC Basic alpha wave controlled computer game.

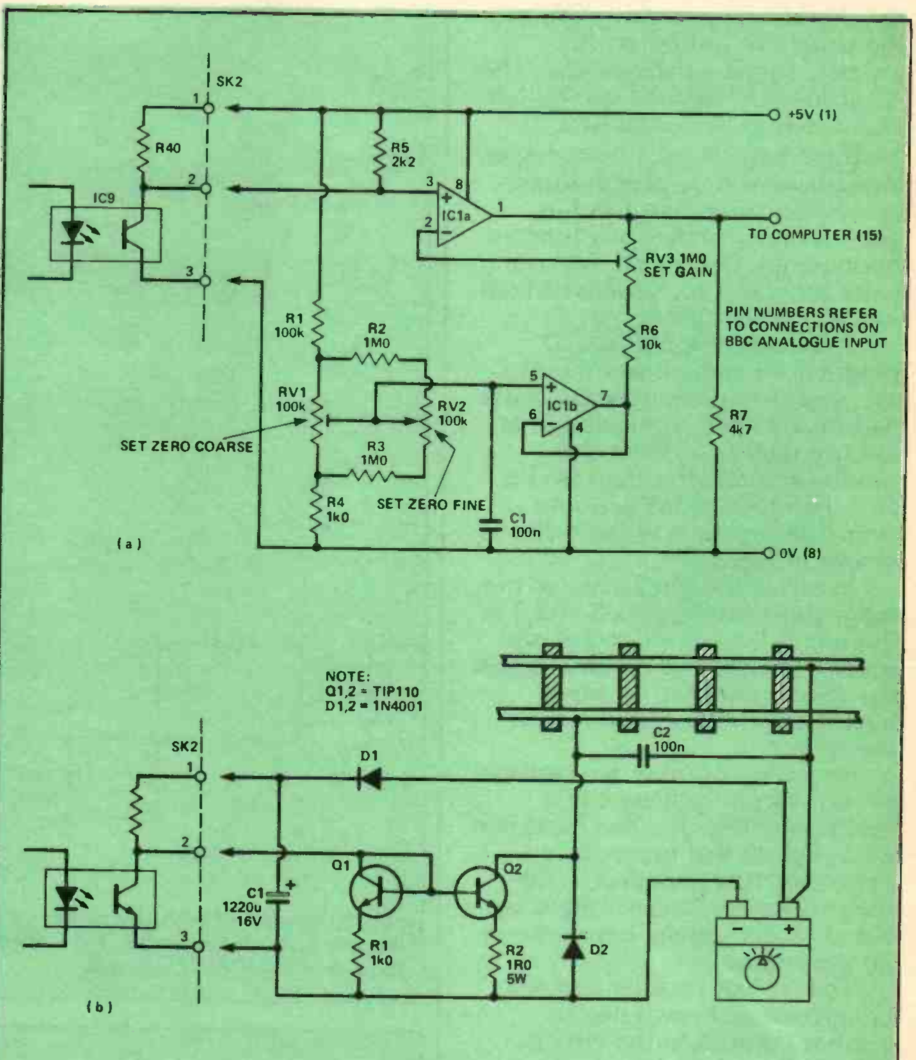


Fig. 3 Interfacing with the analogue output. (a) The circuit for connection to a micro's analogue joystick input. (b) A more sophisticated train set controller.

road. (To get to the other side — right?) Sad to say, somebody has built a wall in the way, so your player must jump over it. You help him by giving a burst of alpha which makes him light as a feather. Stopping the alpha lets him sink back to earth again.

The first screen has only one wall and moves slowly, so use it to set up the interface. Connect up the electrodes, set the monitor's mode switch to *alpha,* the output switch to *integrate* and the gain control to mid position. The sound output may be a distraction, so set it to *mute* or turn down the volume.

Set all the interface pots to mid position. Adjust RV1 to put the player fairly close to the bottom of the screen. If you've learned to produce alpha, try a burst now and see how far the player moves up the screen. Adjust RV3 to increase or decrease the responsiveness as necessary.

If you haven't learned to produce alpha and you're using the game to train yourself, leave RV3 at mid position and adjust RV2 until the player is just a little below the top of the wall. See if you can get your player to float just that bit higher to get over it. The first screen moves very slowly and will give you plenty of time to compose yourself. When you manage to get over the wall, don't go on to the next screen yet. Press Escape to re-start and try again with RV2 adjusted to start your player a bit lower down. Carry on until you can float him from somewhere near the bottom of the screen. You'll need to do this before tackling any of the downward pointing walls or you'll never get underneath!

A simple circuit for speed control of an electric train set is shown in Fig. 3b. The more alpha you produce, the faster goes the train! Q2 will need a substantial heatsink. Set the monitor to *alpha, integrate,* and about half gain to begin with, and away you go. Choo choo!

That completes the tips on using the monitor but if you invent an interesting circuit or application, don't forget our Tech Tips page — we'd all like to have a go! If you develop exceptional alpha-control abilities we'd like to hear about that too.

Commercial EEG Equipment

Just to put things in perspective, you may be interested to know what you'd get for your money (£5,000 for a cheap 'n' cheerful one) if you bought a commercial EEG machine. Photo 1 shows an elderly EEG recorder of about mid-sixties vintage (kindly lent by Mr. J. Fleming, research physicist at the Queen Mother's Hospital, Glasgow) and Photo 2 shows a currently available model.

The differences between these and the ETI monitor are much less than you might think. The essential distinctions are that EEG recorders produce output in the form of a trace on paper and they usually have several channels to make simultaneous recordings from different areas of the scalp.

The essential ingredients of an EEG machine are the electrodes, head box, montage selector, amplifiers and chart recorder.

When an EEG recording is made, the subject or patient will usually be sitting or lying down. The head box is fixed to the chair or couch or to a support close to the subject's head. The box is marked (usually in relation to the 10-20 electrode system) to label each signal that is fed into it.

In the older machine the head box is nothing more than a group of 4mm sockets connected to a cable — there's no electronics inside. The modern trend is to at least buffer the signals at the head box and often to incorporate an electrode tester (an AC resistance meter) and calibration signal source.

Once the signals arrive at the recorder, there's a slight problem. There may be twenty or so inputs and, on a small machine, only eight recording channels! Traces are made from eight electrodes at a time, the selection being changed (say) every five minutes. This requires some kind of switching for different electrode combinations, or 'montages' in the jargon.

It's a little more complicated than just selecting electrodes — there are a number of ways that signals can be combined to produce a recording. The most common is the 'bipolar' recording where the traces show the difference in signals from selected pairs of electrodes. The ETI monitor has a bipolar input — it responds to *differences* between the signals at the two active electrodes.

The other possibility is to make a unipolar recording, where the signal from each electrode is taken relative to some arbitrary zero reference. The 0V signal may be taken from an electrode connected to, say, an earlobe (often both earlobes connected together), or may be an average signal from all the active electrodes.

In the older EEG machine, the left hand half of the box is entirely taken up by a huge multi-way switch which allows various montages to be set up and selected in sequence. At the switch the EEG signals have still not been buffered or amplified!

In modern EEG machines, the Montage selector would very likely consist of a microprocessor, memory and analogue switch ICs

After the montage switching comes the amplifiers and filters. The amplifiers will usually have switched gain to give a calibrated trace of the selected number of microvolts per centimeter. There will be a high pass filter, usually calibrated in terms of the time constant, and a low pass filter giving a gentle roll off above the frequency range of interest. There will also be a 50Hz notch filter for each channel which can be switched in or out as required.

After the amplifier section comes the chart recorder. This will have various switched paper speeds from 15mm/s to 60mm/s and possibly even faster. EEG machines are not economical on paper! The recorder may have facilities for adding a time marker and possibly an extra channel for a heart signal so that any interference with the EEG can be detected.

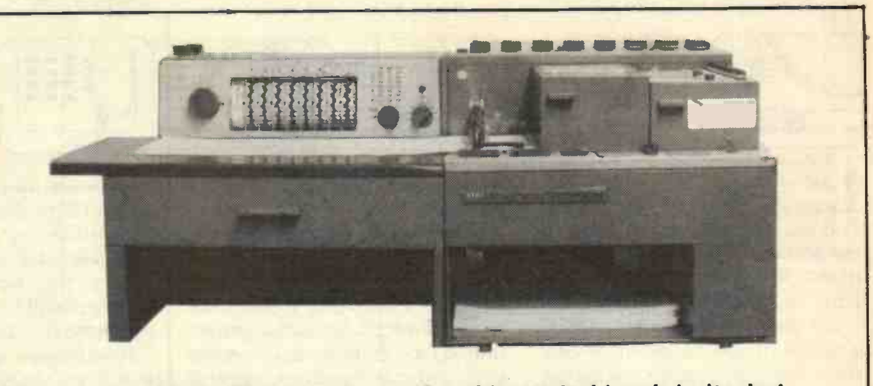


Photo 1. An elderly EEG recorder — the ultimate in hi-tech in its day!

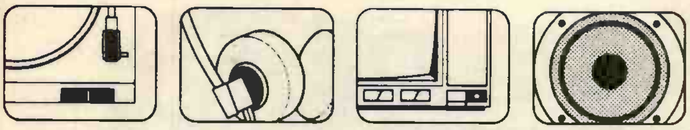
Photo 2. An EEG recorder in current production. You'll need a very understanding bank manager to buy one!

Where next?

Our description of the project has now come to an end, so any further experiment is up to you. You may like to develop a fine degree of alpha or theta control or to devise better ways of putting them to use. Whatever you do, we'd like to hear about it — either for our Tech Tips or letters page or for inclusion in a future article.

Just for fun we are offering a prize for the most spectacular or original brainwave feat reported before the end of December 1987. Be prepared to prove it! The prize will be £50 of ETI project kits from Specialist Semiconductors (See the ad in this issue) with extra prizes of £10 each for the two runners up. Prizes will consist of vouchers to be used in full or part payment for the kits and will be awarded at the discretion and whim of the ETI editorial staff. Winners will be notified early in the new year and reports of any exceptional feats may be featured in future issues of ETI. **ETI**

PLAYBACK



Last month I had a look at the coarser points of loudspeakers. This month I will look at some of the problems associated with multiple speaker systems, which is what most hi-fi loudspeakers are.

It is almost impossible to make a single drive unit perform well over the entire audio range so different sized drivers are used for different frequency bands. 'Full range' units are available but they generally don't cope with extremes of frequency too well.

For example, one 10in full range unit I tested had a resistance of 3R8 and an inductance of 168μH. This gives an electrical corner frequency of 3.7kHz. If this were the whole story the performance would be terrible because the self-inductance of the loudspeaker would act as a first order low pass filter. However, the unit is designed to be more acoustically efficient at high frequencies, so it performs reasonably well.

Crossovers

For a long time the preferred method of obtaining a uniform response over (almost) the whole audio frequency range has been to use two, three, or even four drive units, each optimised for a certain range. The signal from the amplifier is split into suitable frequency bands by the use of capacitors and inductors.

However the crossover units which split the sound into bands introduce their own distortion. Some designs I have seen have used non-polarised electrolytic capacitors to split off the treble signal. These capacitors can change their value with voltage, the phases of the moon, you name it. In addition, they often have non-linear leakage currents.

This is an application in which capacitor quality matters because the capacitor has a substantial signal voltage across it. Good quality polyester capacitors work quite well but paper or polypropylene types are even better.

The inductors used to split off the bass signal can add further distortion. They are normally wound on a ferrite or iron dust core and unfortunately even the best of them exhibit slightly non-linear magnetic responses. Air cored inductors, or ones with an air gap reduce the non-linearity but the penalty is that they use more turns so that the resistance is higher.

To do a good job of designing a crossover unit to match the drive units' own sometimes quirky impedance (and tolerance) can be difficult. Even if you succeed, the impedance presented to the amplifier, and hence the speaker efficiency, can vary dramatically with frequency.

In theory it would be possible to design a frequency splitting network which presents the correct impedance to both loudspeaker units and amplifier to a reasonable degree of accuracy. The phrase 'fearsomely difficult' comes to mind and I don't think that many (if any) loudspeaker manufacturers go to these lengths. Some do provide separate earth connections for treble and bass units, presumably to reduce the interactions caused by common cable resistance. However, this would seem to be a minor aspect of the problem. It's amazing that loudspeakers work as well as they do!

One proposal would be to split the signal into frequency bands before the power amplifier and then to use a separate power amplifier for each speaker unit. This would separate the problems of frequency splitting and impedance matching. In addition, each speaker unit would be well damped because it would be connected directly to the output of its amplifier without intervening components. This really can kill mechanical resonances.

A small further improvement could be gained by designing the bass and middle amplifiers to have a small negative incremental output resistance, almost enough to cancel the resistance of the coil. The coil would then be virtually incapable of moving in any way not specified by the amplifier. Try it. It really can make a small, grotty pair of speakers sound like a quite reasonable pair!

Laser Sound

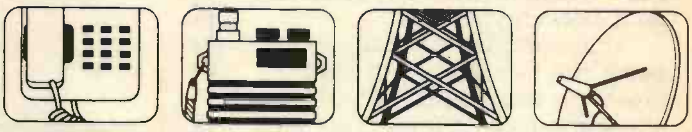
For the 'ultimate' hi-fi loudspeaker, take a good wide range loudspeaker design and add a positional feedback system, perhaps using laser optics, to measure the cone displacement very accurately. Now design a servo system that will allow the cone to follow an input signal over the entire audio frequency range.

The electrical output of the servo amplifier may not be much like the input but if the cone reproduces the input signal under all circumstances it doesn't matter a fig what the servo amplifier is doing internally.

Of course, even with the ultimate loudspeaker system you are still left with the room acoustics which becomes the dominant extraneous effect.

Andrew Armstrong

OPEN CHANNEL



A recent decision by British Satellite Broadcasting (BSB), the British franchise holder for DBS television services, puts into doubt the hope that cheap receivers will be available for the promised DBS launch date of 1989.

It was never seriously in doubt that a version of the MAC (multiplexed analogue component) transmission format would be used in DBS but as many versions of MAC exist the final choice was largely a matter of national concern. The French and German DBS television systems are to use the version known as D2-MAC and many continental manufacturers agree that the development of the necessary chip sets to allow reception is sufficiently far down the road that D2-MAC receivers are just months away.

To use a D2-MAC DBS system for the British service would have meant two important and useful things: receivers would have been available in Britain quickly and programmes broadcast from one country's satellite would have been receivable (albeit with larger aerial requirements) in another.

BSB, however, has opted for another version of MAC, known as D-MAC. Technically, D-MAC differs from D2-MAC in that it has advantages in the amount of extra facilities which can be incorporated in the transmission.

BSB's choice means, though, that the present continental receivers cannot be used to receive British transmissions and vice versa.

British manufacturers now have to design and develop D-MAC chip sets for the British receivers in only two years, if the proposed launch date is to be maintained.

It may seem a bit crazy to use an undeveloped system when other alternatives are almost in existence and probably cheaper. However, things are a bit more subtle than that.

If we were to use D2-MAC, continental manufacturers could quickly flood our market leaving little potential profit for British manufacturers. Few continental manufacturers, on the other hand, are likely to develop D-MAC chip sets just to get at the British market (they've already spent a lot of money developing continental chip sets and need to recoup some of that first).

There's the rub. To make sure British manufacturers get a fair share of their own market we have to use a different system technique to everyone else. This is, of course, no precedent. The British PAL television system differs sufficiently from continental PAL systems to give the same result.

The BSB decision is a text book delaying tactic to give our own manufacturers time to develop British chip sets and British receivers to sell to the British public. I only hope the Japanese haven't got a copy of the same text book!

PMR

Private mobile radio using the old 405-line television frequencies is now in the process of being trialled by GEC. GEC is one of the two licensed national PMR operators. The other licensed operator, Band III Radio was hoping to have commenced operation already but delays in getting equipment has meant delays in starting.

Oui, Oui

British telecommunications personnel will be looking to France over the next year or so, at France's first implementation of an integrated services digital network (ISDN) system to reach actual consumers. At present the system has only a couple of hundred subscribers but it's hoped this number will rise to about 2,000 by the end of next year.

The system, known as RNIS-Transcom (RNIS is the French acronym for ISDN — for some reason they talk in a foreign language over there) started in April this year and already running costs have been reported to be much cheaper than comparable analogue methods.

Bills Down

Talking of comparable analogue methods, I've just received my first quarter's telephone bill from British Telecom since installing my Mercury telephone. Good news (for me if not BT). I estimate the bill is something like 40% lower than it would have been if I was not using the Mercury network for long distance calls. The BT bill even takes into account the cost for fitting a master socket (£25 plus VAT).

The Mercury bills, on the other hand (there are three bills because Mercury invoices monthly) amount to only about 30% of the BT bill which would have been. So, I calculate I have saved about 25% of my telephone charges for the quarter. This pays for the master socket connection and also a good way towards my Mercury telephone. Within three quarters I'll be well into pocket over what I would have been. Tread onwards, oh Mercurial messenger!

Keith Brindley

KEYNOTES

This year's British Music Fair (held at Olympia between 28th July and 2nd August) was as dull as ever, despite being larger than last year's event.

London is often heralded as being the hub of the musical world and so it is incongruous, to say the least, that the BMF should have so little to offer with regard to international presence or new product releases.

ADT, AMS, Fairlight, Hybrid Technology, Ibanez, Kurzweil, Lexicon, Oberheim, OSC, Sequential, Stepp, Synclavier and even household names such as Fender and Gibson were all conspicuous only by their absence.

Perhaps the most exciting new products on display at this year's BMF were the attractively-styled musical socks on the William Elkin Music Services stand!

There must be a good reason for this sad state of affairs and indeed there is one. The show organiser, Philbeach Events, delegates the responsibility of selecting applications from would-be electronic equipment exhibitors to the Music Industries Association.

Membership of the MIA is a prerequisite for exhibiting (reasonably enough) but the catch is that in order to qualify for membership, a manufacturer must be 'established', 'reputable' and able to provide documentary evidence that it sells goods exclusively via 'approved' distributors and has been doing so for more than one year.

Either that, or you have to be on very amicable terms with the committee which comprises representatives from all the obvious and familiar names except those listed above.

The charter of the MIA is, in their own words, *to promote the interests of manufacturers and wholesale distributors.* In practice this means keeping competitors and dangerously-innovative smaller firms safely outside the front door.

Sample Software

Steinberg's 'Soundworks' sample editing software is one of a number of good examples of packages that can turn the combination of a MIDI sampler and personal computer into something greater than the sum of its parts.

In this particular instance the sampler is Akai's 12-bit S900 and the computer is the Atari ST. Capability extends far beyond the usual sample looping, crossfading, enveloping and transposition functions to offer filtering, Fourier analysis/resynthesis, waveform drawing and FM synthesis.

Samples are passed between the ST and S900 via MIDI, using the MIDI Sample Dump Standard (SDS) protocol. This data transfer is twenty-odd times slower than real-time due to the leisurely 31.125Kb pace of MIDI but at least samples can be stored on the S900's floppy disc or replayed instantly, once they have arrived.

The combination of a sampler and personal computer is clearly a powerful one and Akai in particular are very much aware of this fact.

A rumour has been circulating that future versions of the S900 might include a hard disk option for the bulk storage of sound and this was indeed confirmed on the Akai stand at the BMF although the sound option will not be available for several months to come.

Apparently the circuitry was designed in this country and adds not only a 40Mb drive but also a Small Computer System Interface (SCSI) — a popular communication standard. SCSI is fast enough to implement the real-time transfer of two channels of 16-bit, full audio bandwidth and it's also flexible enough to allow the simultaneous exchange of system and control information.

The increased use of computers in MIDI set-ups has in general highlighted the built-in deficiencies of the MIDI standard (which is now past its fifth birthday) and it might be true to say that many equipment manufacturers, software writers and users are becoming impatient with its limitations. After all, MIDI was never designed to handle the many and varied uses to which it is now being put.

Akai is making a brave move with SCSI and it will be very interesting to see how it fares.

I am not for a moment suggesting that SCSI is about to usurp MIDI. Far from it. MIDI is likely to remain the only standard for the routine connection of keyboard instruments for the forseeable future but as musical equipment becomes increasingly complex, the desired information bandwidth of links between equipment will exceed the speed of MIDI to such an extent as to make faster alternatives mandatory.

We can only hope that this does not result in another war between incompatible standards.

Bruno Hewitt

ONCE OVER

There can be no more essential piece of test gear for an electrician than a mains testing screwdriver. There can be no more fundamental piece of equipment for the electronics enthusiast than a continuity tester.

How nice it would be then, to see one piece of equipment that combines the two.

The Amba 'Multi-function Electronic Tester' from Goport is a very simple but ingenious piece of equipment that does just that.

The Multi-tester is a bit larger and clumsier to use than a mains testing screwdriver but considerably smaller than most comparable continuity testers.

It's housed in a plastic case with a sharp insulation-piercing probe at the tip. It looks rather like a pulse injector or logic probe.

On the upper face of the case is an LED and a small aluminium panel with the Amba logo screen-printed on it.

When using the Multi-function Tester as a mains tester the probe is placed on the terminal to be tested and the aluminium plate touched with a finger or thumb (or any other part of the anatomy, for that matter). Should the terminal be live, the LED lights.

For continuity testing the probe is touched to one point in the circuit, the metal plate touched and the other point touched with your other hand (foot, nose, etc). If the two points are connected, again, the LED lights.

To say this device is simple is overcomplicating matters. Inside the red plastic case there is a circuit comprising all of one transistor, one diode, a capacitor, three resistors and a PP3 battery (plus the LED, of course). I'll leave it to readers to work out what the circuit is!

This makes it a bit expensive at £12.60. However, this is an extremely useful little companion and well worth a place in your pocket, briefcase, glove compartment or whatever, for those unexpected emergencies.

As the continuity testing aspect of this device is active rather than just a battery and a bulb (OK, so it's only one transistor but it's still active!) quite large resistances (with correspondingly small currents flowing through them) can be detected as continuous.

This means the tester can be used to check diodes and transistors and when you're working on the car and want to test the continuity between the tail light and the battery you can either use a length or wire as the return loop or someone's body! Just hold hands with a helper (or two) to complete the circuit.

The only real criticism of this device is that it makes rather a hole in your pocket, in two ways — it is far too costly and the probe is very sharp and can get most uncomfortable! A better probe cover than the ½in piece of plastic sleeving would be a good idea.

However, there is no denying that this is a clever and genuinely useful piece of equipment which will pay for itself after a few instant diagnoses.

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E8702-2 Ratemeter ranging board..... F
E8702-3 Photo Process Controller (3bds).................. O
E8702-4 LEDline display board (2 off) .... K
E8702-5 LEDline PSU and controller (2 bds) .... G
E8703-1 Capacitometer.............. F
E8703-2 Geiger Counter L
E8703-3 Credit Card Casino........... E
E8704-1 BBC micro MIDI interface L
E8704-2 ETI Faker patch box .... H
E8704-3 24Hr. Sundial................ E
E8705-3 MIDI Keyboard keyswitch boards (3 boards) .... W
E8705-4 Batlite C
E8705-5 Budget Power Meter .... E
E8706-1 Hi-fi Power Meter .... N
E8706-2 MIDI Keyboard CPU .... U
E8706-3 MIDI Keyboard Front Panel ... O
E8706-4 Flame Simulator .... G
E8707-1 MIDI Keyboard PSU .... H
E8707-2 Telephone Alarm .... J
E8707-3 Nuclear Strategy Simulator ..... J
E8708-1 Remindalite .... F
E8708-2 Rear Wiper Alarm .... G
E8708-3 Rev Counter .... F
E8708-4 Car alarm .... F
E8708-5 Knight Raider .... J
E8709-1 Boiler Controller .... G
E8709-2 Amstrad Sampler (2 bds) .... P
E8709-3 Portable PA .... G
E8709-4 EEG Monitor (2 bds) L
E8710-1 Concept CPU board............ N
E8710-2 Concept Power board........... K
E8710-3 Concept display board......... G
E8710-4 Hyper-Fuzz.................... F
E8710-5 Big Digits digit board........... N
E8710-6 Big Digits minute board......... F
E8710-7 Big Digits battery board......... G
E8711-1 Quiz Controller................. E
E8711-2 256K Printer Buffer............. N

OOPS!

FM Stereo Tuner (February-April 1987)
In the parts list on page 49 of the February issue, C2 and C3 are listed as 270n types. This line should refer to C2 and C23 and the value should be 470n. In Fig. 7 the un-labelled PCB pad in the top right-hand corner is the +15V input from the power supply. In Fig. 1 in the April issue there is an un-labelled arrow leading from the top of the diagram. It should be marked CONTROL VOLTAGE OUTPUT TO MUTING CIRCUIT. The arrow to the right of the un-labelled one is marked '+5V IN' and should read '+15V IN'. In Fig. 6 in the April issue, C63 and C64 should be shown as 330p, not 3300p. On page 36 of the April issue, in the first paragraph, the reference to R62 should read R64.

Flat Alarm (June 1987)
In the circuit diagram Q2 is shown as an NPN transistor. It should be a PNP device as given in the parts list. IC4 is given in Fig. 2 as a 74LS260 and C5 as 470n. They should be 74LS132 and 4µ7 as in the parts list. R13 is incorrectly given as 280R in the parts list instead of 270R.

Nuclear Strategy Simulator (July 1987)
The bridge rectifier (BR1) on the overlay diagram has no polarity markings. It should be positioned with the positive at bottom left, connected to the track which connects to IC8 IN and C4 positive.

Telephone Alarm (July 1987)
In the component overlay (Fig. 2) ICI and IC2 should be swapped. In addition the capacitor to the right of ICl,2 is C1 and the inductor between them is L1. The unmarked resistor to the left of L1 should be a wire link.

Kappellmeisters (July 1987)
The position of the speaker port in the front panel was omitted from Fig.2. This should be a 7¼x4½in ellipse centred across the panel with its top edge 2½in below the panel top.

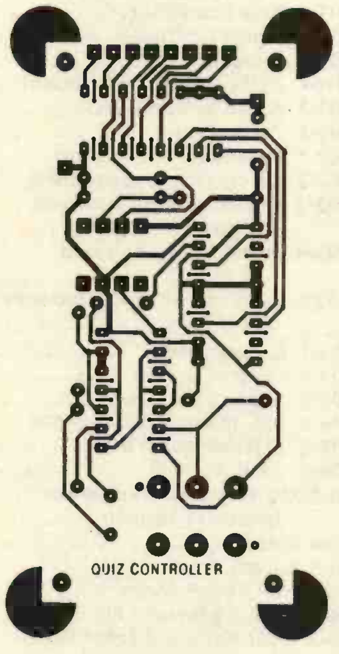
Knight Raider (August 1987)
In Fig.1(a) pins 4 and 5 of ICI are swapped. IC2-3 show the correct pin-out.

Car Alarm (August 1987)
In Fig. 1 Q7 is not numbered and its emitter is shown unconnected. This connects to earth. The transistors in the parts list went a little awry. Q2-6 are BC237 and Q7 is a TIP31.

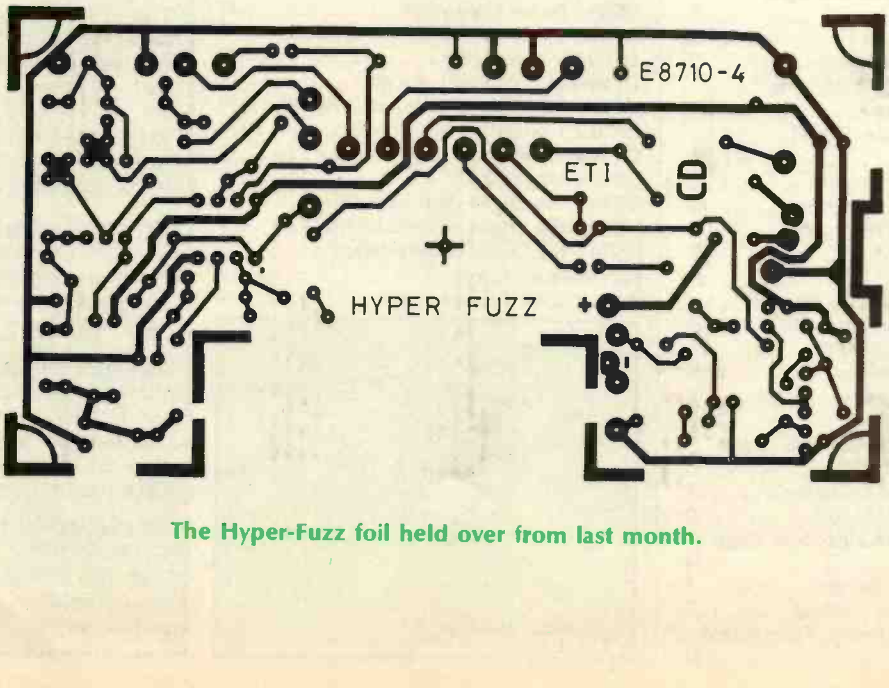
Boiler Controller (September 1987)
In Fig. 2 (a) the primary of T2 is shown connected to Earth. This should be neutral. In Fig. 2(b) one of the bridge rectifier diodes, D6-9, is shown the wrong way around. This is correctly shown in Fig. 5.

ETI Concept (October 1987)
The Power Board parts list wrongly lists R6 as 270R. This should be 270k. Also, note that the power board's 0V rail must *not* be connected to Earth or the 0V rail of the CPU board.

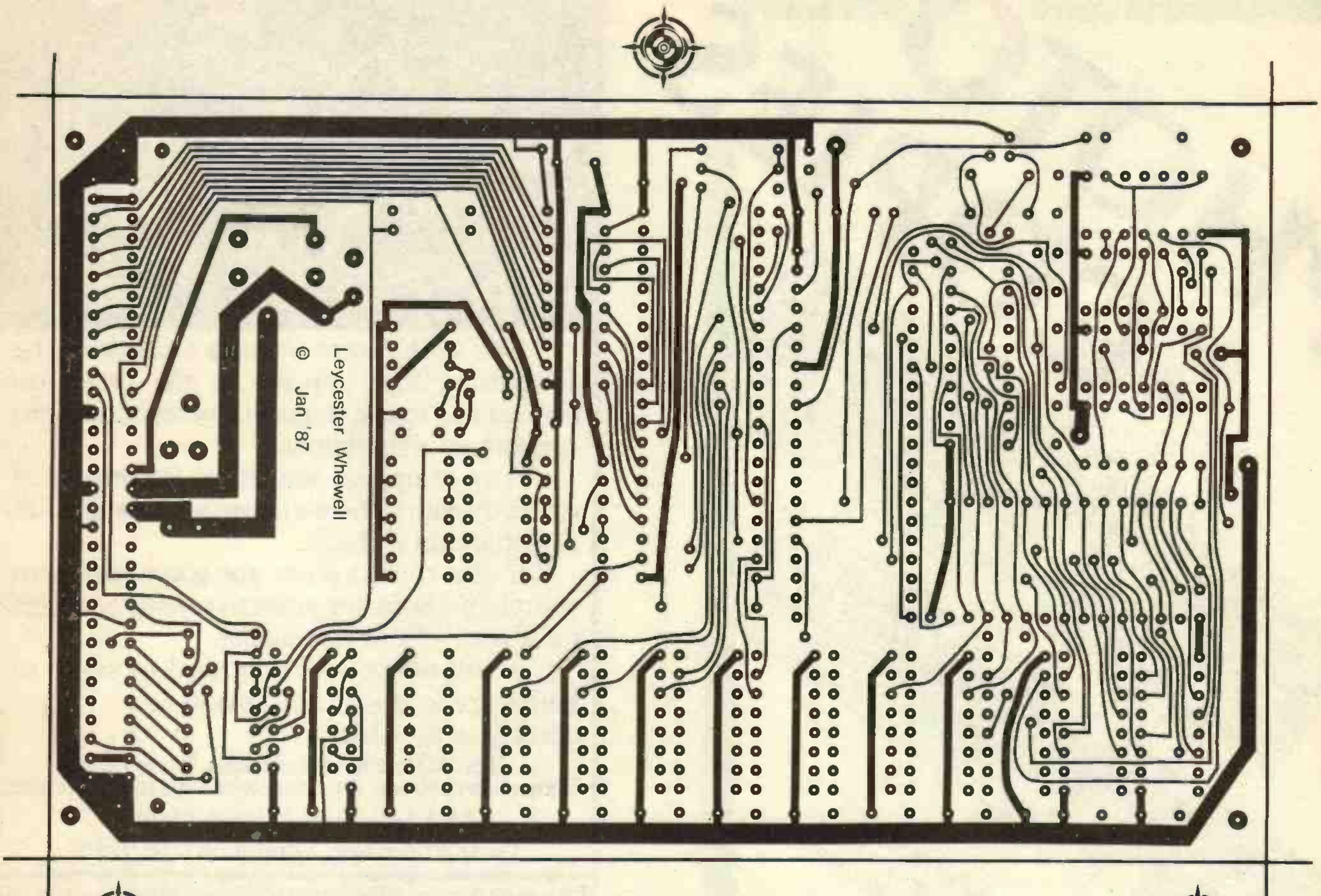
PCB FOIL PATTERNS



The Quiz Controller foil.

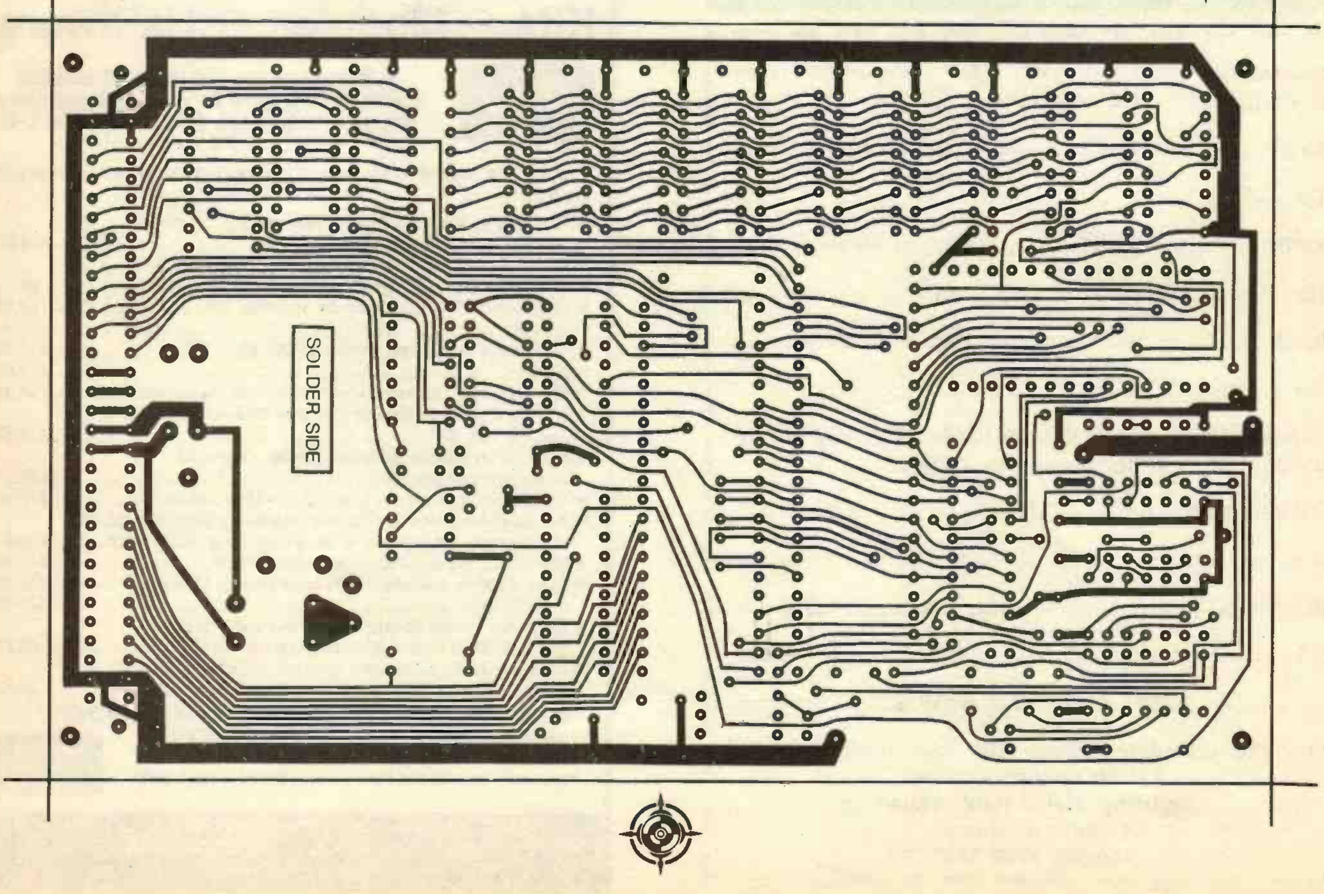


The Hyper-Fuzz foil held over from last month.



The Printer Buffer topside foil.

The Printer Buffer solderside foil.



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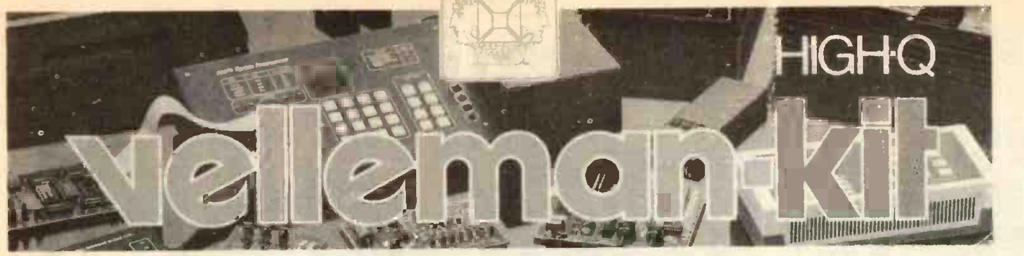

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- Total current consumption in static mode: maximum 400mA
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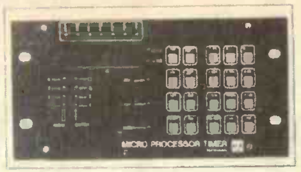
MICROPROCESSOR UNIVERSAL TIMER KIT NR. K1682



This unique timer is in principle a 24-hour clock provided with 4 relay-switched outputs and a programmation period of 1 week. 20 switching programs can be memorized and via the membrane keyboard be programmed. Outputs or timing periods can be selected at random.
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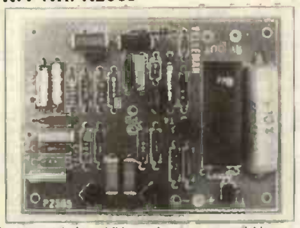

Actually, a lot of tape/slide synchronizers are available on the market. The price of these devices varies from expensive to very expensive.
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- Output amplitude:+250mV.
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- Oscillator: AMV type.
- Input Impedance (B): 1 KOhm.
- Output impedance: 15 KOhm

Price £12.75 + p&p

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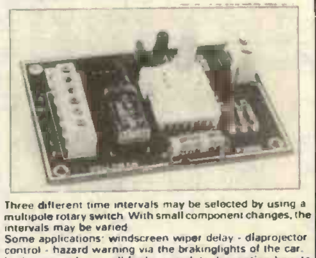

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- Intervals: 5-10-15 seconds
- Relay output: 240V/2x3A.
- Relay output with two change-over contacts
- Current consumption:
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- Output 'ON': 100mA.
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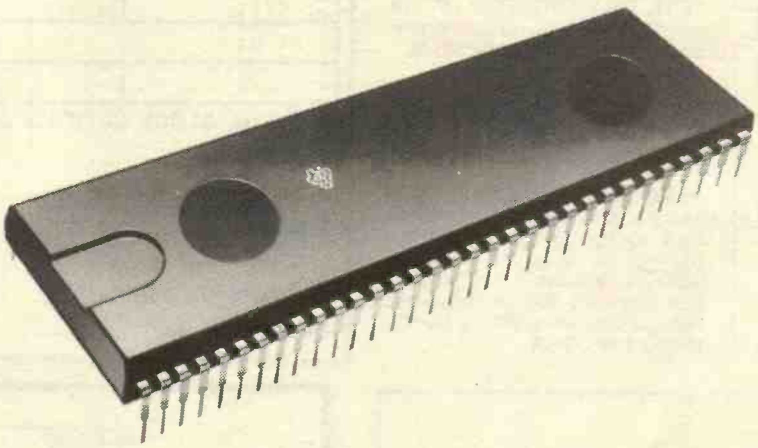

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