THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

JANUARY 1989 £1.50

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ELECTRONICS TODAY INTERNATIONAL

R·D·S

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The Full Explanation

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In-car Power Supply

Granny-Aid Hearing Booster

EPROM Programmer
– The Latest Model

Rev-Rider
– Wake Up Your Wheels

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OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz –3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. –130dB. Size 330 × 175 × 100mm.
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RES, FREQ, 45Hz. FREQ, RESP, TO 7KHz. SENS, 98dB. .... **PRICE £36.66 + £3.50 P&P.**
12" 100 WATT C12100TC TWIN CONE) HIGH POWER WIDE RESPONSE, P.A., VOICE, DISCO.
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MXF400 (200w + 200w) **MXF600** (300w + 300w)
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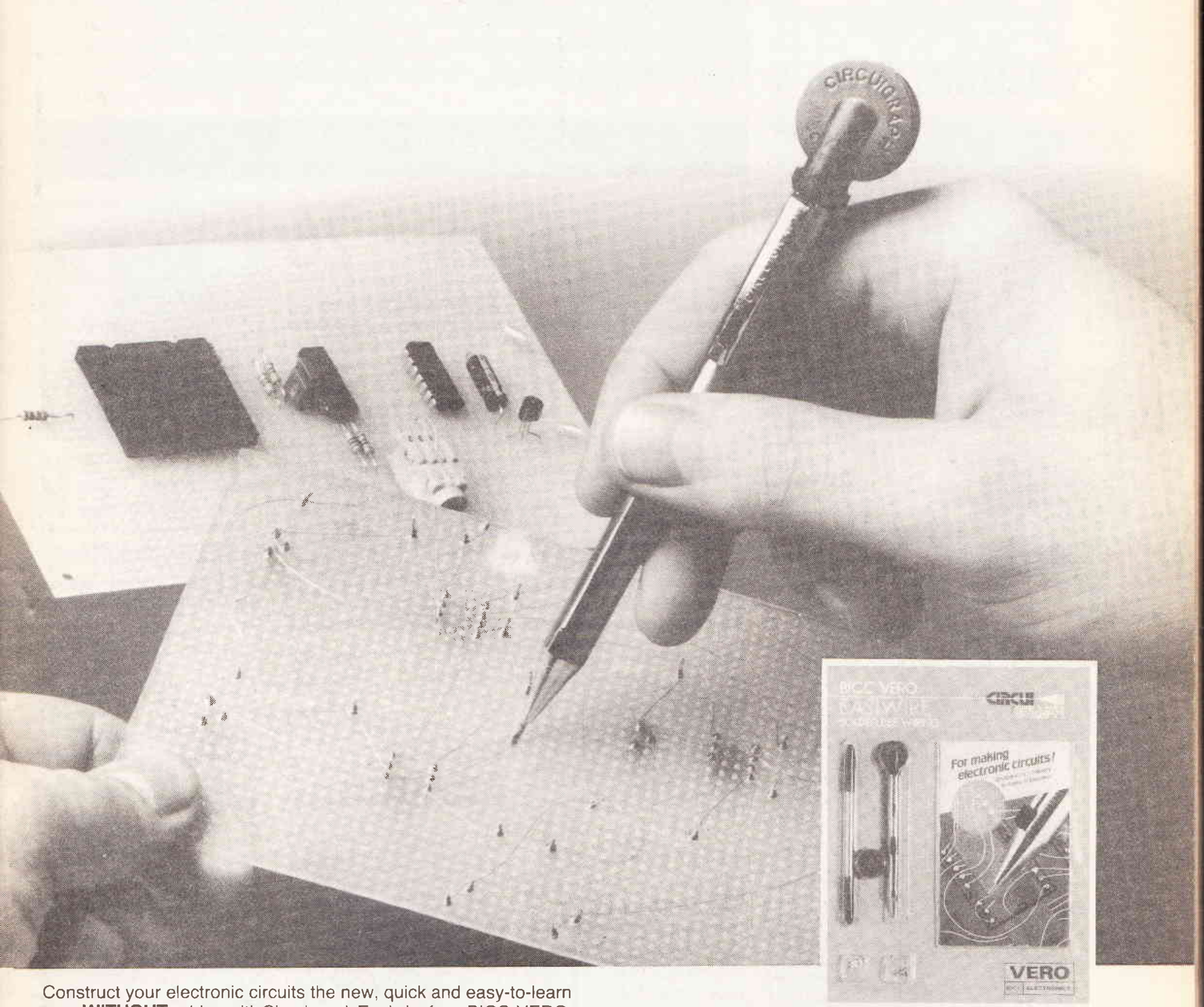

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January
1989
VOLUME 18 No 1

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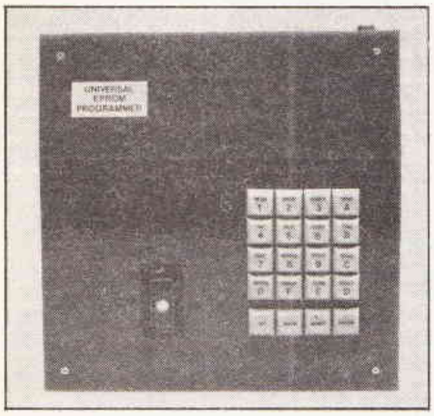

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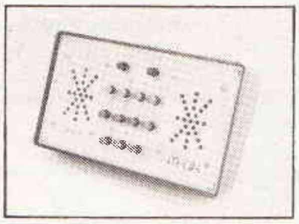
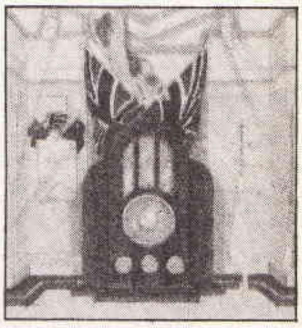
REGULARS





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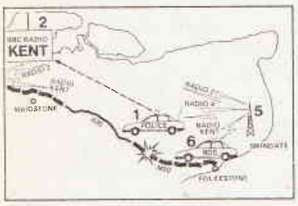
TODAY INTERNATIONAL

FEATURES/PROJECTS



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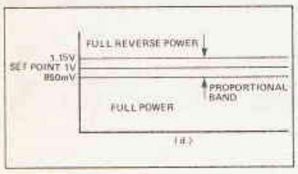
RDS

The BBC's Mark Saunders reveals the codes and codicils of the Radio Data System, the BBC implementation and the future of Radio as we know it



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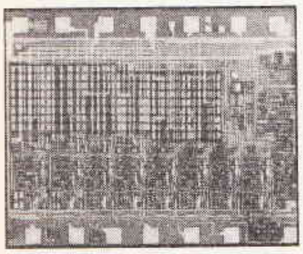
Op-Amps

Paul Chappell takes errors in his stride with a discussion of feedback for this month's *Circuit Theory*



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Language Lesson

Mike Barwise looks at high level languages and microprocessors for this month's *Chip In*

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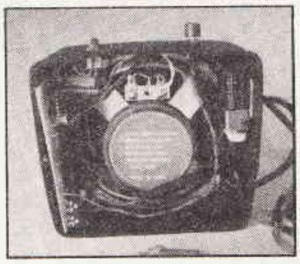
ETI Cell Guide

Bill Higgins assaults the battery market with a survey of all you need to know about all battery types



PROJECT 28

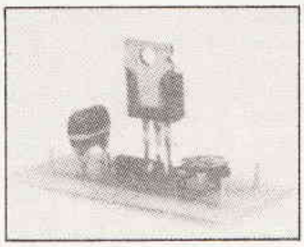
Rev-Rider

If you get a bicycle for Christmas but really want a motor bike, Stuart Richards has the answer

PROJECT 33

A Christmas Present For Granny

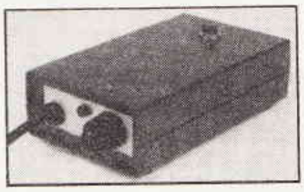
John Linsley Hood moves away from his usual top-notch hi-fi designs to present a low voltage, automatic gain control hearing booster to help Granny listen to the Queen's speech



PROJECT 36

In-Car Power Supply

Keith Brindley has a super-simple *1st Class* project to let you run all your low voltage cassette players, radios, fly repellers or whatever inside the car or caravan



PROJECT 38

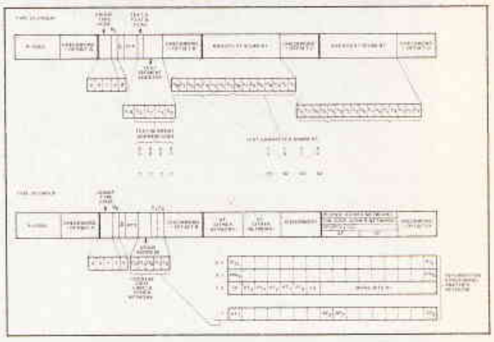
Son Of Variat-Ion

Paul Chappell won't let a sleeping project lie and here presents a quick update to October 1988's Variat-Ion air ioniser

PROJECT 42

Stand-Alone EPROM Programmer

Mike Bedford and Gordon Bennett upgrade the Universal EPROM Programmer MkII of summer 1985 to work with any RS232 equipped computer



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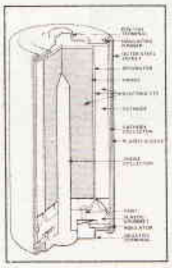

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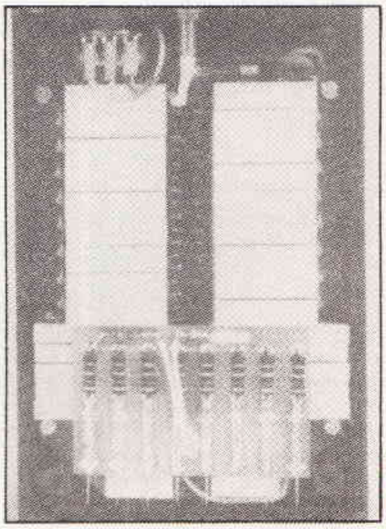

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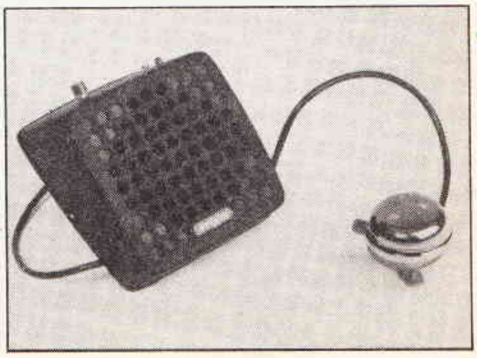

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NEWS

THE BIG SCREEN

The Japanese Ministry of Trade and Industry is developing a wall size liquid crystal television screen, as beloved by sci-fi writers for decades.

Twelve Japanese companies will be participating in the research which will initially be aimed at producing a 40in screen. The companies include Casio, Sharp, NEC, Hitachi and various printing and glass companies.

The aim is to get a screen no more than 10 centimeters thick so it can be easily wallmounted while still overcoming the problems of multiplexing the massive array of pixels. It is hoped that the first units will be on the market by 1995.

ULTRASONIC TAPE

A pair of very reasonably priced ultrasonic measures are now available from Solex International.

The UR2000 and UR3000 measure distances in feet or metres simply by pointing the ultrasonic transmitter/detector at a surface up to 10m distant. Imperial units can either be feet and inches or feet to two decimal places. Accuracy for both units is 1%.

In addition the UR3000 has memories for three dimensions and can calculate cubic capacity and floor area.

The UR2000 costs just £29+VAT, the UR3000 is £49+VAT. Both units are available on 14 days approval.

Contact Solex International, 95 Main Street, Broughton Ashley, Leicester LE9 6RE. Tel: (0455) 283486.

SCRAMBLE FOR STV CHANNELS

Rupert Murdoch has decided to scramble at least one of his four Astra STV channels in response to pressure from film distribution companies.

It was originally proposed that the Astra channels would be available without subscription, making the £199 price tag of the Amstrad/Murdoch STV receiver the only expense for new STV viewers.

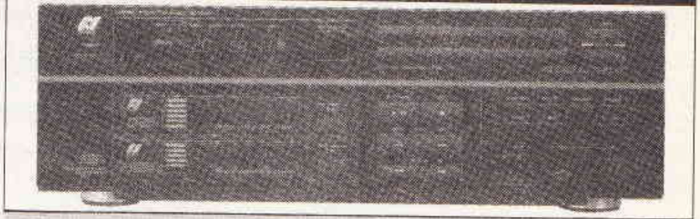
The announcement that Sky Movies, probably to be the most popular of the four channels, is to be scrambled four months after its launch is a major departure from the single-payment concept originally planned.

Eurosport, another of Murdoch's Astra channels, may follow suit.

The pressure from the film distribution companies followed their realisation that the Sky channels were buying movie rights for the UK only, while the unencrypted Sky Movies would be available across much of Europe. The main advantage to viewers will be better films, financed by the (as yet unannounced) subscription charge.

Not that Mr Murdoch himself is able to watch anything at the moment. Westminster City Council recently rejected his application for a satellite dish on the roof of his St James's Place residence in London. Had he been content to use Amstrad's smaller dish, planning permission would not have been necessary!

MULTI-MAGAZINE CD



Sansui has taken the concept of multi-disc CD players one step further with the new CD-X510M, which can hold up to 12 discs in its pair of 6-disc magazines. This gives you over 12 hours of listening entertainment without leaving your seat — a questionably useful facility.

It does however allow you to keep your top 12 discs permanently in the player, removing all that tedious nail-breaking opening of boxes.

The CD-X510M also has a remote control with a numeric keypad so that everything can be chosen from the comfy chair.

The normal range of CD functions is included — programming, repeat, skip, random play — plus a few more unusual facilities such as random intro play which plays through introductions randomly while you construct a program.

The CD-X510M retails at £299.95 and uses 16-bit twice oversampling.

Contact Sansui, Axis 4, Rhode Way, Watford WD2 4YW. Tel: (0923) 226499.

BITS FOR KITS

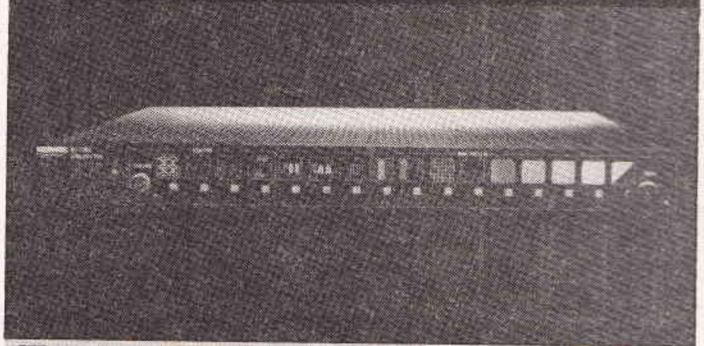
I-TRON UK is a Berkhamsted company producing some clever little kits to fill those winter evenings.

Among them is the Theramin Music Generator (based on the legendary ancient mystical instrument . . .) at £12.75, and a low-price VHF-transmitting bug at £5.25.

For a full data sheet send an SAE, for orders enclose 95p postage.

Contact I-TRON UK, Castle Mill, Lower Kings Road, Berhamsted, Hertfordshire HP4 2AD.

THE GENERATION GAME



Two specialised signal generators have come on the market this month.

The first is the Kenwood DA3531, a reference generator to evaluate CD players. There are various test patterns covering frequencies from 20Hz-20kHz. Eight error patterns are available and sixteen subcodes. The DA3531 costs £1850+VAT. The highly complicated DA3500A is also available, price £20250+VAT.

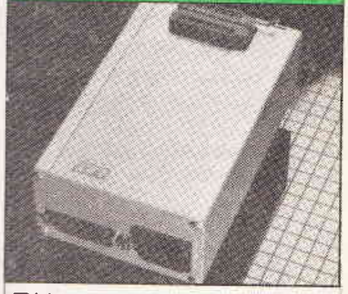
The second unit, again for professional test work, is the 7765 Packet Test Signal Generator for D-MAC and D2-MAC signals. This replaces the program for testing a transmission channel, receiver or code converter, generating all test signals digitally on 10-bits at the D2-MAC clock frequency.

The 7765 has a top price of £5850+VAT.

Contact Schlumberger Instruments, Victoria Road, Farnborough, Hants GU14 7PW. Tel: (0252) 544433.

For details of the DA units contact Thurlby Electronics, New Road, St Ives, Cambs PE17 4BG. Tel: (0799) 26699.

BLOWING IT



If the construction of the ETI Stand-Alone EPROM Programmer is too much for you and you want a programmer off the shelf, the ART EPP-1 from Brian Price Electronics is worth a good look.

The EPP-1 can program all 27x EPROMs from 2716s to 27513s as well as various 25x EPROMs and the X2564 EEPROM.

Control is from any computer via an RS232 link. Single character commands enable very simple operation and any instruction is halted by an ESC command.

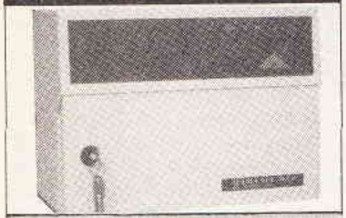
The EPP-1 retails at £97 including VAT and postage. There is an operational program available for IBM compatibles, price £12.00. Brian Price also supplies the range of Bohm programmers.

Contact Brian Price Electronics, 389 Aspley Lane, Nottingham NG8 5RR. Tel: (0602) 296311.

Another unit which can program over 50 types of device is the Model 18 from MQP Electronics of Malmesbury. This can be controlled either by RS232 communication similar to that above or by MQP's Promdriver Advanced Features User Interface Package, which works with MS-DOS, PC-DOS and CP/M80 operating systems.

The Model 18 retails at £189.95+VAT. Contact MQP, Unit 2, Park Road Centre, Malmesbury, Wilts SN16 0BX. Tel: (0666) 825146.

ON GUARD



A new security system, the Audiogard 1000 from Abbey Security, not only informs the police of intruders on the premises but specifies the number of intruders, how they broke in, where they are now and quite possibly what their names are!

This seemingly impossible task of recognition and identification is performed by perhaps the most advanced listening device available — the human ear.

The concept is simple enough. When the on-site unit picks up any unusual noises from one or more high specification microphones it phones up Abbey Security's head office in Nottingham.

The 24hr monitor girls (girls can hear better than boys apparently) then listen in real time down the telephone link to check up on the details. The police are then alerted, and the possibility of a false alarm is eliminated.

The possibility of false alarms is an enormous problem in the security systems marketplace as 98% of all alarm triggering are false alerts — a situation that cost the police £28 million last year and has resulted in them threatening to charge for wasted police time or even withdraw support if false alerts continue.

Without police support, insurance companies will not cover premises and without insurance, most business are unable to operate. Clearly the situation must improve.

With Abbey's system the police are certain of their information and can respond in a far more positive manner than if they are 98% expecting nothing to be wrong.

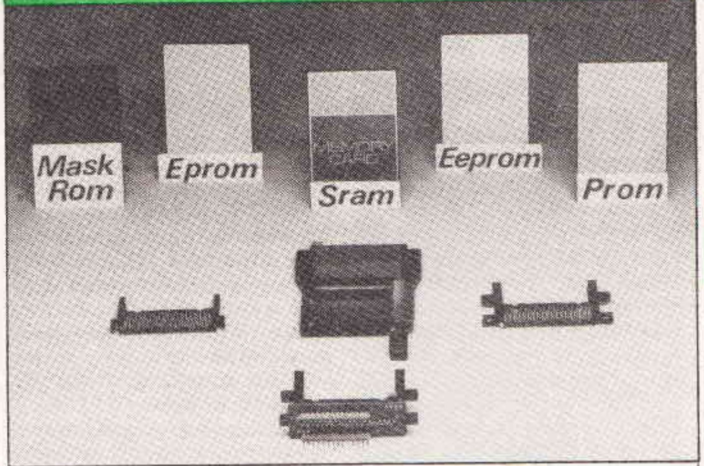
The only hitch in the Audiogard's operation is the definition of an 'unusual' sound. If any sound detected were to trigger the alarm, the number of alerts reaching Abbey's HQ would be unmanageable.

So the Audiogard uses a noise recognition system based on EPROM recordings. This is claimed to distinguish between a cat knocking over a milkbottle and a thermic lance or between a thunderclap and the door crashing in. Only if an 'unfriendly' sound is identified will the alert be triggered.

A basic Audiogard 1000 system will cost around £1500 and although the first Abbey base is in Nottingham, any premises in Britain can be covered. Further bases in London and Manchester should follow.

Contact Abbey Security, Abbeyfield Road, Lenton Industrial Estate, West, Nottingham NG7 2SZ. Tel: (0602) 860164.

IT'S ON THE CARDS



Credit card memories in various formats are now available from Hakuto in Waltham Cross.

The cards are available as SRAM, PROM, EPROM, masked ROM and now EEPROM memory, accessed through the edge connector at the top of the card.

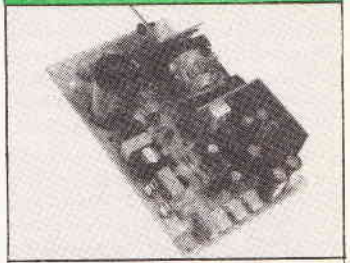
Hakuto is also marketing a parallel read/write unit for the cards, fully MS-DOS controlled. The BB1R connector is also available, a mechanically locking card holder which prevents the card being removed accidentally.

The various cards start at £22.89 + VAT (8K SRAM), the programming unit retails at £296.81 + VAT. Contact Hakuto UK, 33-35 Eleanor Cross Road, Waltham Cross, Herts EN8 7LF. Tel: (0992) 769090.

£3 AMP

This month's special offer from KIA in Ilkley is a fully assembled 10W amplifier, at a bargain price of £3.00. Contact KIA-8, Cuncliffe Road, Ilkley LS29 9DZ or clip the coupon in the Classified section.

POWER



Switch mode power supplies have been reduced in price by Powersolve of Newbury. Two 40W units, SNP8171 and SNP8172 are available, measuring just 127 × 76 × 40mm with outputs at either +5V and ±12V or +5V and ±15V.

The 1-off price is £38 but in quantity this can come down to below £25.

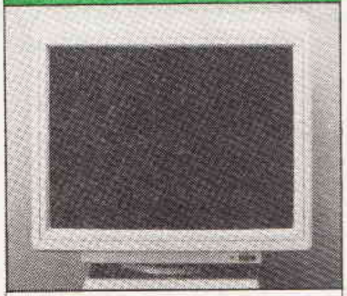
The pictured 65W unit has +5V and ±12V outputs and an input that will take any signal from 90-260V AC. The 65W supply costs £59 — again much lower for quantity orders.

Contact Powersolve Electronics, 9 The Paddock, Hambridge Road, Newbury, Berks. Tel: (0635) 521858.

THE WINTER COLLECTION

Last month saw the launch of most of the catalogues from the main component suppliers — Maplin (£1.95, Tel: (0702) 552911), Greenweld (£1.00, Tel: (0703) 772501 and Electromail (£4.95, Tel: (0536) 204555). Cirkit has two catalogues, one for the hobbyist (£1.30) and one for industrial users (free if you can get it). Tel: (0992) 441306.

WHAT A WHOPPER!



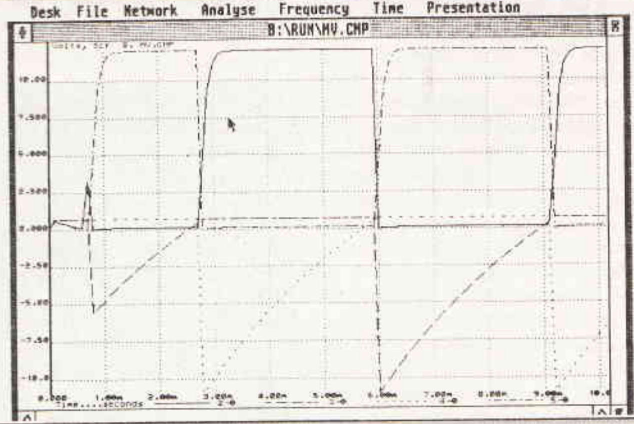
Monitors are going up in the world with the Ranger 21 FST autosynch 21in colour monitor, launched at the Computer Graphics 88 show in October.

Dynamic beam forming, automatic picture size compensation and automatic synchronisation combine to make the large screen 'possibly the best picture in the world'.

But then at £2100, you might expect that.

Contact Aydin Controls, 64 Wilbury Way, Hitchin, Herts SG4 0TP. Tel: (0462) 58804.

ENTER THE SPICE AGE



The latest product in the Spice range of circuit analysis software from Those Engineers is Spice*Age, a high speed complex analysis program for PCs.

Spice*Age can model simple components together with non-linear devices such as transistors, CMOS gates and saturating op-amps.

All devices may be amended so that different and modified devices can be produced.

The program can model frequency response, DC quiescent voltages, transients and can analyse down to Fourier components.

Circuits are subjected to seven types of user-definable disturbances and both tabular and graphical results are produced.

A modular version of Spice*Age is available from £70, a multi-user version from £500. Special prices are available for educational establishments.

Contact Those Engineers, 106a Fortune Green Road, London NW6 1DS. Tel: 01-435 2771.

READ\WRITE

RAT ZAP

The *Recurring Dream* article in the September 1988 issue had a concluding section on biofeedback. Neil Miller of Rockefeller University did indeed try to show that rats could be taught to control their heart rate. Unfortunately, the work that seemed to prove this hypothesis was never replicated by other groups either at Rockefeller or other universities.

David VanDercar MD, Ph D, who was one of my lecturers in the Department of Biomedical Engineering at the University of Miami, worked with Neil Miller's group and discovered an instrumentation fault that actually put several volts DC through the rats' hind brains, when the intent was to stimulate the pleasure center with a few minute pulses.

This simply burnt out the rats' brains and caused the heart rate to be controlled at the idiopathic rate determined by the ventricles which is usually much slower than the normal rate. Indeed, when David tried to replicate the experiments without curare, the rats performed backflips, much to everybody's amazement and consternation.

David is of the opinion that conscious control of heart rate is not possible because there is no evolutionary benefit. The autonomic rate and cardiac output are much too important for the body to allow conscious processes to interfere with them.

The idea of conscious control of heart rate is very attractive in number of ways. For example, being able to reduce high blood pressure using biofeedback techniques. In a study that VanDercar performed using women subjects there was only one person who showed any control.

When questioned about what she was thinking about to slow her heart down, she said that she imagined herself relaxing on a beach, and when she wanted to speed her heart rate up she envisoned herself the object of a violent sexual encounter with a gang. The bottom line is that this was not direct nervous control of heart rate, but that the changes were mediated via humoral mechanism.

Once again, I greatly enjoy your articles, which are always full very interesting ideas. Keep up the good work with ETI.

André Routh
Miami Lakes, Florida

One of the hazards of writing a never-ending stream of projects for ETI is that there's never enough time to check original sources so it's always good to hear from someone who's to the centre of things, as it were. Thank you for correcting us.

BAR-MY

As the writer of one of the 'profusion' of letters you received to inquire as to how to 'read a can of beans', I thank you for taking the trouble to put together the *Behind Bars* article in your November issue.

The subject of bar codes is indeed much more complicated than it first appears. Although I still can't march around the supermarket declaring where an item was grown or made, at least I now know why I can't!

George Hickman
Ludlow, Salop.

It certainly does liven up the Saturday shopping doesn't it. Another wizard wheeze is to use a black marker pen to turn your can of beans into a pot of shrimps or a bottle of brandy. You can sit back and chuckle as the manager calls the fraud squad.

D FOR DESTRUCTION

With reference to your NiCd Charger project in the ETI for November 1988, I feel you should have pointed out very clearly that some D size NiCds are not 4Ah but only 1.2Ah and if charged at the 340mA rate they will overcharge and could explode.

John Tyzzer
Guildford, Surrey

Yes indeed. Most D-type NiCds are of the lower capacity and should not be charged at 340mA. Indeed, many C-type cells are only 1200mAh also. Both these types should be charged at 120mA using a 115R resistor. Coincidentally this is the same value as is used for charging a PP9 and so no modifications are required to the circuit.

SECURITY CONSCIOUS

Congratulations on the November issue and the free gift to build the *Burglar Buster* alarm. I look forward to next month's free PCB.

Perhaps you could embark on a course, covering say 12-18 months dealing completely with DIY projects to totally safeguard a house, including perhaps some manufacturers' equipment.

Might I also comment on the Nite Sentry reviewed in *Once Over*. I fitted two of these units a while ago. They are very good with a range of 8m or so but their limitation is that according to both the manufacturers and Maplin no sounding device can be attached.

Finally, I am currently fitting an alarm system to my bungalow using various commercial equipment. I need about 150 spade terminals to fit 2mm screws in the junction boxes. Can you tell me where I can purchase these.

F. G. Lawrence
Doddington Park, Lincoln

Thanks for your comments on the November issue. We hope the December issue and even this one, go down as well. As to the series of home projection projects, we feel that would be turning ETI a little into a security-specific magazine. Nevertheless, we have in the past featured many security projects and will continue to do so in the future as particularly good ones come our way.

Any mains powered sounder can be simply connected to the Nite Sentry with the auxiliary lamp outputs. Alternatively, battery powered units could be connected with a mains activate relay. Spade connectors are available from most component stockists — Maplin stocks them — and from motorist accessory shops.

BONNIE BLUES

Further to your letter regarding the recent demise of Bonnie Langford in the new *Doctor Who* series, is there any truth in the rumour she is to be retrospectively substituted for Angela Cartright as Penny in Channel 4's repeat showings of *Lost In Space?*

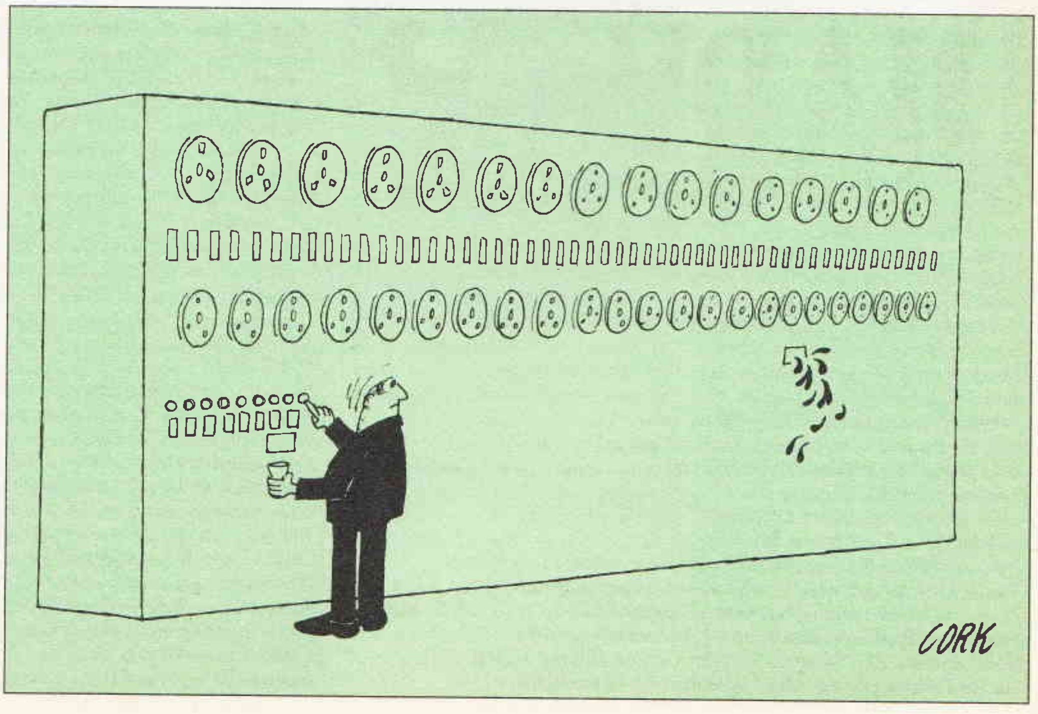
In trepidation
Barry Peterson
Matlock, Derbyshire

PS Stair-climbing Daleks — wow!

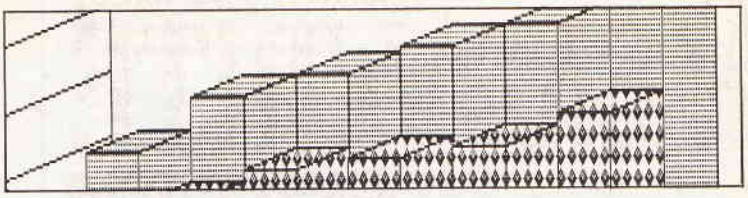
The new series of *Doctor Who* may well lack the dear departed and much mourned Bonnie Langford (or is that much departed and dearly mourned?) but it does include stars from *Eastenders* and *Upstairs Downstairs,* not to mention the set from Ali's cafe.

Ian Gillman
Woodeaton, Oxford

What is it with you guys? This is meant to be an electronics mag, if you have to go on about Doctor Who and Bonnie Langford, at least try and fit in a few references to electronics.



INSIGHT



British electronic equipment manufacturers can be almost totally confident of renewed growth over the next few years, says a new and optimistic report published by ICC Business Ratios.

Short term growth should once again be strong after the virtual standstill between 1985/86 and 1986/87 sales — an unprecedented pause in the electronics market.

Despite the slack trade, many British companies managed rather impressively to raise profit margins and other indicators such that despite static sales overall profits rose slightly.

This optimism contrasts strongly with other recent reports such as the National Economic Development Office's work compiled by McKinsey which slated home-grown companies as having badly underperformed in recent years compared with UK subsidiaries of US and Japanese companies. That report was labelled by GEC ex-MD Lord Weinstock as 'not frightfully helpful'.

The ICC report shows indigenous UK firms leading the pack. Apart from IBM's UK holdings which are ahead on sales overall, the next six companies — English Electric, STC, Plessey, Racal, Marconi and GEC — are British through and through.

However, as many reports have stated in the past, much of the UK's electronics expertise lies not in the huge and wide-reaching but in the small and specialised. Niche products that defy mass production are the mainstay of many of our smaller producers.

This situation looks unlikely to change drastically despite frequent calls for mergers to streamline the UK industry ready for a frontal assault on Europe come the revolution in 1992.

Plessey is often chosen as a shining example to us all in the art of streamlining, acquisition and co-operation, although it is often insufficiently stressed that 1992 is not simply a UK versus the rest of Europe situation.

Co-operation between our own companies and the best of Europe to create an international unit to rival the US and Japan is perhaps even more important in the long run. However, such unions are rare — one exception from the component industries being Plessey's work with Philips on the D-MAC and D2-MAC chipsets.

Our small companies, then, remain as much of the flesh of the industry, if not the skeleton. The ICC report shows that these companies are no less successful than the big boys (taking the ratio of return to employed capital as an indicator) with only two of the top ten performing companies having turnover above £10m.

Around the middle of this top ten comes Amstrad, worth singling out for some quite remarkable results in the last two years. Last year the ratio of Amstrad sales to fixed assets was 42:1, an outstanding ratio when the average for UK companies was less than 6:1.

This figure results from Amstrad managing to turn over about £600,000 for each employee — the nearest rival to this was IBM, turning over about £150,000.

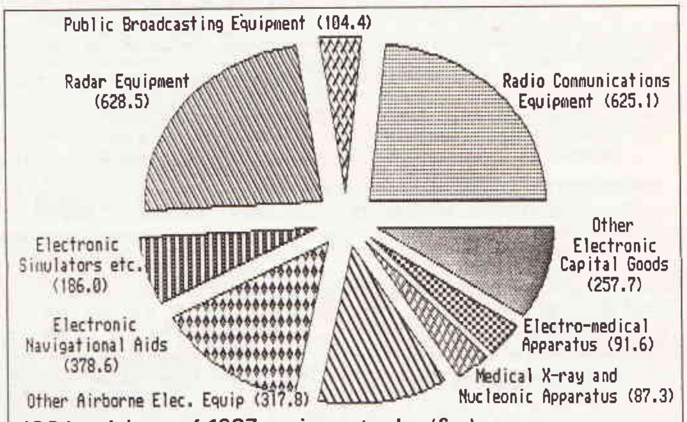
Meanwhile in the export market there are some examples of those niche markets mentioned earlier.

While IBM leads the field in terms of sheer volume, in terms of exports as a percentage of sales, the winner is Solid State Logic of Oxford, manufacturer of the legendary SSL studio mixing desks.

SSL is famous worldwide not only for the quality of its products but for the backup it provides at and following installation. A very specific market area is addressed but a reputation in that area has generated enormous success. Mass production would quite likely be counter-productive.

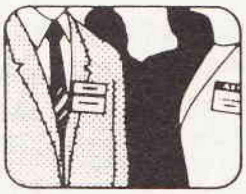
Overall the report is very optimistic, praising the small for being small and the big for being big. While it is recognised that the electronic equipment market can be heavily influenced by new developments and new markets (such as the recent takeoff of the Vodaphone network), it is confidently expected that next year's report will announce a further renewal of growth which will be maintained or exceeded in following years.

The report *Electronic Equipment Manufacturers, Business Ratio Report — An Industry Sector Analysis* is available for £185 from ICC Information Group, 28-42 Banner Street, London EC1Y 8QE. Tel: 01-253 3906.



ICC breakdown of 1987 equipment sales (£m)

DIARY



Frequency Spectrum Management — December 5th
IEE, London. Lecture by IEEIE. Contact IEEIE on 01-836 3357

Interactive 88 (Interactive Systems) — December 6-8th
Metropole Exhibition Centre, Brighton. Contact PLF Communications on (0733) 60535

Electronic Messaging Systems — December 6-8th
Tara Hotel, London. Conference. Contact Blenheim Online on 01-868 4466

Graphic Display Devices — December 8th
IEE, London. IEE Colloquium. Contact IEE on 01-240 1871

Cassini — The Mission To Survey Saturn And Land On Titan — December 8th
IEE, London. IEE Lecture. Contact IEE on 01-240 1871

CD-ROM — December 8th
IEE, London. IEE Colloquium. Contact IEE on 01-240 1871

Computer & Technology Show — December 11th
Music Hall, University of Aberdeen. Contact SATRO on (0224) 273161

Satellites And Broadcasting — December 13-14th
IEE, London. IEE Christmas Lecture. Contact IEE on 01-240 1871

Radio Propagation In Bad Weather — January 5th
IEE, London. 24th Appleton lecture. Contact IEE on 01-240 1871

Digital Audio Broadcast Systems — January 10th
IEE, London. IEE discussion meeting. Contact IEE on 01-240 1871

Computer Vision For Robots — January 24th
IEE, London. IEE Colloquium. Contact IEE on 01-240 1871

Super Conductors And Their Practical Uses — January 25th
RSA, London. Lecture by Royal Society for the Encouragement of Arts, Manufacture and Commerce. Free tickets from RSA on 01-930 5115

The UK Direct Broadcast Satellite — January 26th
IEE, London. IEE Colloquium. Contact IEE on 01-240 1871

Sound 89 — February 21-22nd
Heathrow Penta Hotel, London. Contact Sound and Communications Industries Federation on (06286) 67633

Which Computer Show — February 21-24th
National Exhibition Centre, Birmingham. Contact Cahners Exhibitions on 01-891 5051

Internepcon Production — March 14-16th
NEC, Birmingham. Electronics manufacturers show. Contact Cahners Exhibitions on 01-891 5051

Cable And Satellite 89 — March 16-19th
Olympia, London. Contact Montbuild on 01-486 1951

Corporate Electronic Publishing Systems — March 21-23rd
Olympia, London. Contact Cahners Exhibitions on 01-891 5051

Connectors 89 — March 23rd
Crest Hotel, Walsgrave, Coventry. Contact A F Hayes & Co. (0533) 881208

Automan — May 9-12th
NEC, Birmingham. Automated manufacturing show. Contact Cahners Exhibitions on 01-891 5051

Energy 89 — May 16-18
NEC, Birmingham. Contact Emap Maclaren on 01-660 8008

PROFESSIONAL

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

All kits come fully documented with concise assembly and setting-up instructions, high quality fibreglass PCB and all components necessary to complete the module. All prices are inclusive but please add £1 50 to cover P&P. Orders over £50.00 post free. Please state requirements clearly and enclose cheque or PO to cover.

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NOTE: It is illegal to operate a transmitter in the UK without a licence

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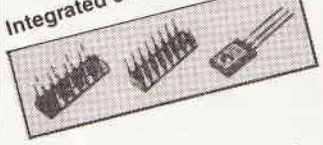
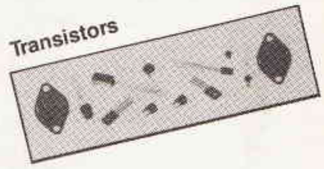
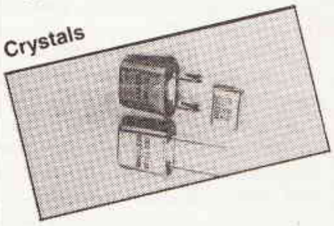


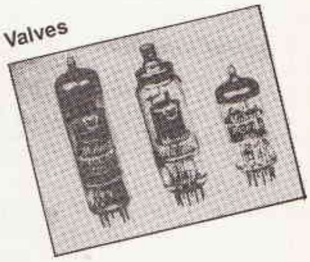
Integrated circuits



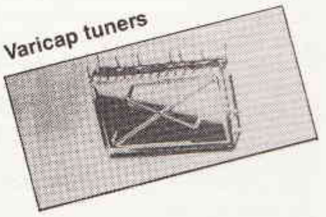
Transistors



Crystals



Valves



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Don't miss it!

Jackson slipped across the hallway and into the darkened library. The voices from the dining room wafted through the doorways unabated. The shrill laughter of Lady Grimshaw could be clearly heard above the rest of the company and Jackson smiled wryly to himself as he hid being the library door. It had been her screams which had brought Sir William and the Colonel running to the scene of his last attempt to get into Wilkington Hall that morning but now her falsetto was working to his advantage.

Timing the creak of the French windows with her next outburst he slipped out onto the croquet lawn. The moon was nearly full and through the thin September mist he could clearly see the figure of the Colonel crouched over his workbench in the potting shed window.

'Now' thought Jackson 'Now we'll see what's the secret behind the blue pagoda'. He stole over to the shed darting between the lilac trees which fringed the lawn, conscious all the time that Sir William could at any moment tire of teasing his wife and burst out onto the lawn for his customary evening game.

As he reached the shed door he heard voices inside. The Colonel was not alone and Jackson quickly recognised the second voice as Inspector Claptrap's. Could the Inspector be caught up in this dastardly plot too? He inched open the door and drew his revolver from his pocket. 'Hands up Colonel, and you Inspector' he announced as the two conspirators looked up in surprise from the circuit board in front of them. 'The game's up and it's Parkhurst for the pair of you.'

'That's where you're wrong, Jackson' said a deep voice behind him. Jackson spun around — just in time to see the rolled-up copy of ETI as it hit him square between the eyes.

As he crashed to the ground he heard the stranger murmer '. . . handy thing, the February issue of ETI . . .'

* * *

Other uses for the February ETI include learning all about NICAM. John Linsley Hood reveals all about this stereo sound system for TV. We also start a major new project to build a complete stand-alone, intelligent plotter. First up is a versatile stepper motor drive board usable with most computers.

There's also the next part of the EPROM Programmer and the Quest-Ion ion counter to complement the Variat-Ion ioniser, not to mention a pet scarer *1st Class* project to humanely protect your flowerbeds.

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These articles are in an advanced state of preparation but the Colonel, Sir William or the Blue Pagoda may prevent publication and herald the end of freedom in the Western world.

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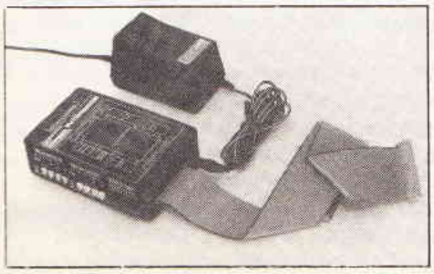

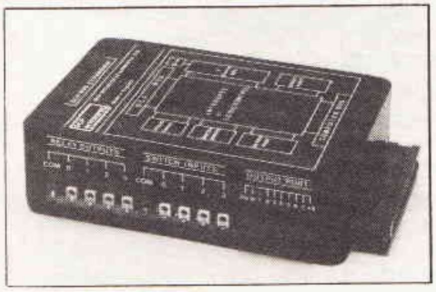

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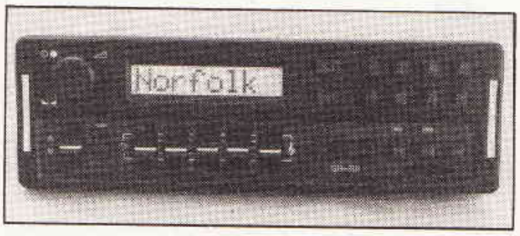
RDS

Mark Saunders is the BBC's Development Manager for the Radio Data System and here explains the background to the system, the BBC implementation and possibilities for the future

In October the BBC launched a new radio service — the Radio Data System — or as it is more generally known RDS. RDS warrants an official launch as it marks the most significant development in radio technology and radio services since the introduction of the transistor thirty years ago which bred a new generation of portable radios.

Simply, RDS is a data signal added to the audio on VHF FM broadcasts carried by all major broadcasters throughout Europe. The data is used primarily for either display or control purposes at the listeners' radio sets (Fig.1).



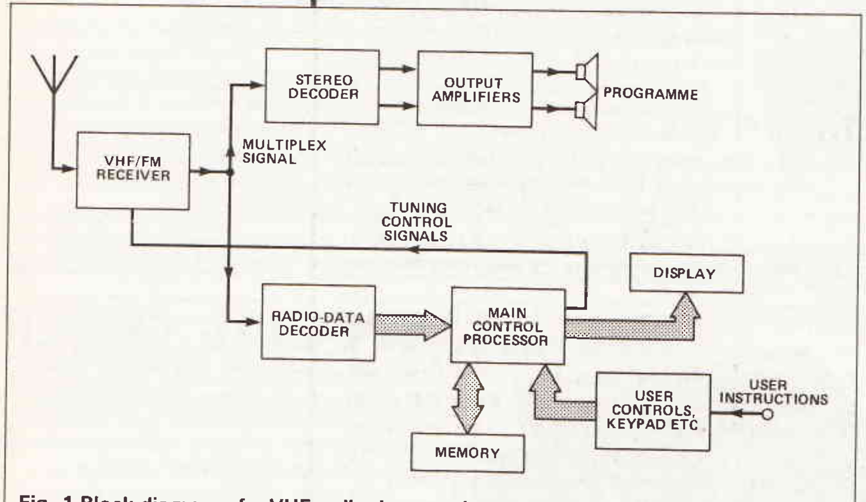


Fig. 1 Block diagram of a VHF radio data receiver

Background

The Radio Data System has been the subject of development since the early 1970's when the European Broadcasting Union (EBU) charged a specialist technical committee to research and agree a common standard for subsidiary data broadcasting on FM band 2 for use throughout Europe. The three principal participants were the BBC Research Department, IRT (the German Broadcasters' Research Organisation) and the Research Group of Swedish Telecom Radio. The latter was chosen because of its considerable experience of adding data to FM broadcasts to run the MBS Paging service in Sweden.

The creation of a data format for use on conventional broadcasting creates unique problems. Most data transmission methods in non-broadcasting environments assume the terminal devices at each end of the data network are in fixed locations and under direct control of the data user, with a relatively predictable path. With data used to supplement a broadcasting service, the send equipment is under the control of the broadcaster but the receiver is controlled by the public who must be assumed to have no technical knowledge or ability.

As the data path is essentially one way only (from transmitter to receiver), there is no possibility of any handshaking between the receiver and transmitter to verify correct reception of the data. In addtion, whereas Teletext data is sent to TV receivers in fixed locations in the home which are usually fed with good fixed aerial systems, a large number of radio sets are used in cars where reception conditions will vary from minute to minute and will be entirely unpredictable. One moment the vehicle will be in a high signal strength area, the next it may be receiving in an area with severe multipath conditions.

The criteria for such a data system obviously creates problems not encountered in other areas and demands that the data format is very rugged.

The other problem to overcome is to ensure that any new service added to existing broadcasts does not in any way degrade reception of programmes on existing receivers, or at least not perceptively. There are about eighty million radio sets in the United Kingdom alone and billions worldwide. It is clearly unrealistic if the system chosen was to make these sets obsolete or in any way affect their performance.

The implication of this is that the data-stream needs to be sent at a considerably lower level than any audio signal, and must in some way be transmitted so as not to cause any undesirable audio effects. The need to send rugged data at a low level demands a very unusual data structure.

Extensive practical tests were carried out in varying terrains to evaluate which of several possible data structures carried on different sub-carriers at convenient gaps within the FM spectrum produced the desired combination of reliability of reception and lack of audio interference. The outcome was that the results favoured carrying the data on a 57kHz subcarrier (Fig.2).

This sub-carrier frequency is three times the 19kHz stereo pilot tone and is locked either in phase or quadrature to the third harmonic. A 57kHz sub-carrier is one that had been used successfully by the Swedish PTT for operating their paging system and also added to FM broadcasts in Germany for their traffic information system (ARI).

The normal deviation of the main FM carrier due to the unmodulated sub-carrier is ±2.0kHz which is a relatively insignificant proportion (approx 3%) of the entire transmitted signal. The sub-carrier is amplitude-modulated by the shaped and bi-phase-coded data signal, which results in the sub-carrier itself being suppressed. The basic data rate of the system is 1187.5 bits per second which can be obtained by dividing the transmitted sub-carrier frequency (57kHz) by 48.

Base Band Coding

The largest element of the data structure is a 'group' of 104 bits which in turn comprises four blocks, each of 26 bits. Of these 26 bits, the first 16 (termed the information word) carry the data and the remaining 10 bits (checkword) provide both error protection and group and block synchronisation (Fig.4). This unusually high ratio of checkword bits: information bits to ensures a remarkably high degree of error detection and correction is possible. The error protection code will:

- detect all single and double bit errors in a block
- detect any single error burst spanning 10 bits or less
- detect about 99.8% of bursts spanning 11 bits and about 99.9% of all longer bursts.

In addition, the code is capable of correcting any single burst spanning five or less bits.

Several different types of group of 104 bits have been defined, each type carrying data for different applications according to the needs of the individual broadcasters.

The basic principles which underlie the message format and addressing structure are that:

- Messages which are most essential to the successful acquisition of data as a whole and which are required to be decoded regularly are repeated frequently and at a fixed position within every group. This ensures they can be decoded without reference to any block outside the one which contains the information.
- There is no fixed rhythm of repetition of the various type of groups allowing ample flexibility for broadcasters to interleave various features of RDS to suit their needs and also allowing for future developments and features to be added.
- Within any one group the mixture of different kinds of message is kept to a minimum. This is important because it allows broadcasters not broadcasting the Radio-Text facility, say, to omit the group types containing this information entirely. Capacity is not wasted by transmitting groups containing unused blocks, allowing groups containing the required features to be repeated more often.
- A number of group types remain undefined allowing for consequent future applications to be developed and awarded a group type of their own, for detection by later-generation receivers.

Group Types And RDS Features

For ease of reference the individual blocks in each group are referred to as A, B, C and D. At present nine group types have been defined. Each group contains different combinations of the various RDS features. The features are:

AF	Alternative Frequencies. The purpose of this data is to tell the radio receiver about other frequencies in the same and adjacent areas on which the same programme is also being broadcast.
CT	Clock Time and Date.
DI	The Decoder Information code informs a receiver of any audio processing being used by the broadcaster.
IH	In-House. Used by the broadcaster for his won needs rather than for public reception.
MS	This bit indicates simply whether the programme content is music or speech.
ON	Other Networks Information. Enables a receiver tuned to one network to 'learn' what is happening on other stations in the area.
PIN	Programme Item Number. This code uniquely indentifies individual programmes on a station.
PI	Programme Identification Code. This is a number comprising four hexadecimal digits which are allocated uniquely to each radio station. 'Programme' refers to what we in the UK would term a 'station'.
PS	Programme Service Name. This feature provides an eight character alpha numeric display of the name of the station being received.
PTY	Programme Type Code. Five bits used by broadcaster to label individual programmes (what we in the UK would call 'shows') according to their type or content.
RT	Radio Text. Text messages of up to 64 characters can also be transmitted.
TA	Travel Announcement. This bit is set only when a travel announcement is actually being spoken at that time. This bit is only used in conjunction with the TP bit.
TP	Travel Programme. A single bit set on a station to indicate that this station carries travel messages for the local area.

The single most important feature of RDS is the PI code. This sixteen bit code is essential to ensure all other data is correctly referenced to the appropriate station. It is used by the microprocessor in the receiver and is never displayed to the listener. This code always appears as the 16-bit information word in Block A of each group type.

The 16 bits are represented as four hexadecimal digits, each having a special significance. The first indicates the country of origin of the transmission; in the UK this is a C. The second digit indicates the intended coverage area of the station — International, National, Regional or Local. The third and fourth digits are freely allocated by the broadcaster to ensure that no stations have identical PI codes.

Two other features of RDS require frequent repetition and hence occur in a fixed position in Block B of each group. These are the 5-bit PTY code and the single bit TP flag. These features, although less important than the PI code, are required to be received regularly as they are intended to cause rapid switching and returning within a receiver. A further 5 bits in Block B indicate the group type number and one of two possible variants. These bits allow the receiver microprocessor to identify which group type is currently being received and decode the data accordingly.

The remaining bits in Block B and Blocks C and D vary from group to group.

Type 0 Group

One of the most attractive features of RDS is to inform a receiver of other frequencies for the currently received station within or adjacent to the transmitter service area. This information allows the receiver to compare the signal strength of the currently tuned frequency with those alternatives referenced in the RDS data. When an alternative provides an improved signal, the receiver will retune to this alternative, whereupon it will begin to acquire a new list of alternatives from this transmitter.

Each alternative frequency referenced in this way requires eight bits, thus two alternatives are carried within Block C of this group as shown in Fig.5. Several repetitions of this group type are required for lists of several alternatives. The eight bits for each allow any of the 200 possible 100kHz spaced channels on FM band II to be referenced. The 56 remaining codes are

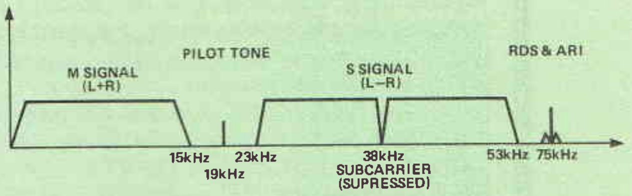


Fig. 2 The radio data sub-carrier frequency

Applications	Group types which contain this information	Recommended minimum repetition rate per second
Programme identification (PI) code	all	11
Programme service (PS) name	0A, 0B	1
Programme type (PTY) code	all	11
Traffic programme (TP) identification	all	11
Alternative frequency (AF) code	0A	4
Traffic announcement (TA) code	0A, 0B, 15B	4
Decoder identification (DI) code	0A, 0B, 15B	1
Music/speech (M/S) code	0A, 0B, 15B	4
Programme item number (PIN) code	1A, 1B	1
Radiotext (RT) message	2A, 2B	0.2

Table 1 Recommended transmission repetition rate for individual RDS features

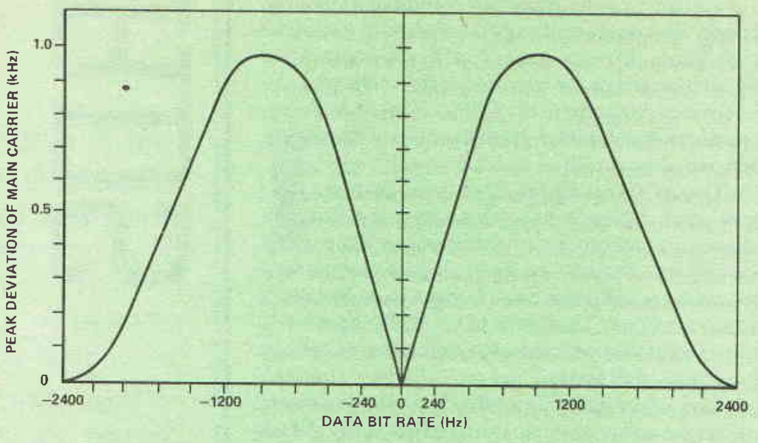


Fig. 3 The effect of the data bit rate on the carrier frequency deviation

used to indicate 25kHz offsets (although these are no longer used since the last Geneva band plan agreement) or to cross-refer to AM frequencies.

Block D of this Group Type provides for the receiver to display the name of the station. Two characters of the eight allowable for the Programme Service Name (PS) are sent at a time, completing the name in four successive transmissions of this block. Two bits in Block B indicate which pair of letters are currently being sent.

At the time of RDS development (which it must be remembered was in the mid 1970's) there was a degree of opposition to this feature because, although it was regarded as being an extremely useful feature, the display requirement was considered to be too expensive by the receiver manufacturers. Fortunately in the intervening years the costs of suitable displays has reduced significantly and although some receivers limit their display capability to numbers and upper-case characters only, others are capable of showing lower case and accented letters as well.

Type 1 Group

The 16 bits comprising Block D in this group type are the PIN code or 'Programme Item Number' (Fig.6). This is a unique code number that identifies an individual programme on a radio station. The combination of the PIN and that station PI ensures a unique code for each specific programme, for at least a month. Five bits are used to indicate the day of the month, five bits indicate the hour (using the 24 hour system) and six bits give minute information.

This code reflects the scheduled starting time of the programme. The intention is that this code is sent at precisely the moment the programme to which it occurs begins transmission. This has obviously a considerable advantage over a simple time clock in the receiver which cannot take into account a programme starting either early or late, as many frustrated users of video recorders will have found to their cost.

Type 2 Group

This group allows transmissions of text messages of up to 64 characters to accompany programmes (Fig.7). Typical applications of Radio Text would give extra detail about the currently transmitted programme, for example the programme title, the name and composer of the record currently being played or the telephone number to call to participate in a phone-in programme.

The text is free-format, so there is no limit to the text messages the broadcaster may choose to send (even adverts!). An impressive demonstration witnessed in Sweden was using Radio Text to sub-title a Mozart opera in English.

Type 3 Group

These are intended for use for the Other Network (ON) information, potentially the most useful and exciting of RDS features as it allows receivers tuned to one station to learn what is happening on other stations. The group structure is shown in Fig.8.

As a national broadcaster with four national networks and a chain of local stations the BBC is amongst the first to recognise the importance and use of the ON features. This can best be demonstrated by illustrating a practical situation.

A motorist commences a journey from London to Manchester listening to Radio 2. His RDS car radio had identified that the best frequency for him while in the London area as 89.1MHz from the BBC Radio Two transmitter at Wrotham.

While the radio is tuned to Radio 2 and receiving a list of alternative frequencies via group 0 it is able to retune inaudibly to the best frequencies for Radio 2 on the journey to Manchester. Typically, the radio would retune six or seven times on the journey, finally settling on 89.3MHz, from the Holme Moss Transmitter.

Once in Manchester, the driver wishes to listen to Radio 4 to catch the latest happenings from Ambridge. The driver presses the button that he has previously allocated to Radio 4. Without Other Network information, the frequency stored behind this button was that of the London area transmitter (93.5MHz) as this was the last known frequency for Radio 4.

However, the required frequency in the Manchester area is 93.7MHz. In order to find Radio 4, the radio without ON will need to search the entire band looking for a PI code match corresponding to Radio 4, which would also have been stored along with the frequency, behind the Radio 4 button. This search could take several seconds.

However, a radio incorporating software to evaluate Other Networks information will be updated not only about the best frequency for the currently received station but all other stations referenced in the ON information carried within the type 3 group. Hence the driver arriving in Manchester and pressing the Radio 4 button will be instantly tuned to 93.7MHz. ON also provides the only way of achieving a realistic travel news service, capable of supplying local information to a motorist listening to a national radio broadcast and is the 'gateway' to other advanced features.

Type 4 Group

Group 4 is used to transmit date and time information. The time information is expressed in terms of Co-ordinated Universal Time (UTC) using 11 bits, plus a further 5 for local offsets. The date information uses the modified Julian day system in which days are expressed as a single number in the range 0-99999, the receiver converting this to provide day, month and year information. This group is inserted in the data stream once per minute immediately preceding the minute edge (Fig.11).

It is expected that once this group has been received by the radio, the latter will be able to self-run and provide second information if required, and to maintain the clock within the receiver during periods when no RDS is being received (if the radio is returned to a station not carrying Time/Date information).

In the United Kingdom the reference for the RDS time information is from National Physical Laboratory 60kHz transmissions from Rugby received off-air at each transmitter site and then re-encoded into RDS format. In the event of a loss of Rugby transmissions (during maintenance periods for example) alternative sources are used automatically to maintain the service.

Type 5 Groups

These groups are configured to carry a channel of what is termed 'transparent data'. As the name implies the channel is used purely as a data highway between the broadcaster and a receiver at a consumer's home or in the car. It may, therefore, be used for data at this relatively low data rate. The data itself is carried in blocks C and D of this Group Type, with five bits within block B being used to address the data to one of 32 possible peripheral devices (Fig. 10).

At the current stage of RDS implementation it is not believed that any broadcaster is using this feature as a service, but within the BBC there have been discussions about using this feature to send information sheets or teachers' notes to a computer-type printer to accompany schools broadcasts.

Type 6 Groups

Group 6 information is not intended for reception by the general public and hence this group type should be ignored by domestic receivers. The unused bits in block B and all those in blocks C and D are free for unilateral assignment by an individual broadcaster for his own use. These so called In-House applications may be used for any purpose the broadcaster thinks necessary and could, for example, be used to control transmitter switching.

Type 7 Groups

This group type was not defined in the original specification (published March 1984) and is an example of the expandability of the original format, in that this group type has only recently been standardised and added to the system. Group type 7 defines the way in which a paging service may be added within RDS.

Broadcasters in some countries have already adopted this feature with its attractive revenue-earning potential.

Type 15 Groups

A final group type which was defined in the original specification is a type 15B group. It is intended that this group type is used to increase the repetition rate of the basic switching information contained in Blocks A and B of type 0 groups, without increasing the repetition rates of the other information within the type 0 group. Blocks C and D are simply repeats of Block A and B information.

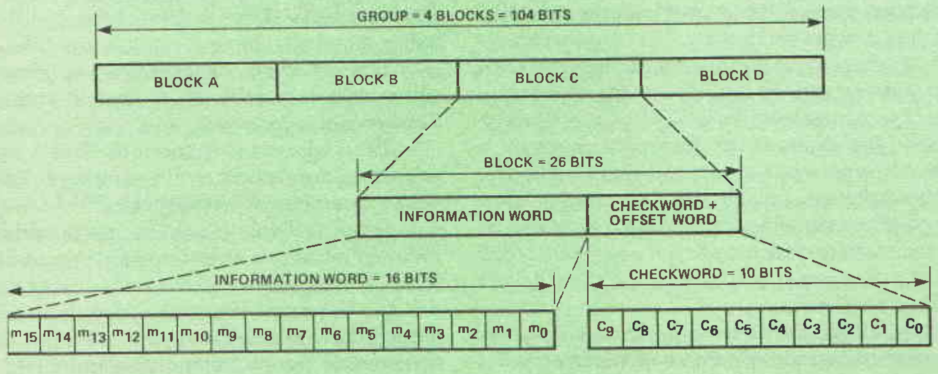


Fig. 4 The structure of a data group

Data Stream Make-up

The entire data stream package comprises various groups according to the wishes of the broadcaster to suit the service features he is offering. However, to ensure accurate reception of the features there is a recommended minimum repetition rate for transmission of each individual feature, which is shown in the Table 1.

Although the EBU specification was fully defined and published by 1984, as with any new broadcast development a willingness had to exist on the part of both the broadcaster and the receiver manufacturer to introduce the service. The problem is that no broadcaster feels justified in spending a large sum of money to develop and implement a service until there are receivers in the market to take advantage of the new service.

In a similar way no manufacturer is willing to spend money, time and effort in the research and development of receiver design until there are services available. This chicken and egg situation looked like occurring with RDS.

In 1985 the BBC and two or three other broadcasters resolved to solve this dilemma by guaranteeing a minimum public service of RDS using some of the basic features in an effort to stimulate the development of receivers.

RDS offers a wide range of features but realistically not all can be introduced from day one, across a country as complex and comprehensive in terms of broadcasting as the UK. The BBC carefully considered ways of introducing RDS as a phased programme. It made the general decision that initially the service offered should not rely upon heavy daily operational costs until the take-up of receivers had been established.

After careful examination of its own broadcasting structure it was also concluded that it was not possible to convert every single FM transmitter to carry RDS in a single phase, there being in excess of 300 transmitter installations required.

There appeared to be two possible routes. The first was to equip in its entirety across the UK one single network — for example Radio 2 — and then gradually add a second, third, fourth and then a Local Radio network to the system. This is the practice that has been adopted in other countries but it seemed to the BBC to lack a degree of logic for two reasons. Firstly, having spent money on a new radio, a listener would reasonably expect to find RDS on all services in their particular locality and secondly as the transmitters for the network services are co-sited, it makes sense to equip all services at a transmitter in a single visit, rather than make several visits to the same site to convert each service separately.

The conclusion of these deliberations was that the BBC planned to equip its RDS service on a geographical basis and to ensure that the maximum number of people could benefit as quickly as possible. About 75% of the United Kingdom population receive their radio services from transmitters in England which also has relatively few transmitters when compared to the number required for Scotland and Wales. England was

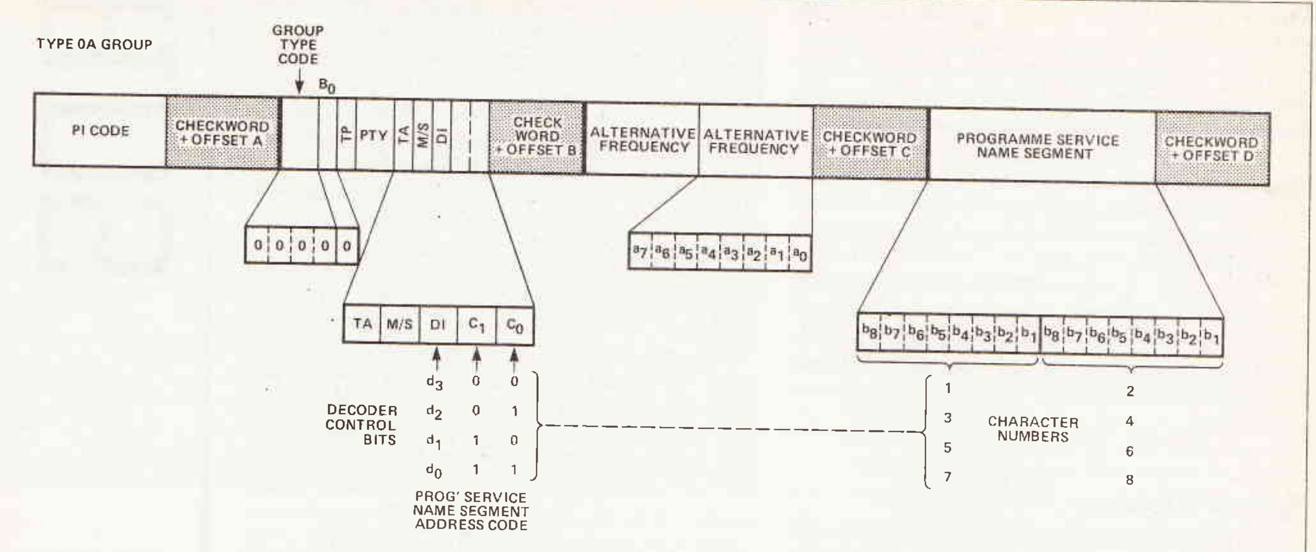


Fig. 5 The type 0 group structure

chosen therefore to form the first phase of installation with National services and Local Radio transmitters being equipped.

Encoders

It is relatively easy to undertake an equipment installation programme if suitable equipment is available and its purpose well defined and predictable.

RDS was designed to be an expandable system allowing an initial simple implementation with a limited range of features and also for the possibility of adding others as the need arises. The BBC determined that its equipment and installation strategy should allow the transition to more complex applications without major re-engineering or equipment replacement. The requirements at each of the BBC's transmitter sites vary and there was an obvious advantage in keeping the number of encoder variations to the minimum.

When examining the market for suitable commercially-made encoder equipment the BBC found, perhaps not surprisingly, that no equipment meeting these parameters was already produced.

The BBC decided therefore that it would need to design and manufacture in-house. This proved to be a particularly farsighted decision as it gave the BBC the ability to react to the minor fine tuning of the specification that was discovered to be required after the design process had begun. The plan was for the BBC to equip all its English transmitter network by the beginning of September 1987. Due to the tremendous efforts of engineers from the BBC Design and Equipment and the efforts of the Transmitter installation teams, this target which earlier had looked optimistic was actually beaten. By July 1987, 98 separate transmitters had been modified and these together with 52 relay transmitters were broadcasting five initial RDS features, a greater number than in the whole of the rest of Europe put together.

The encoders themselves are self-running and self supporting without any external input, the data coming from a PROM installed within each encoder unit. In this state they are capable of radiating the so called 'static' features of RDS. These are the PC code, the Programme Service name, the list of the Alternative Frequencies for that station and information about the frequencies for Other Networks.

The fifth feature, Clock Time and Date, although it is dynamically changing information, is static in the sense that it is derived at the transmitter site without the need for external data links.

These five features formed the basis of the first phase of RDS implementation and in themselves offer a considerable improvement for listeners, particularly those listening on FM in the car. The range of Band II FM VHF signals, unlike their AM MF and LF counterparts, is typically 40 miles radius as far as National Network transmitters are concerned. To cover the entire United Kingdom with just one service, over a 100 transmitters and 22 different frequencies are used.

The static RDS feature allows the automatic retuning of a car radio to the best available frequency for the required service, together with a confirmation of the service being received via the programme service name. The time feature, as well as ensuring that the clock in the car is always accurate, takes care of the biennial Winter/Summer time switch and also eliminates the need to have to reset the clock after the garage has obligingly disconnected the battery during car service. On a continental motoring holiday, this is the one clock that won't need adjusting as you cross time-zones.

Before more advanced service features of RDS can be introduced, there is a requirement to be able to change the radiated data to make it relate to transmitted programmes.

Programmes for the four National Networks are controlled from Broadcasting House, London, so RDS also needs to be controlled from this location and fed to the encoder units.

The audio for the programmes is distributed to the transmitters via the BBC NICAM system which also has the capacity to carry data.

To achieve dynamic control of RDS, a computer addressing the encoder units and taking an input from desk-top terminals was required.

Broadcasting is a somewhat specialised environment in that there is a need to maintain a service at all times. This is generally achieved by having duplicate sets of all essential equipment and duplicate feeds throughout. The failure of any one single item therefore doesn't affect the transmitted programme and a series of failures, provided they are within different parts of the system, similarly do not cause any problems.

RDS was seen as having no lesser priority than the audio and from the outset two sets of encoder equipment had been installed at network transmitters. At Broadcasting House there was a need for the central computer to be backed up by a second computer to maintain this duplication of essential equipment. At the time that decisions were being made concerning the choice of computer system for this task, DEC were beginning to market a pair of PDP/11 computers arranged such that one computer was a hot standby for the other. This configuration ensured that if a on-line computer was to fail, an automatic changeover to the stand-by was achieved instantly.

Travel News

With the computer installation decided, the BBC undertook market research to establish which of the more advanced 'dynamic' features now possible should be adopted first. It soon became apparent that the enhancement of the travel service provided by the BBC was seen by the listener and manufacturer as being a real added advantage and one that the listener would be prepared to pay a small price premium to receive.

Two features within RDS — TP and TA — emulate the German ARI system, allowing a quick method of searching for a local station by looking for a data stream with the TP bit set 'on'. Once having found an appropriate station, the switching on by the broadcaster of the TA bit will increase the radio volume or cause a switch over from in-car cassette or CD listening back to radio. This straightforward system, however, is not desirable for either the broadcaster or the listener. In order to hear Travel News, the listener is forced to listen to a particular station which may not be to their taste, and if this is the case, listeners will turn off the radio and listen instead to pre-recorded music.

The BBC recognised the considerable potential for improvement by combining the TP and TA feature with the 'Other Network' information carried by a National Network.

The data carried in the ON information already informs the radio of the frequency for the Local Radio station in the area but can also inform the receiver at the precise moment that a local radio station switches on the TA flag. This arrangement allows the listener to have his choice of BBC national or local radio station, with the radio retuning away from the national service to the local radio only for the period of a travel announcement. This is seen as having the potential to provide the most sophisticated travel service ever provided by a broadcaster as it effectively provides local travel news while listening to a national station (Fig. 11).

The practical implementation of this feature is not simple to achieve, as every local radio studio scattered around England needs to be connected back to the central RDS computer in London to change the ON data at the national network transmitters, and also to their own local transmitters to switch on the TA flag.

Although some saving in line installation has been achieved by some innovative techniques, it will still take two or more years before this service could become nationwide. The intention is to field-trial this feature on five stations as the first phase of this development.

System Development

The original EBU specification outlines only the data structure both broadcasters and receiver manufacturers must follow to take advantage of RDS. It does not attempt to influence the design of either the broadcasters' hardware or the receiver manufacturers' equipment.

With any new standard, it is inevitable that those who wish to exploit it first are required to learn and develop the best methods of meeting the standard. RDS proved to be no exception and a couple of examples illustrate this point.

The original EBU specification had allocated eight addresses for Other Networks information. It would not be illogical to imply from this that 8 other networks was considered to be the maximum that could need referencing. As the BBC soon discovered, in the case of, for example, services from the Holme Moss transmitter near Manchester, references need to be made to four national networks and five or six Local Radio services. The BBC took a lateral approach to the problem and reasoned that the same ON address need not always reference the same other network. It was quite in order to send information about one network and simply increment the ON address reference by one, before sending information about another network.

Using this philosophy there is no limitation to either the maximum or minimum number of other networks that could be referenced, and the receiver still had sufficient information to make intelligent use of the data.

A second example of decisions taken only when into the engineering test phase of RDS concerned the PI code itself. A problem can exist if the broadcaster does not clearly think how he is to allocate them to his services.

Take as an example the common practice throughout Europe of a service being available as a national service during parts of the day but at other times being split into several regional variations. While the transmitter chain is configured as a national network it is desirable that each individual transmitter should radiate the same PI code, allowing the automatic retuning between transmitters intended by the system.

On the other hand when the network splits into regional variations, they should not continue to radiate the same PI code, as a mobile receiver in a car between the service area of one region and the next would suddenly find the programme material changed as the radio discovered a stronger signal from a transmitter with the same PI code. In the overlap area where signal strengths from two adjacent regions are nearly equitable the receiver is likely to cycle several times between the two different programmes from adjacent regions.

This clearly is highly undesirable and the preferred solution would be to arrange that the PI code will change when a regional split occurs. As outlined above few countries in Europe have the necessary data infrastructure to effect dynamic changes of this sort. There was a need to solve this dilemma by allocating PI codes for all transmitters that could allow an appropriate

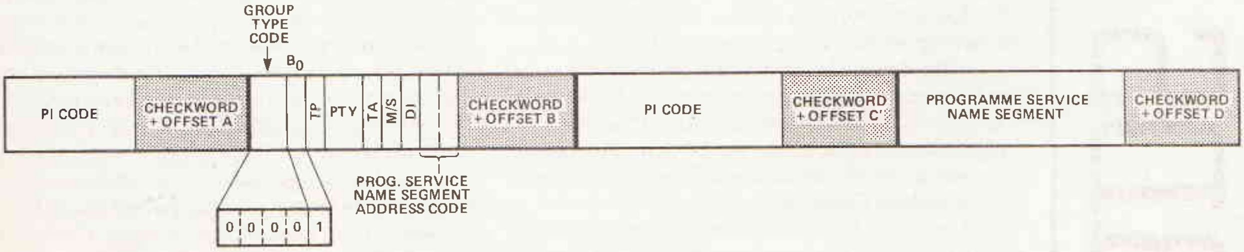


Fig. 6 Type 1 group structure

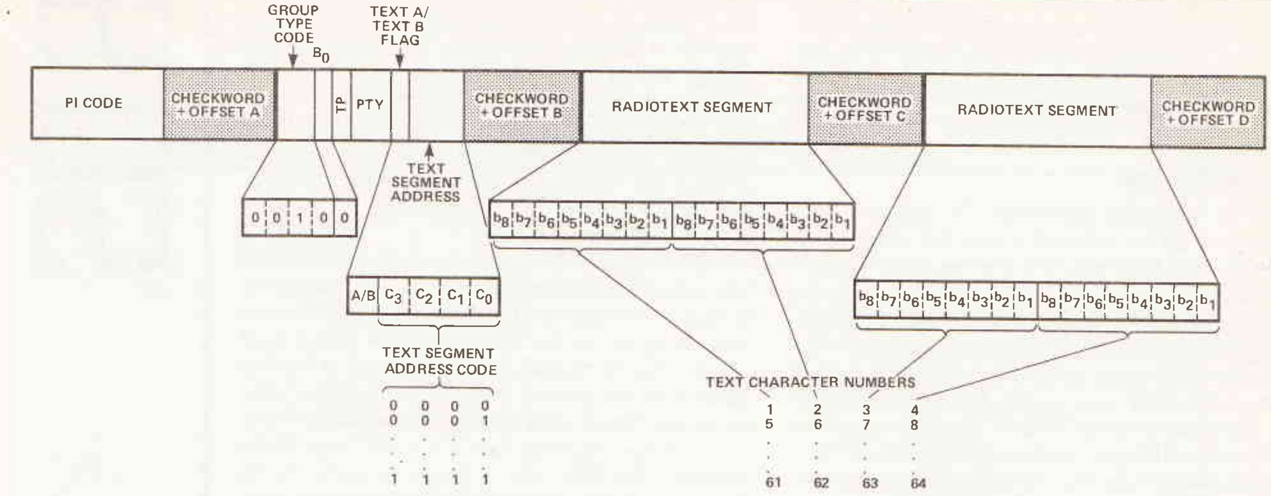


Fig. 7 Type 2 group structure

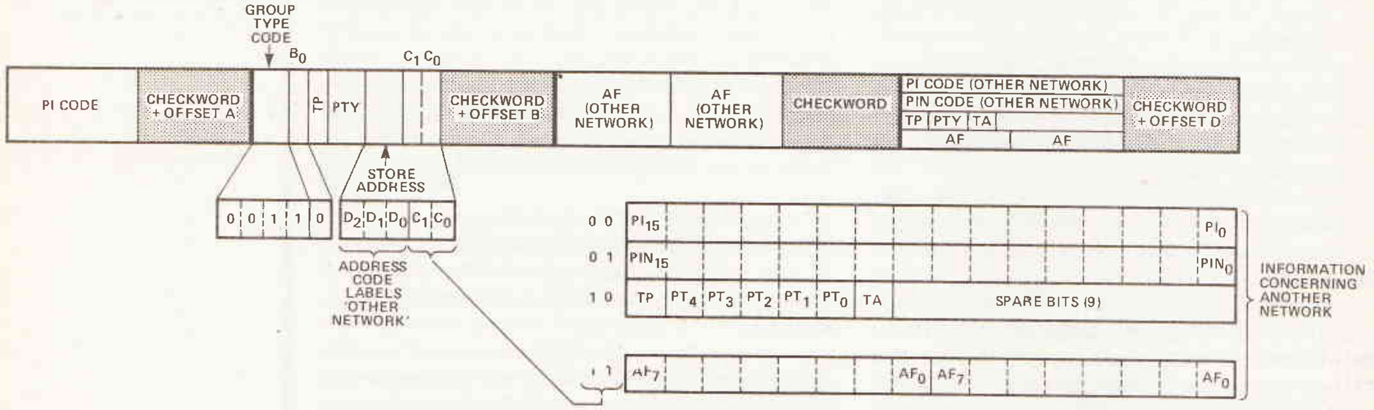


Fig. 8 Type 3 group structure

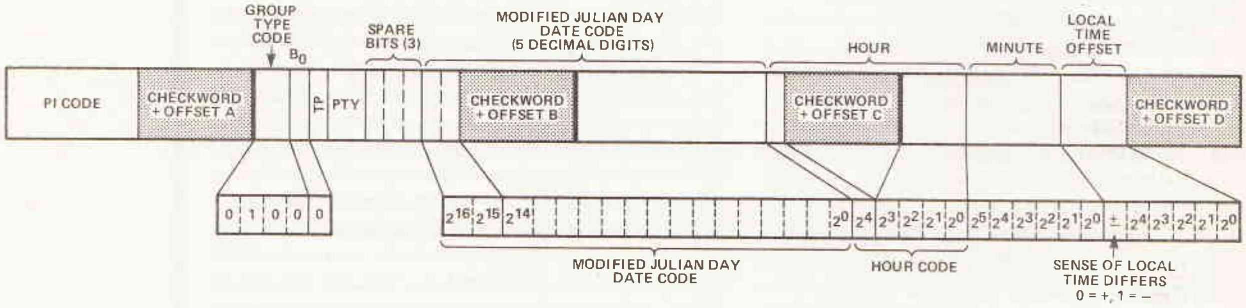


Fig. 9 Type 4 group structure

solution at the receiver end.

Although this problem does not exist for the BBC, which does have the ability to change PI codes when regional splits occur, the solution has enabled a further attractive feature to be introduced for BBC Local Radio listeners.

In practice this means that the PI codes allocated to each of the BBC Local Radio stations are almost identical, varying only in the second of the four hexadecimal digits.

When a receiver is beginning to lose the signal strength from the currently received transmitter and can find no better signal within its AF list, the radio tries to find a better signal by doing an inaudible search for another occurrence of the same PI code. If this search fails, it then does a second level search this time looking for PI code that matches only in the 1st, 3rd and 4th digits, treating the second digit as a wild card.

If a match is made this time, the receiver knows this station is not identical in programme content to the current one but is a similar station in style, content and presentation to the current. The frequency of this new station is loaded into the memory behind the original push button used to select the first BBC local station. When the listener decides that the audio quality has deteriorated sufficiently that he no longer wishes to listen to the station, a press of the same pre-set, will select the next local radio station geographically.

To extend initial RDS Features to the remainder of the UK is just a matter of time. To a large extent this process is inevitably slow, each new installation adds ever smaller audiences to RDS as the more remote areas are reached but if all goes well, this should be completed during 1990.

While this installation work is going on, the best ways of using the more advanced features of RDS will be determined. The BBC's installation has meant that the Radio Text, Programme Item Number and Programme Type code information can be transmitted on all of the BBC's national services. Tests using these features are already occurring, ready for manufacturers to develop their sets to this level of technology.

The Future

Development will continue for the foreseeable future. The system was designed to be 'future proof' allowing the addition of new features and new facilities by defining a new group type as the need was indentified. On the horizon a particularly attractive further enhancement to information for motorists is likely to become part of the system within the next decade.

Several companies are already developing on-board navigation systems for cars. These in general rely upon an on-board computer which is loaded with a nation-wide map of the road network. Dead reckoning or other techniques pin point the precise location of the vehicle and it only remains for a driver to state his destination to allow the computer to quickly advise the best route for the journey. The short-coming of this system as it stands is that this does not take account of prevailing road conditions and hold-ups or temporary road closures.

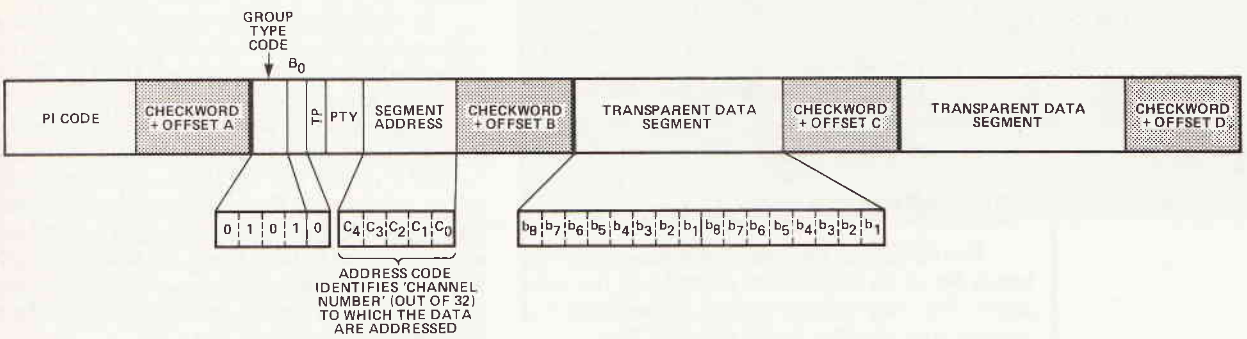


Fig. 10 Type 5 group structure

RDS is likely to provide the means to update dynamically the on-board information to take account of the prevailing conditions.

A second future application of RDS will allow pre-coded traffic announcements to be carried to the motorist. A European-wide vocabulary of all likely road traffic messages is being compiled. Each individual phase relating to a traffic problem: cause, effect, location, direction of travel, advice, and expected duration of the problem is assigned a code number. By transmitting a sequence of code numbers an entire message may be quickly built up. In the motorist's car, the receiver is able to reconstruct the message which can then be output via a number of devices. A driver switching on his ignition in the morning may well be presented with a 'rip-and-read' printed summary of the travel problems still relevant to his area. On route this information is likely to be provided to him by a voice synthesiser.

The unique advantage to messages handled in this way is that the message does not have to interrupt existing programmes and because the language structure has been agreed throughout Europe, a motorist driving abroard will receive the message in his own native tongue.

Before this can become a reality there is clearly much to be done in finalising the vocabulary required and creating suitable code numbers to cover every possible location throughout Europe, as well as the not inconsiderable work to collect and then transmit the information. Although altogether an awesome task this is well within the capability of the Radio Data System and is just a foretaste of things to come.

Acknowledgements

The Author acknowledges the help of his BBC colleagues involved in RDS and in particular Managing Director Network Radio for his permission to publish this article.

References

Specifications for the Radio Data System RDS for VHF/FM Sound Broadcasting, European Broadcasting Union. Tech 3244

1 Police learn about an accident in the Ashford area of Kent on the M20.
2 They tell BBC Radio Kent of the incident using conventional means.
3 Just prior to reading the travel announcement, BBC Radio Kent pressed a button which is communicated via a data link to Broadcasting House, London and the RDS Central Computer.
4 The computer changes instructions to the network transmitter at Wrouton which serves the West Kent area. The RDS data from the network services (Radios 2,3 and 4) is altered which in turn will inform an RDS radio that Radio Kent is to carry a travel announcement.
5 The transmitter at Swingate near Dover which serves East Kent relays the same RDS information received from Wrouton transmitter.
6 A suitable RDS radio in a car will switch over to the Local Radio Service to receive news of the accident.

A typical first generation RDS car radio (the Volvo SR-701). This particular model responds to PI, PS, AF, CT, TP and TA features of RDS.

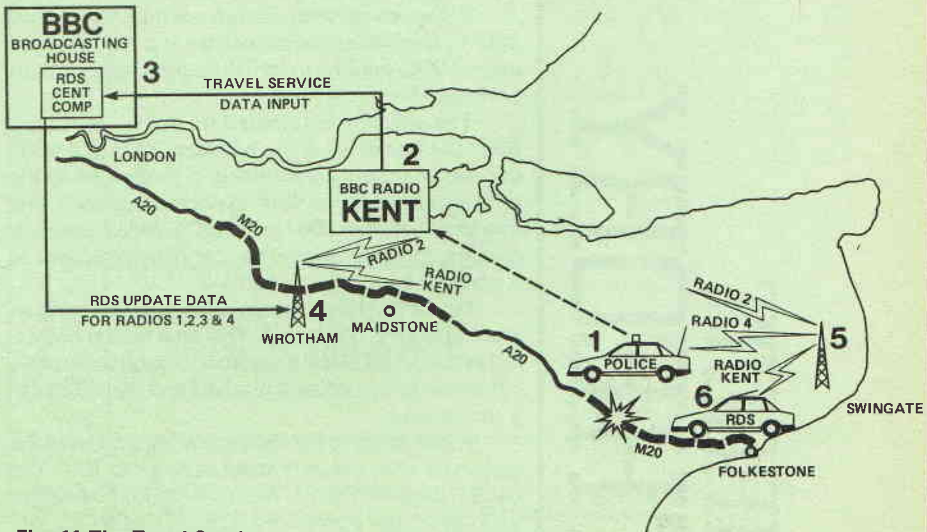


Fig. 11 The Travel Service

CIRCUIT THEORY

OP-AMPS

Paul Chappell continues to cook up op-amp oven control circuits and finds there's much to be gained from errors

Continuing last month's investigation of temperature controllers, without further ado I'll give you an improved version. It's shown in Fig. 1. If you remember, we were trying to improve the performance of the controller by sensing how far it was from its target and using this error signal to increase or decrease the current to the heater, with the aim of making it respond more quickly to changes in the set temperature and sit more firmly at the proper temperature when outside influences tried to change it.

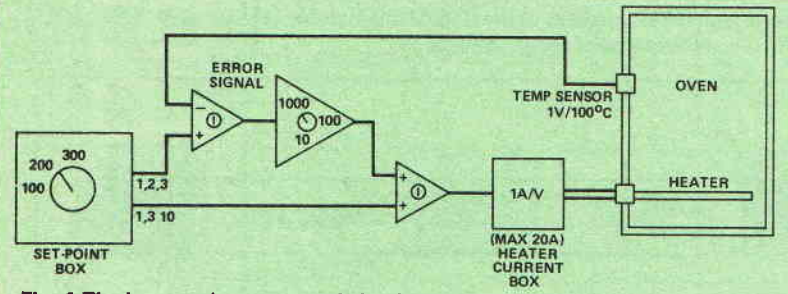


Fig. 1 The improved oven control circuit with error gain

The addition to the system, which we have high hopes for, is an amplifier to multiply up the error signal. The odd looking triangle with a knob is a variable gain amplifier which does just that.

Let's set the amplifier gain to 10, the temperature set-point control to 300°C, and turn the system on. The oven is initially at room temperature and the temperature sensor will be giving an output of about 200mV (assuming room temperature is about 20°C) so the error signal will be about 2.8V. This is multiplied up to 28V by the amplifier and added to the 10V output from the set-point box which gives the heater the current it needs to sustain the set temperature once it reaches it, giving a total of 38V. This goes into the heater current box and since it gives a maximum of 20A, the heater will be full on.

The heater will remain full on until the oven temperature reaches 200°C at which time the amplified error signal will begin to fall below 10V and the current will decrease. At 300°C the heater will be receiving the 10A needed to sustain the temperature.

If the oven temperature should rise above 300°C, the heater current will fall at a rate of 1A for every 10°C, tending to let it drop more quickly to its set level.

The situation is summed up in Fig. 2a. Below 200° the heater is full on, between 200° and 400° the heater current correction is in proportion to the error signal and above 400° the heater current is zero. The band between 200° and 400° is called, naturally enough, the proportional band and the technique as a whole is 'proportional control'.

Figure 2b shows the situation where a temperature of 200°C is selected. This time the set point is not in the centre of the proportional band (why not?) but the set temperature is reached and maintained in a similar way.

A gain of ten to the error signal has improved the system no end, so how's about setting it to 100? The result is shown in Fig. 2c. We now have full power right up to 290° and a proportional band that is only 20° wide. The advantage of a narrow proportional band is that if the temperature strays from its set value, the heater current will change very quickly indeed to restore it. It also means that if the set point is changed, the heater will spend more time with either zero or full power, so reaching the new temperature as quickly as possible.

Yet another advantage concerns a question I raised last month. Where will the temperature stabilise if the oven is placed in a draught (or moved to the land of the Eskimos or the Zulus?). Unless the heater is under-powered and couldn't sustain the proper temperature even with the full 20A or unless the temperature of the surrounding air is higher than the set-point, the temperature must stabilise somewhere in the proportional band, no matter where the oven is placed. With a ±100°C proportional band as in Fig. 2b, the temperature could be anywhere within this region.

By narrowing the proportional band as in Fig. 2c, we've reduced the maximum error to ±10° and if we increase the gain still further to 1000 (Fig. 2d), the maximum error is now only ±1°.

There's just one last change I'd like to make the to the control system. If you think about it, the controller covers the full range of heater currents within a 2°C band. This band has to be very close to the set point because otherwise the amplified error signal would be so large that it will swamp any other signal the controller can come up with. So what would happen if the 'sustaining current' output from the set-point box was removed? Not a lot!

The revised circuit is shown in Fig. 3a and the effect on the action of the controller in Fig. 3b. The proportional band has dropped so that it's entirely below the set-point (because if it ever reached the set point the error, and therefore the heater current, would be zero). We have to face the sad fact that this system can never hit the selected temperature spot-on but on the other hand we can still make the error as small as we please by increasing the error amplifier gain. It seems a small price to pay for getting rid of the awkward, non-linear output from the set-point box.

A Postcard Home

We've come a fair distance now but where are we exactly (and what are we doing here)? Looking back over the journey, we started out with a control system which was working blind. It had no way to check on the results it was achieving and so couldn't correct for any errors or disturbances that upset its workings. This kind of affair is called an *open-loop* system (control theory is a very metaphysical discipline which sees every string of components as a potential loop, if only someone would join the end back to the beginning!)

Another open-loop system is shown in Fig. 4a. Here the thing that is being controlled is the op-amp's own output voltage and since it can't 'see' it, it doesn't make a very good job of it. Inside the IC, one transistor passes on the signal to the next and the slight drifts and errors introduced by each stage accumulate so that the output is a very poor attempt at an amplified version of the input.

To improve the temperature controller, our first step was to take a reading of the output (the oven temperature) and feed it back to compare with the input. The way we decided to use this *feedback* was to oppose any deviation of the output from the set point. If the temperature fell, the error signal would rise and vice versa. Feedback which opposes any straying of the output from the required value is called *negative feedback*.

Applying feedback results in a loop. In Fig. 3a it goes: subtractor — error amplifier — heater current supply — heater — oven — temperature sensor — and back to the subtractor again. The controller is now a *closed loop* system. We also discovered that the forward part of the loop (in Fig. 3a, the error amplifier, heater current supply and heater) can be activated by the error signal alone. The need for a certain steady heater current is accommodated by the loop with very little change in accuracy.

The benefits of negative feedback appear to be that you can make the temperature as accurate as you like by increasing the amount of feedback (that is, by increasing the loop gain), that outside influences have very little effect on the temperature and that the inherent non-linearity of the open-loop system (the 1-3-10 curve of heater current needed for linear temperature increases) is absorbed by the feedback loop, so it's no longer necessary to measure the exact characteristics of the actual heater and oven used.

So how does all this relate to op-amp circuits? Have a little more patience with me and you'll see! For a start, take a look at Fig. 4b. Let's suppose we're making a sample and hold circuit and that C1 is to be the capacitor that holds the sampled voltage. We'd like it to follow the input pretty smartly so that when the hold signal comes along it will have an accurate sample of the input voltage.

With the circuit as it stands, if the input voltage is moving slowly the capacitor will follow it quite well. If it moves quickly, the capacitor voltage will lag behind and for a very fast moving signal it would be just as good to guess at the voltage as to rely on what the capacitor says!

Let's see if we can put together a feedback loop to improve the performance of the circuit. Following exactly the same procedure as for the temperature controller I'll take a signal representing the output (the voltage across C1) and since it's already in the form of a voltage I'll just use the output itself. This voltage is subtracted from the input to form an error signal (which will be zero if the output and input are at the same voltage — the situation we're aiming for). The error signal is amplified and applied to R1 and C1 (Fig. 4c). Let's see if it works.

Suppose the input voltage and the voltage across the capacitor are both initially at 0V. The input then steps up to 1V and we'd like the voltage across the capacitor to do the same. The error signal will start off at 1V and the error amplifier will step this up to . . . 100V? Probably not! Let's suppose it has an output voltage swing of ±15V.

At first the output will be at +15V (full power if you like) and C1 will charge at the highest possible rate. When it gets to within 150mV of its target, the amplified error voltage will begin to fall at 1V for every 10mV rise in output. The circuit is in its proportional band.

The voltage across C1 will eventually settle a little less than 10mV below the 1V 'set point'. Can you see why it won't settle at exactly 1V?

The same kind of diagram can be drawn as for the temperature controller (Fig. 4d). The circuit has areas of operation analagous to the full power, proportional and minimum power bands of the control circuit. Can you see why the set-point is right in the middle of the proportional band for this circuit and above it for the temperature controller? (What if the amplifier could only give an output in the range 0 to ±15V? Or if the oven heater was a Peltier device which could cool the oven down if the current was reversed?)

With the circuit of Fig. 4c, it appears once again that increasing the loop gain will bring about all manner of good things. If the gain is increased to 1000, the capacitor will charge at its maximum rate all the way up to 985mV and the voltage will settle to within 1mV of the input. If you imagine that the circuit is following a changing voltage instead of aiming for a fixed one, this will work well too. The slightest difference between input and output will quickly supply a voltage to push charge in or out of the capacitor, and as the input gets further away from the output, the voltage increases to enable the capacitor to keep up. If the input gets as far as 15mV away from the output, the capacitor will be following as fast as it possibly can and only if the input moves faster still will the circuit run into difficulties.

In Fig. 4c, the error amplifier is an op-amp, and since it has a subtractor built in there's no need for a separate device to perform this function. In theory, if the op-amp has a voltage gain of 10^5, the output

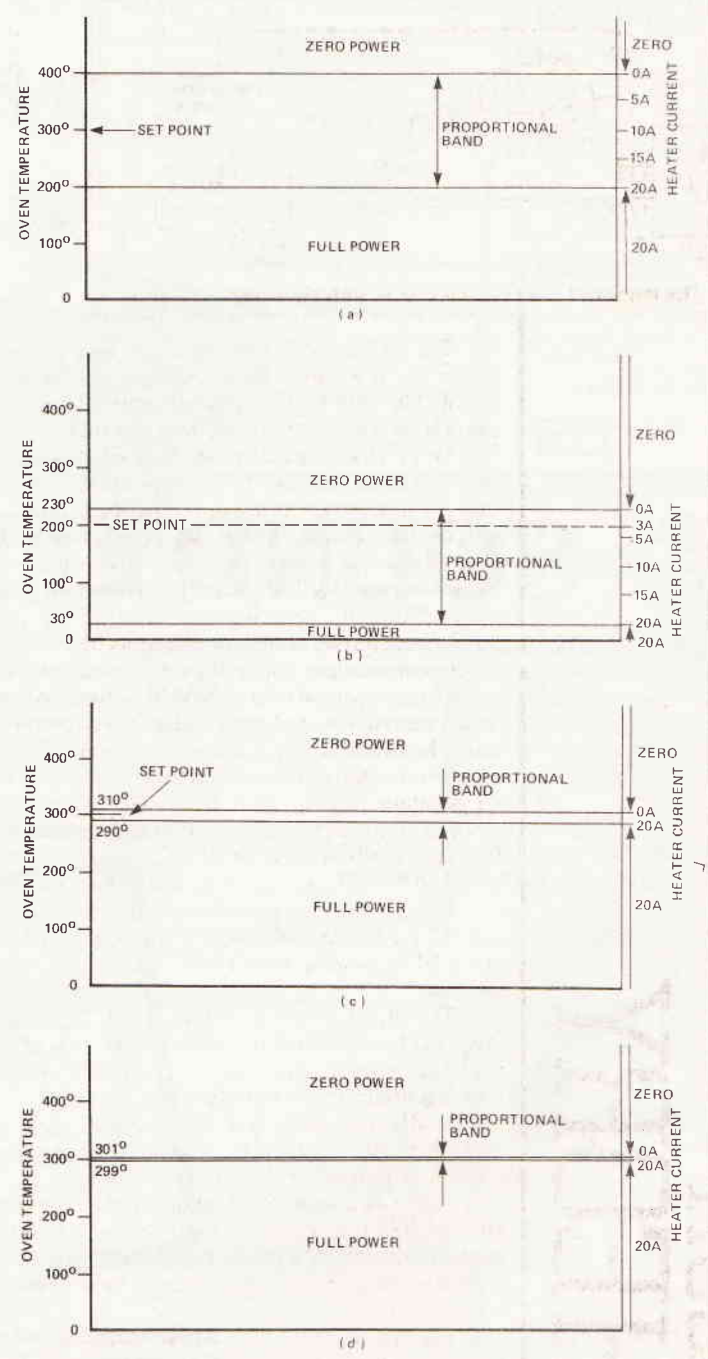


Fig. 2 The controller results. (a) With the circuit of Fig. 1 and an error gain of 10 and a set point of 300°C. (b) With a set point of 200°C. (c) Boosting the error gain to 100. (d) With an error gain of 1000

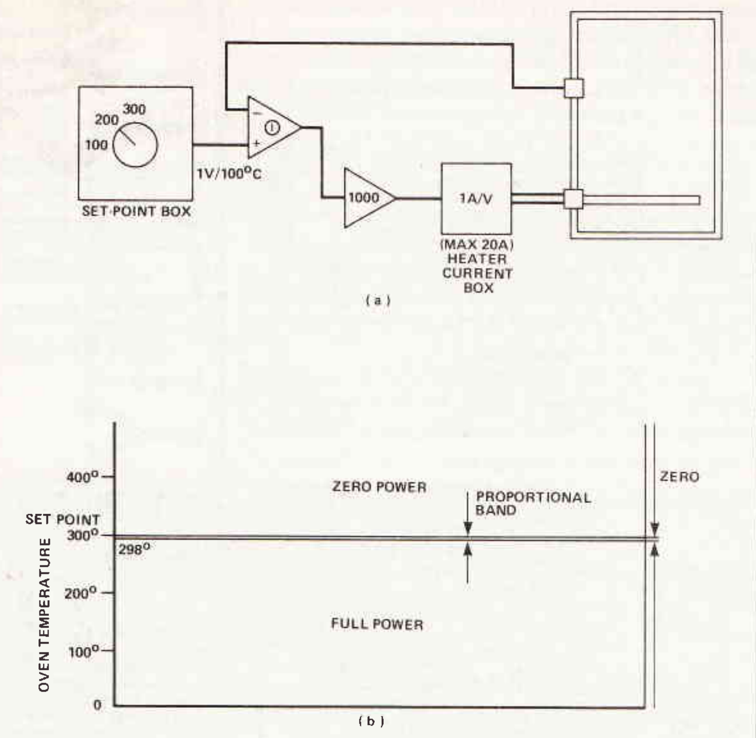


Fig. 3 The Revised control circuit with no 'sustaining' current. (b) The result

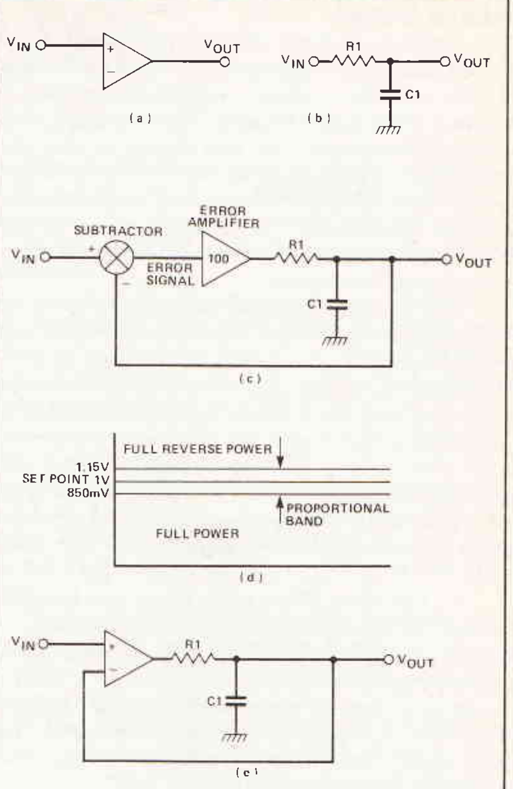
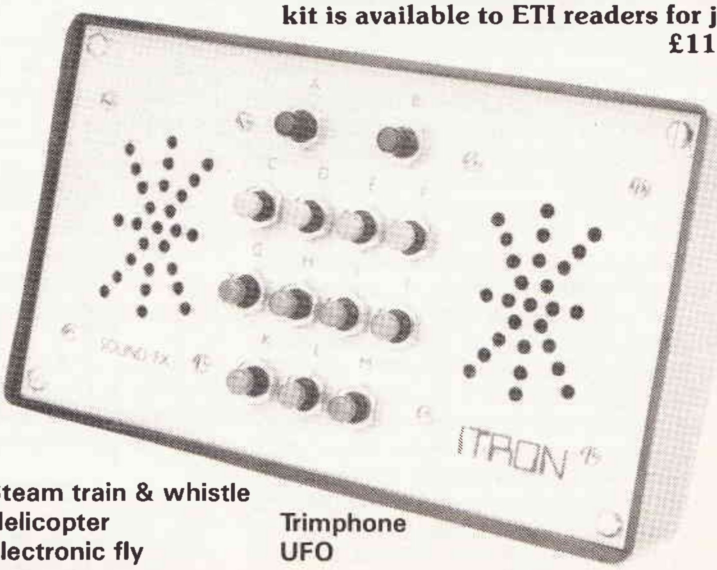


Fig. 4 (a) A simple open loop op-amp circuit. (b) An open loop sample-and-hold circuit. (c) Applying feedback. (d) The results. (e) The real circuit

should settle within about 10μV of the input but in practice the op-amp's subtractor isn't always up to scratch — remember input offset voltages? It should charge the capacitor pretty smartly, though.

So far we've only seen the good side of negative feedback but it has a dark side too. Next month we'll see some of the problems it can cause and how to cope with them.



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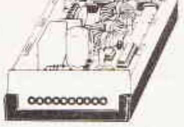

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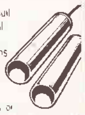

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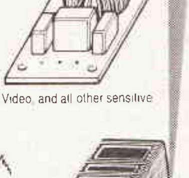

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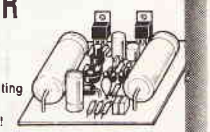
FEATURED IN PE
JULY 1988



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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

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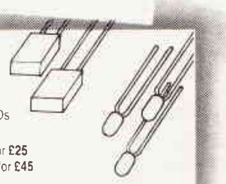

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The most astonishing project ever to have appeared in an electronics magazine Similar in principle to a medical EEG machine this project allows you to **hear** the characteristic rhythms of your own mind! The alpha beta and theta forms can be selected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

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LANGUAGE LESSON

Mike Barwise takes a look at the range and types of programming languages available to designers of microprocessor based projects

Having looked on various occasions at microprocessors, input and output devices and other microcomputer hardware, I think the time has come to examine software — the bit that makes all the hardware more useful than a hi-tech doorstop.

By software we mean the user program: a sequence of instructions which cause the microsystem to arrive at a given result. This instruction sequence always consists of machine op-codes. We will later examine high level languages but it is absolutely crucial to remember that regardless of the language you write a program in, the end product which the microsystem executes is a sequence of machining op-codes.

```
 10 MODE3
 20 VDU14
 30 VDU2
 40 VDU1,27,1,69,1,27,1,71
 50 C=OPENIN("EPROM")
 60 FOR A%=0TO&1FFF STEP 16
 70   IFA%=&06C0 A%=&1F00:PTR#C=&1F00
 80   IFA%=&1F90 A%=&1FF0:PTR#C=&1FF0
 90   A$="000"
100   IFA%>&F A$="00"
110   IFA%>&FF A$="0"
120   IFA%>&FFF A$=""
130   PRINT;A$;~A%;"  ";
140   FORI%=1TO16
150     D%=BGET#C:IFD%<&10PRINT;"0";
160     PRINT;~D%;" ";
170     NEXT
180   PRINT
190   NEXT
200 CLOSE#0
210 VDU3
220 END
```

Fig. 1 A BBC Basic program as seen on the screen — in full ASCII

What is an op-code? That's very simple (although many people have been misled into thinking it's not). An op-code is a binary bit pattern which directly or indirectly controls the internal data path and active elements of the microprocessor (CPU).

Although the codes are relatively unmemorable, they are far from arbitrary (though a lot of popular authors have suggested they are). If you knew which bit of the op-code controlled which internal element of the CPU, you would see a consistent pattern (similar functions use similar bit patterns). A simple illustration of the mechanism of control was given in my resumé of the discrete ALU using multipliers (ETI January 1988).

Each op-code is brought into the CPU in turn together with any parameters associated with it and the bit patterns are used to control multiplexers (an over-simplification of course) which pass data to various manipulating elements.

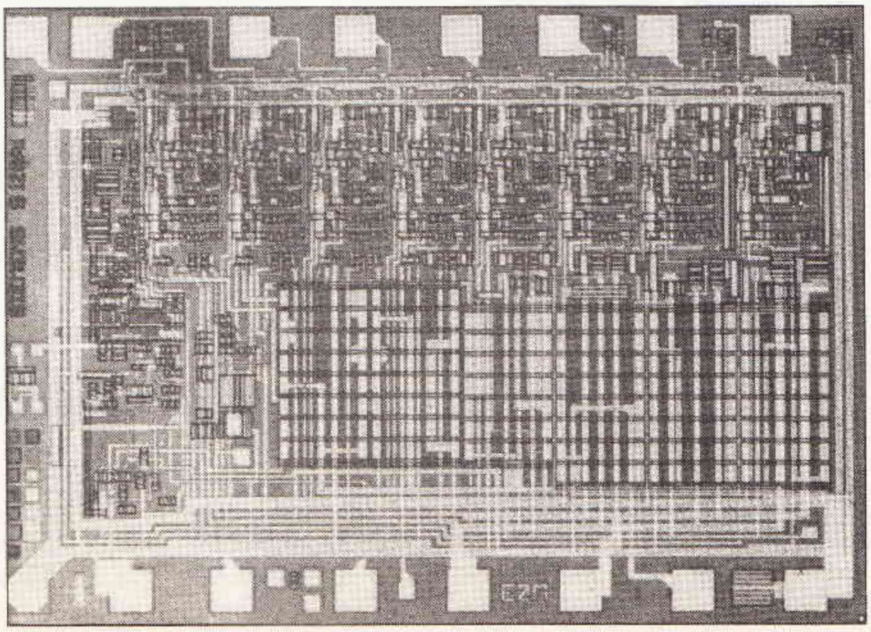
Having got this fundamental straight, let us look at methods of programming.

Levels And Languages

The most commonly quoted terms are *high* and *low level*. Low level languages are those in which you need to know (and are kept aware of) the structure of the individual CPU hardware you are using. These really amount to machine code assemblers. In the old days (15 years ago!) you had to program CPUs by directly keying in the op-codes in sequence. This caused a significant evolutionary change in Homo Sapiens in California — creating a mutant breed of hairy human that could only communicate in hexadecimal number notation.

The world of computing has not yet recovered entirely from this ecological catastrophe but the invention of the assembler was a significant contribution to the cure. The assembler substitutes a relatively memorable alpha-numeric *mnemonic* for each op-code and latterly provides additional control features called directives, which facilitate the coding operation. The source code of an assembler is inevitably longer than the machine code it generates so your typing job is a big one!

The advantage of low level programming is the control which the programmer has over the end product. Critical timing constraints can be met and a high efficiency of execution attained. The trade-offs are increased programming time and comparatively heavy testing burdens, due to the difficulty of tracing



errors without a pre-defined check environment (more of this later).

High level languages are basically methods of programming where you need not be aware of (and have no control over) the exact sequence of op-codes at any given point in the program. You work instead in terms of larger entirely pre-coded routines. This means someone else has done most of the work for you. For example, instead of laboriously coding a 32-bit division each time you need it, you can call a routine known by a human readable name (which will vary according to the language you are using) which will eventually execute a division in machine op-codes.

Obviously, this is quicker and less error-prone when you are writing the program but it is frequently ignored that you are entirely at the mercy of the guy who wrote the machine code you are calling. This can be efficient or far from it, depending on the quality of the language package you are using.

The actual (quite small) amount of typing you have to do to create the source code (the human readable input to the programming system) usually bears very little relation to the size of the resultant executable program. An example of this is a Fast Fourier Transform written in C by a colleague of mine, which consisted of only about 35 lines of source code.

Compile Or Not Compile?

Both compilers and interpreters are high level language conventions but they differ in their method of operation. The most familiar type of high level language is the *Interpreter*. This includes BASIC and FORTH. The main point about an interpreted language is that it is quick to write in and debug but executes relatively slowly.

Quite simply, an interpreter is a method of program execution which uses your source code as a run time list of routines for execution. A special piece of permanently resident machine code in the micro (called a command line interpreter in the case of BASIC) scans the program from start to finish and every time it succeeds in resolving a command which is acceptable, it looks up the entry address of the relevant machine code routine and goes to it.

This means between each command and its successor, some time out is taken to interpret the new command. This obviously slows things down (especially when a command may consist of three to eight characters) so various people have considered ways of speeding things up. The first major breakthrough was in FORTH, which was originally expected to control real world mechanical systems, albeit slow ones.

The problem facing FORTH was that although it came with a limited set of commands (the *primitives*) which were to execute fast, you can define new commands consisting of routines built out of the primitives, further commands built out of your first commands and so on.

The resulting nest would have executed excessively slowly if the ASCII commands were all interpreted at execution time, so instead of this an interpreted *Intermediate Code* is generated, which consists of a list of literal entry points of the routines to be executed. However, this left a problem to the designers of FORTH. Any parameters associated with routines are normally entered with the routine calls to allow the programmer to remain sane. A separate list of parameters would be impossible to cross reference reliably.

The address list has no provision for parameters, so something else has to be done. The answer is the *stack*. The stack is an area of memory set aside for parameters and has one major peculiarity. It is addressed by a *pointer* rather than directly. This is a counter (stored in a special memory location) which points to the next sequential location at all times. Data can only be read from the stack in the reverse order to that in which it was written.

As you type in a FORTH program, user parameters are placed on the stack as they are encountered. They are ready for the relevant routines to access them when the program is running.

An alternative approach was used by the inventors of BBC BASIC. This followed from a previous Acorn BASIC which was a conventionally scanned ASCII source code. To speed up the execution phase, the BBC BASIC input control program substitutes a *token* (a single byte code) for each command word *as you type in the program*. Thus the record in memory or on disk consists of a sequence of tokens instead of a sequence of human readable command words.

This token list is interpreted at run time as before but each command is only one character (plus any parameters) in length which speeds up interpretation.

The next step is to look at compilers and I will discuss these next month, together with some more detail on internal mechanisms of code generation and testing.

ETI

```
1900   0D 00 0A 06 EB 33 0D 00    .....3..
1908   14 07 EF 31 34 0D 00 1E    ...14...
1910   06 EF 32 0D 00 28 18 EF    ..2..(..
1918   31 2C 32 37 2C 31 2C 36    1,27,1,6
1920   39 2C 31 2C 32 37 2C 31    9,1,27,1
1928   2C 37 31 0D 00 32 10 43    ,71..2.C
1930   3D 8E 28 22 45 50 52 4F    =.("EPRO
1938   4D 22 29 0D 00 3C 15 E3    M")..‹..
1940   20 41 25 3D 30 B8 26 31    .A%=0.&1
1948   46 46 46 20 88 20 31 36    FFF...16
1950   0D 00 46 21 E7 41 25 3D    ..F!.A%=
1958   26 30 36 43 30 20 41 25    &06C0.A%
1960   3D 26 31 46 30 30 3A CF    =&1F00:.
1968   23 43 3D 26 31 46 30 30    #C=&1F00
1970   20 0D 00 50 20 E7 41 25    ...P..A%
1978   3D 26 31 46 39 30 20 41    =&1F90.A
1980   25 3D 26 31 46 46 30 3A    %=&1FF0:
1988   CF 23 43 3D 26 31 46 46    .#C=&1FF
1990   30 0D 00 5A 0C 41 24 3D    0..Z.A$=
1998   22 30 30 30 22 0D 00 64    "000"..d
19A0   12 E7 41 25 3E 26 46 20    ..A%›&F.
19A8   41 24 3D 22 30 30 22 0D    A$="00".
19B0   00 6E 12 E7 41 25 3E 26    .n..A%›&
19B8   46 46 20 41 24 3D 22 30    FF.A$="0
19C0   22 0D 00 78 12 E7 41 25    "..x..A%
19C8   3E 26 46 46 46 20 41 24    ›&FFF.A$
19D0   3D 22 22 0D 00 82 12 F1    ="".....
19D8   3B 41 24 3B 7E 41 25 3B    ;A$;~A%;
19E0   22 20 20 22 3B 0D 00 8C    "..";...
19E8   0C E3 49 25 3D 31 B8 31    ..I%=1.1
19F0   36 0D 00 96 18 44 25 3D    6....D%=
19F8   9A 23 43 3A E7 44 25 3C    .#C:.D%‹
1A00   26 31 30 F1 3B 22 30 22    &10.;"0"
1A08   3B 0D 00 A0 0E F1 3B 7E    ;.....;~
1A10   44 25 3B 22 20 22 3B 0D    D%;".";.
1A18   00 AA 05 ED 0D 00 B4 05    ........
1A20   F1 0D 00 BE 05 ED 0D 00    ........
1A28   C8 07 D9 23 30 0D 00 D2    ...#0...
1A30   06 EF 33 0D FF 00 00 FE    ..3.....
```

Fig. 2 The same BBC Basic program as held in memory — tokenised for compactness and speed

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ETI

CELL GUIDE

Battery manufacture advances apace. Bill Higgins takes charge with his guide to the marketplace

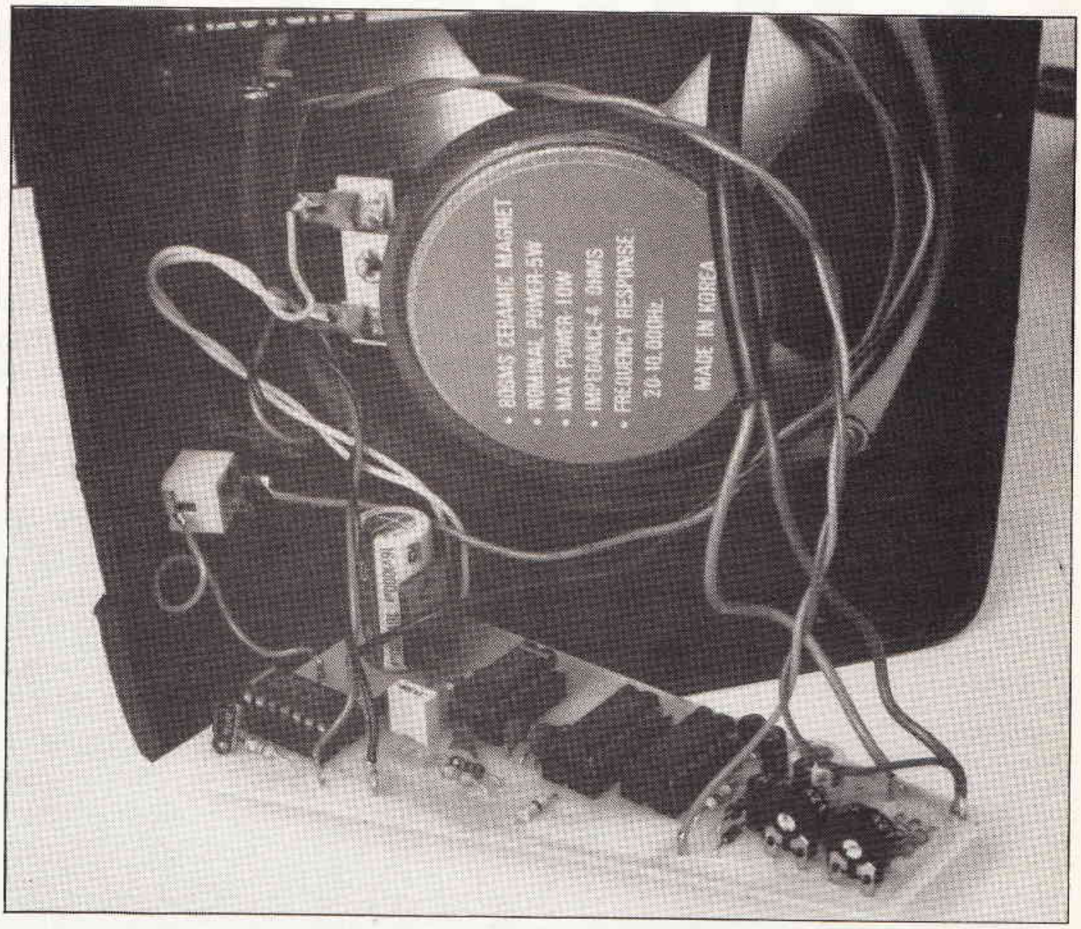
There are two basic types of cell: primary cells and secondary cells. Primary cells are non-rechargeable, they are thrown away when their duty cycle is finished. Secondary cells are rechargeable with multiple duty cycles.

This table lists the main battery of each type with detailed information for the engineer to consider when selecting a cell to specific requirements.

	ELECTRICAL					PHYSICAL					OTHER	
		Max Over-charging Voltage		Ah Range			Temperature Range					
Type of Cell	Nominal Voltage		Operating Range	Smallest	Largest	Size Range	Min	Max	Shelf Life	Ah/Mass (gms)	General Remarks	Some Sources of Cells
PRIMARY												
Alkaline manganese	1.5V	1.56V	1.3 to 0.8V	0.05Ah	15Ah	mainly cylindrical some disc	−30°C	70°C	3 years	0.111	High humidity may cause corrosion	Duracell, Crompton Vidor
Lithium manganese dioxide	3.3V	3V	3V to 1.4V	0.03Ah	1.25Ah	wide range, cylinder disc and rectangular	−40°C	70°C	6 years	0.078	Often used on rescue beacon equipment and life jackets	Dowty, Duracell
Lithium sulphur dioxide	3V	2.9V	2.9V to 2V	0.85Ah	8Ah	Cylindrical and disc	−55°C	70°C	10 years	0.0842	High external pressure can inhibit its functions	Dowty, Duracell, Crompton Vidor
Lithium thionyl chloride	3.6V	3.7V	–	–	18Ah	cylindrical and rectangular	−55°C	70°C	10 years	0.0758	–	Crompton Vidor, Dowty, RS
Mercury cadmium	0.9V	–	–	–	–	disc	−40°C	120°C	–	NRA	–	Dowty
Silver oxide	1.5V	1.6V	1.5V to 1.49V (rapid fall off)	0.075Ah	0.13Ah	disc and cylindrical	–	–	2 years	0.0118	Often used in digital watches and so on	Duracell
Zinc air	1.4V	1.45V	1.4V to 0.9V	0.07Ah	2.4Ah	disc, cylindrical and rectangular stacks	0°C	60°C	4 years	0.242	Relative humidity should be between 25 and 75	Duracell
Zinc carbon	1.5V	–	–	–	–	layered stacks and round cells	−10°C	50°C	1½ years	0.0513	Best blow 0°C	Crompton Vidor
Zinc mercury	1.35V	1.55V	1.3V to 0.9V	–	–	cylindrical	−30°C	70°C	2½ years	0.074	–	Crompton Vidor
SECONDARY												
Nickel cadmium	1.2V	1.8V	1.8V to 0.9V	0.01Ah	7Ah	cylindrical, disc and rectangular	−10°C	50°C	1 year	0.0295	Temperature variations can cause self discharge	Alcad, Ever Ready, Friwo, Sonnenschein, Tungstone, Varta
Lead acid	2V	2.3V	2V to 1.75V	1Ah	9.5Ah	large (multicell)	−50°C	50°C	6 months	0.0171	Temperature variations can cause loss of available capacity	GNB Absolyte, Sonnenschein, Yuasa

REV-RIDER

Stuart Richards converts his Raleigh into a Kawasaki 1300 with the help of this motorcycle simulator



This project was inspired by my childhood memories of making my bicycle sound like a motor bike by fixing a piece of cardboard near the rear wheel so that it flapped against the rotating spokes. The customary items to use were a piece of cigarette packet from the gutter and a wooden clothes peg stolen from Mum.

The Rev-Rider described here is a solid state version complete with ignition key, adjustable tickover, push-button revving control, flashing LED and last but not least a siren to annoy the neighbours.

The project is simple to construct, will give hours of pleasure from a small 9V battery and can be fitted to any vehicle (even an exercise bike!)

Construction

The prototype was built in a surface mounting car speaker case with a piece of paxolin as the back baffle to the case (Fig. 2). The speaker was left in situ and the PCB designed to fit to one side of the case (which explains the lop sided shape of the board!).

Cheap car speaker units are easily obtainable for little more than the cost of a drive unit alone. A high quality drive unit is not required as the Rev-Rider is hardly hi-fi.

Before assembling the board, familiarise yourself with Fig. 3, checking orientation of all polarised components.

Start with smallest components first — resistors, diodes and links — then progress through to ICs and capacitors finishing with presets and the power Darlington, Q1.

I recommend fitting IC sockets. They prove invaluable if you need to change an IC.

Insert single sided pins at the off-board connections. This will allow wires to be connected and disconnected from the component side of the board. To fit these, push them through from the copper side as far as you are able then carefully push them the rest of the way with a hot iron, then solder to the track. This completes assembly of the board.

For convenience, the 'Ignition Switch' is simply a 3.5mm jack socket, with a short-circuited plug for the key. Drill a 2mm hole through the plastic plug cover to accept a key-ring and fob. This key will prove easy to replace if lost!

Drill holes in the case to accept jack socket, LED (5mm diameter) and push buttons if fitted. The LED will be a tight fit but should be secured with epoxy adhesive. Install the jack socket and push buttons, connect these together following the diagram leaving sufficient length of wire to enable the board to be released if necessary. Mount a 9V alkaline battery to the side of the case using a double sided adhesive pad. You shouldn't need to change this very often!

The two push buttons SW1,2 can either be fitted in the speaker case or mounted near the handlebar grip and connected to the board using thin 3-core mains cable taken through a hole on the case.

A simple way to mount the switches this way is by using a metal bicycle bell, first removing the striker and other internal bits. One or two holes are drilled in the side to accept SW1 and/or SW2 and the bell clamped to the handlebars so they can be operated by the thumb.

A back panel for the case can be cut from a sheet of plastic or hardboard using the speaker case as a template. Drill the two holes in the rear panel and mount to the speaker case using M3 nuts and bolts.

Parts from two bells were again used to clamp the case to the handlebars of the bicycle but suitable clips can be obtained from any hardware/cycle shop.

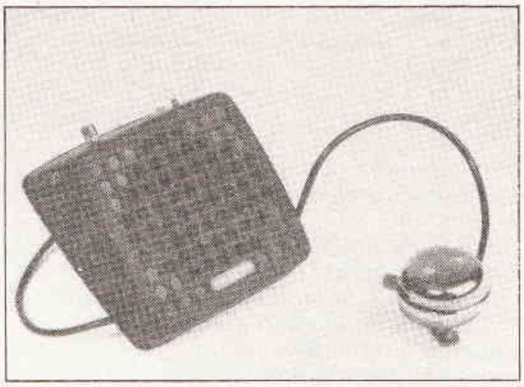
Check again all wiring, battery polarity and correct insertion of all ICs. Insert ear plugs and switch on!

Kick Start

You should hear an engine type noise somewhere between a slow tickover and a high-pitched scream. Adjust the tickover control RV2 to the desired tickover speed. If you get no sound at this stage, check first that 9V is getting to the board. The VCO input of IC3, Pin 9 should be at 1.9-2.6V according to the charge on C2. If this seems in order, look for a square wave output on Pin 4 of IC3.

If you have no scope, a multimeter connected from 0V to Pin 4 should read an average of half supply volts (4.5V). The voltage on the reservoir capacitor C9 will be almost 9V at tickover and will decrease as the revs increase, as more energy is used by the speaker.

Press SW1, revs should increase slowly up to a maximum which can be set by adjusting RV1. Release SW1, revs should decrease again to the set tickover



HOW IT WORKS

The heart of this project is a voltage to frequency converter. This gives out a square wave pulse train, the frequency of which is proportional to a DC voltage that we apply to its input. For convenience, we use a 4046B phase lock loop IC which includes the voltage to frequency converter.

By applying an increasing voltage input to IC3, the 'revs' will increase and vice-versa. Capacitor C2 gives the circuit inertia, acting like a flywheel in an engine. Pressing the Rev button SW1, charges C2 via R1, R3 and D2, the maximum revs being set by RV1. Releasing SW1 allows C2 to discharge via RV1, R1, R2 and D1.

To achieve a steady tickover speed, independant of battery condition, the VCO input requires a positive offset of about 1.9V. To do this, a constant current of 0.56mA from regulator diode D3, passes through R4 and 'jacks up' the bottom end of C2. RV2 allows this voltage to be adjusted by shunting R4 and R5. D4 prevents C2 from being reversed biased. C3 ensures the circuit starts up slowly at switch on.

To give a high volume output with low battery consumption, the loudspeaker is fed with short duration pulses at 4-6V in amplitude. Q1 drives the speaker in emitter follower mode, drawing peak currents of over 1A from the reservoir capacitor C9. Resistor R15 limits the current drawn from the battery.

IC4 is used as two monostables triggering on alternate positive and negative edges of the VCO square wave output. To achieve a more reallistic sound, these monostables are given different time constants, (typically 50 and 150 microseconds) resulting in alternate short and long pulses to the speaker.

Capacitor C8 slows the edges of the pulses making the noise more 'user-friendly'.

The resulting output provides ample volume while the drain on the battery is less than 5mA at tickover, rising to about 20mA at high revs.

The siren effect is obtained by utilising a 4066B quad analogue switch IC to change over the input of the VCO IC3, from the revving circuit previously described to triangular waveform generator IC2b.

The triangular signal from IC2 pins 1 and 2 passes through the switch IC1a and is AC coupled via R6 and C1 to the cathode of current regulator diode D3, modulating the VCO input signal to IC3 via R7 and closed switch IC1b.

Pressing the siren button SW2, brings this into action and also effectively shorts R15 allowing greater volume in the Siren mode.

Two paralleled spare gates, IC2c, drive the flashing LED directly from the square wave output of IC2b.

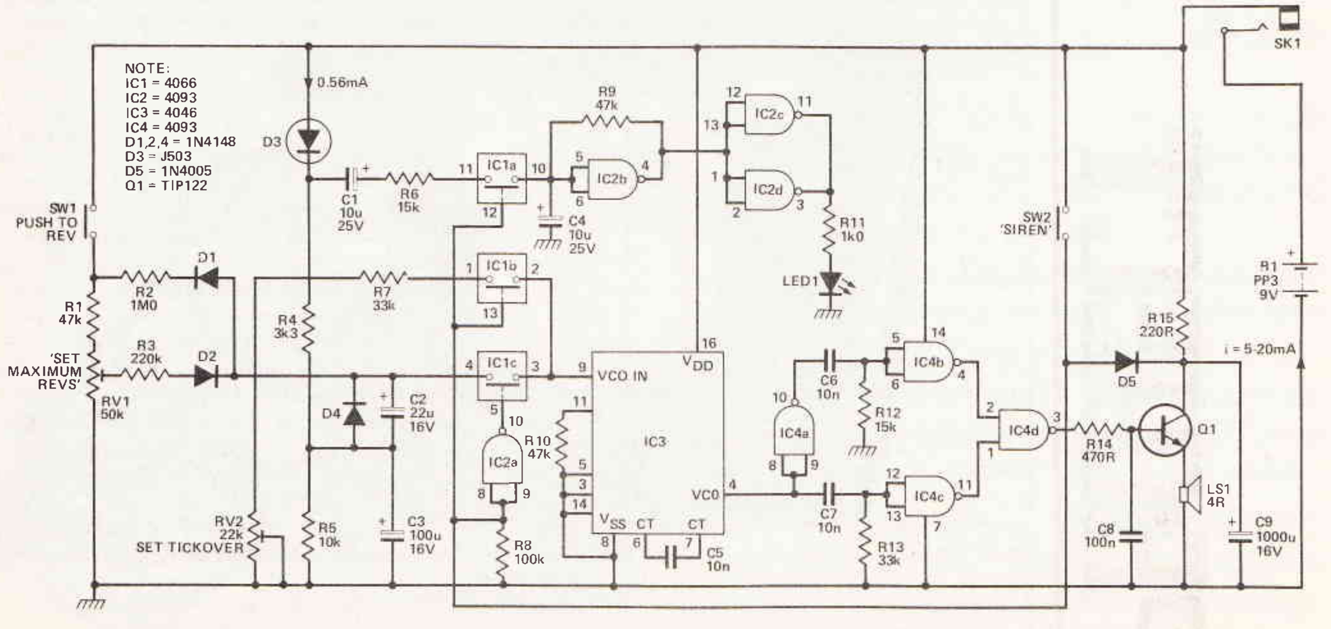


Fig. 1 The circuit diagram of the Rev-Rider

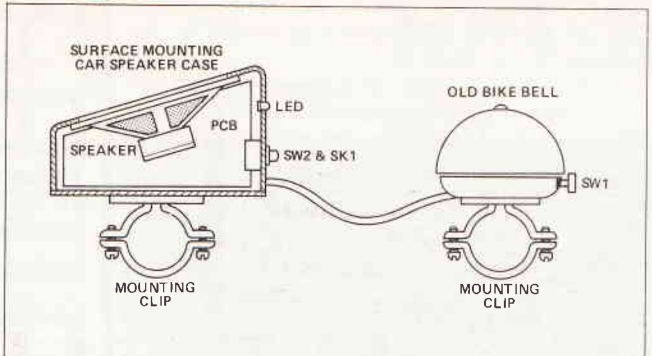


Fig. 2 Construction of the Rev-Rider

speed. Press Siren button SW2, the circuit should give loud wailing noise.

You can increase or decrease wailing speed by reducing or increasing the value of R9. For test purposes (or for indoor use) it may be desirable to insert a resistor (10-47R ¼W) in series with the loudspeaker to reduce the volume to a tolerable level.

Further Thoughts

The project outlined here suggests only one means of varying the speed of the output. Readers with mechanical flair might like to fit a proper throttle using a potentiometer connected either to a twist-grip or lever operated throttle.

'Gear changes' can be effectively achieved by switching in different values of charge resistor instead of R3 to give differing rates of charge/discharge of C2.

A slightly unstable tickover speed, as in many two-strokes can add further realism by slowly changing the voltage at the junction of R4/R5.

Types of speakers and enclosures will change the sound dramatically — a speaker mounted inside a cardboard tube for example will add resonance and give a nice popping sound like many 50-100cc machines.

With small changes the circuit could be adapted to other toys such as lawn mowers, pedal cars and so on. I wish you hours of fun.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,9,10	47k
R2	1M0
R3	220k
R4	3k3
R5	10k
R6,12	15k
R7,13	33k
R8	100k
R11	1k0
R14	470R
R15	220R
RV1	47k preset
RV2	33k preset
CAPACITORS	
C1,4	10μ 25V radial electrolytic
C2	22μ 16V radial electrolytic
C3	100μ 16V radial electrolytic
C5,6,7	10n ceramic
C8	100n polyester
C9	1000μ 16V radial electrolytic
SEMICONDUCTORS	
IC1	4066B
IC2,4	4093B
IC3	4046B
Q1	TIP122
D1,2,4	1N4148
D3	J503
D5	1N4004
LED1	5mm Red LED
MISCELLANEOUS	
B1	9V battery
LS1	4R 10W loudspeaker
SK1	3.5mm jack socket
PL1	3.5mm jack plug
SW1,2	SPST push switch

PCB. Case. Battery clips. Connecting wire Mounting clips. Nuts and bolts.

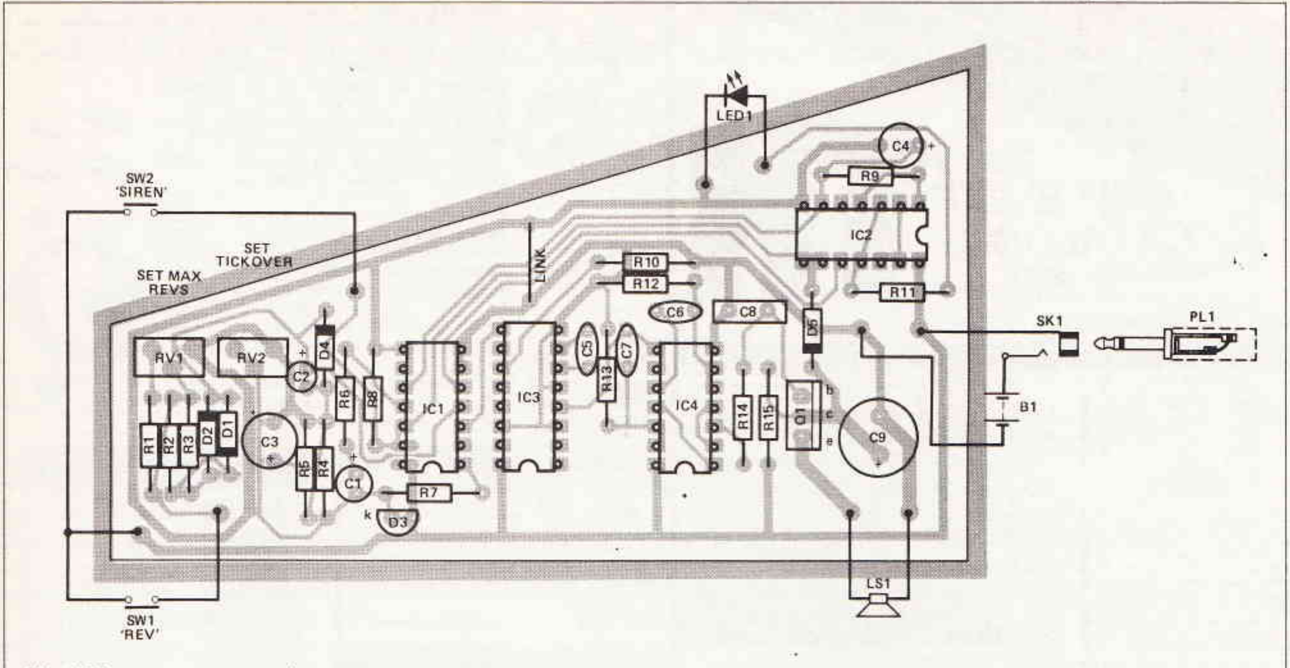


Fig. 3 The component overlay

BUYLINES

Most of the parts for the Rev-Rider should pose no particular problems. A complete kit of parts for the Rev-Rider excluding a battery and the case back baffle is available from Technova Developments, Grange Walk, Wroxham, NR18 8RX (Tel: (06053) 2215) for £16.50 plus VAT plus £1.75 postage.

A suitable speaker and case can be purchased at a variety of shops including Tandy, motorist accessory shops and your local component stockists. The case and speaker used in the prototype is available from Technova for £3.95+VAT+£1.75 postage. The J503 constant current diode (D3) is available from Electromail as part number 283-463 or from Technova for £1.20+VAT+75p postage. The PCB is available from Technova for £2.25+VAT+75p postage.

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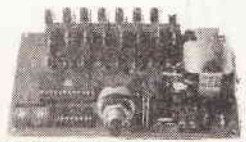

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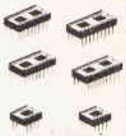

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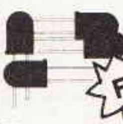

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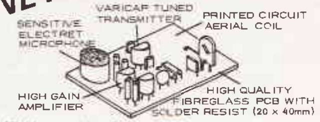

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CHRISTMAS PRESENT FOR GRANNY

John Linsley Hood presents a low voltage, AGC, nearly hi-fi boost for granny's lug'oles

One of the most common problems that elderly people have to put up with is a gradual loss of hearing sensitivity. Unfortunately, this problem is made more irritating by the way that the rest of us tend to assume that they are daft as well — when they simply didn't hear what we said.

The NHS does its best to help but they have only a limited range of appliances which they can dispense. These are mainly small units which sit on top of the ear, with a microphone which points backwards — fine for hearing what people are saying behind one's back but not as useful for hearing what the person standing in front of one is saying.

The NHS units, being small, are also liable to get trodden on, mislaid or dropped into unlikely places, and are dear (hundreds of pounds-ish) to replace when lost.

However, from the point of view of the DIY electronics fraternity, the task of making a gadget which will amplify the output from a small microphone and will operate an earphone is neither difficult nor costly, provided that one doesn't aim to make it too miniaturised. This, in a sense, can be an advantage since if it isn't too small, it won't be so easily lost.

A word of warning is necessary at this point. The manufacture and supply of 'hearing aids' is a very profitable business — especially for the private enterprise side of the market. It is therefore, quite predictably, hedged around with official restrictions to prevent others from homing in on this market. So, no-one other than an officially approved manufacturer can market such devices as 'hearing aids', and no-one but a registered 'hearing aid' dispenser can sell them.

This does not restrict what one can do oneself if one has a mind to but it must be called something other than a 'hearing aid'! The few firms which exist in this country outside the patronage of the NHS refer to their products as 'binaural amplifiers' or 'microphone amplifiers'. Again, I suppose one can call it what one likes so long as it isn't sold.

Design Considerations

There is quite a range of small 'electret' condenser-type microphones available, nearly all of which contain an integral FET buffer amplifier, of the general form sketched in Fig. 1. These require a small DC voltage in the range 2-15V to make them work.

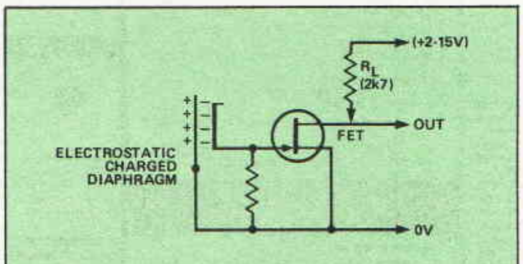


Fig. 1 Internal connections to an electret microphone

Some of these are '3-terminal' devices, with the FET load resistance inside the unit but most require the load resistor to be added externally, as shown in the diagram. Either of these types are usable.

There is also quite a range of small headphones on sale, for use with 'Walkman' type personal cassette players or personal radios. These are typically 30R impedance and require a few milliamps of drive. Check these before you buy, since some of the very cheap ones are too insensitive to be of much use.

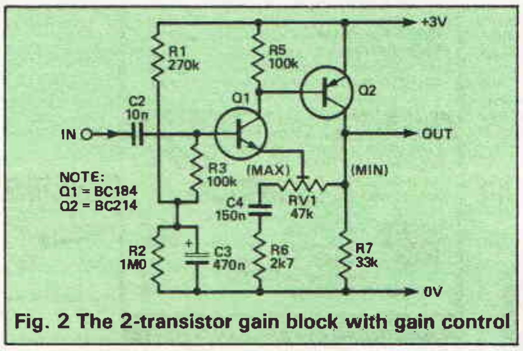


Fig. 2 The 2-transistor gain block with gain control

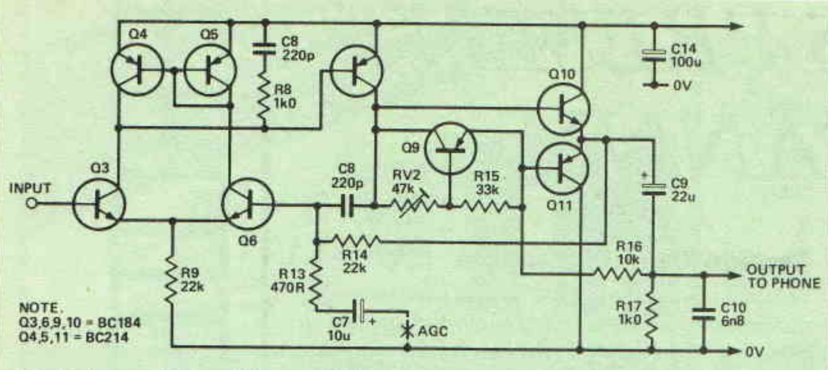


Fig. 3 The headphone driver amplifier

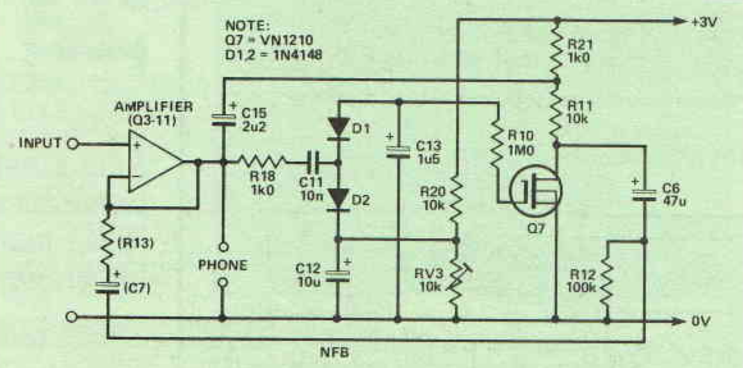


Fig. 4 Automatic volume control system

Between the microphone and the earpiece one must insert an amplifier giving an adjustable gain somewhere in the range 30-500 which will operate from 3V DC (the electret microphone requirements rule out 1.5V operation, as does the need to produce enough volume from a 30R earphone) and which won't take too much current.

Finally, it has to fit inside some fairly strong metal container to give electrostatic screening and protection, such as the little hinged lid tins in which, in more expensive days, tobacco and cough sweets were sold and which are now largely to be found in the workshop or mending box, full of screws or safety pins.

Circuit Design

The basic 2-transistor gain block of Fig. 2 will operate quite happily down to about 1.5V and will provide a peak-to-peak output voltage swing which is close to the limits set by the supply lines. It also provides a convenient means of adjusting the gain, by varying the amount of negative feedback. R1 and R2 are chosen to set the DC output level at about half the supply line voltage.

The following stages Q3-Q11, shown in Fig. 3, comprise a miniaturised hi-fi amplifier with a push-pull output operating on a 1mA quiescent current setting, giving a total quiescent battery demand of 2mA.

The 'bootstrapped' driver load (C9/R16), though now not used much in true hi-fi designs where a constant current source load for the driver stage is preferred, makes the best use of the limited supply voltage. Prior to clipping, with a 30R load and 3V supply, the overall THD is of the order of 0.02%.

Automatic Gain

This is a facility which lifts this circuit out of the ordinary 'run of the mill' microphone amplifiers and greatly adds to its usefulness. Unfortunately, with the very limited available supply voltages and output swings, most of the normal AGC systems are inapplicable.

The circuit of this is shown in Fig. 4, and it operates by using the dynamic impedance of a small signal MOSFET device as part of the feedback loop of the amplifier to Fig. 3. When the MOSFET device (in this case a VN1210 but any similar enhancement-mode MOSFET will work as well) is conducting, it has a dynamic drain-source impedance of only a few ohms and the gain of the amplifier of Fig. 3 is 22k/470 = 47.

In the normal quiescent state, the MOSFET is biased into conduction by the voltage developed across RV3, at a forward gate-source potential of about 1-1.5V. The AGV action arises because the output signal voltage from the amplifier is then rectified by the diode-pump circuit of D1, D2, C11 and C13, to provide a negative-going output voltage which progressively biases off the MOSFET and causes its dynamic impedance to rise.

As the MOSFET becomes an open-circuit, the gain of the output amplifier drops towards unity since the load resistor for the MOSFET is also bootstrapped by C15 and R21.

Sadly, this kind of AGC wouldn't be useful in true hi-fi applications since, when it is operating with the MOSFET somewhere between fully on and cut-off, it worsens the THD from about 0.02% to about 0.5%, mostly second harmonic. At small signal levels or large ones, when the MOSFET is either fully on or cut-off, the THD reverts to the lower figure.

This circuit will hold the output constant over at least a 100:1 input signal range and will do a lot to compensate for the wide range of ambient sound levels which exist in practice.

Construction

The complete circuit of the unit is shown in Fig. 5. A suitable PCB layout is shown in Fig. 6. The mic should be mounted at one end of the case in a small rubber grommet to give some measure of sound isolation

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	270k
R2,10	1M0
R3,5,12	100k
R4,6	2k7
R7,15	33k
R8,17,18,21	1k0
R9,14	22k
R11,16,20	10k
R13	470R
R19	470k
RV1,2	47k preset
RV3	10k preset
CAPACITORS	
C1,3	4µ7 tantalum
C2,11	10n ceramic
C4	150n ceramic
C5,8	220p polystyrene
C6	47µ tantalum
C7,12	10µ tantalum
C9	22µ tantalum
C10	68n ceramic
C13	1µ5 tantalum
C14	100µ tantalum
SEMICONDUCTORS	
Q1,3,6,9,10	BC184
Q2,4,5,8,11	BC214
Q7	VN1210
D1	1N4148
MISCELLANEOUS	
B1	2x AAA batteries
SW1	SPST toggle switch
PCB. Electret microphone. Case. Battery holders. Connecting wire.	

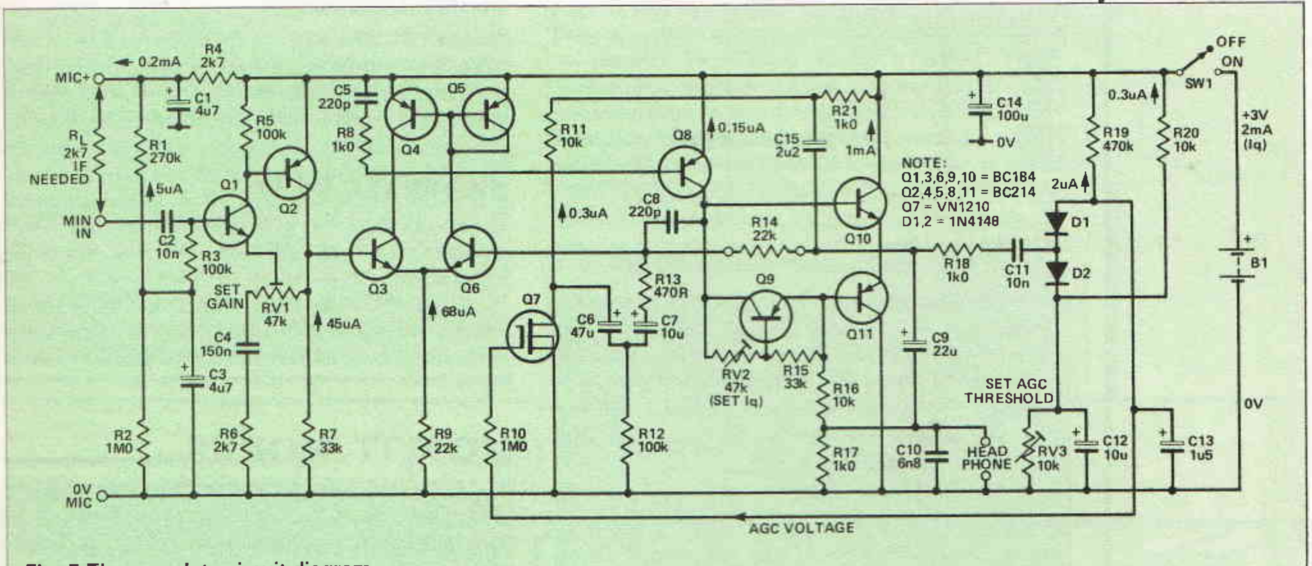


Fig. 5 The complete circuit diagram

from the case. The 3mm phono jack for the headphone is mounted at the other end. A small preset pot is mounted on the hinged lid of the tin to allow an easily accessible adjustment to the sensitivity of the unit.

Power is provided by a pair of AAA sized batteries in small battery holders and should give a life of some hundreds of hours before battery replacement is needed. Ideally, the works would have been held in place by screws and stand-off spacers but on the prototypes the relative shallowness of the tin did not give adequate height, so the PCB was held in place by a couple of small strips of double-sided adhesive foam, after the copper side of the PCB was liberally covered with insulating tape to prevent any short-circuits from the protruding solder blobs to the tin can.

Setting up is simple. Set RV1 and RV3 to maximum and RV2 to minimum resistances and then adjust RV2 to give a total supply current of 2mA. Set the gain (RV1) to a level at which there is an adequate level of loudness on some sound (such as a radio) and gradually reduce RV3 from its maximum resistance value until the output sound level just begins to fall.

With devices of this type, it is undesirable that the LF response should be too good since most LF sounds are just noise or room resonances and add nothing to the information content. The LF gain can be reduced further, if needed, by reducing the values of C4, C7 or C9. In the prototypes, I mainly used tantalum bead types for all the larger values in the interest of compactness but this is at the constructor's choice, depending on how much space there is available.

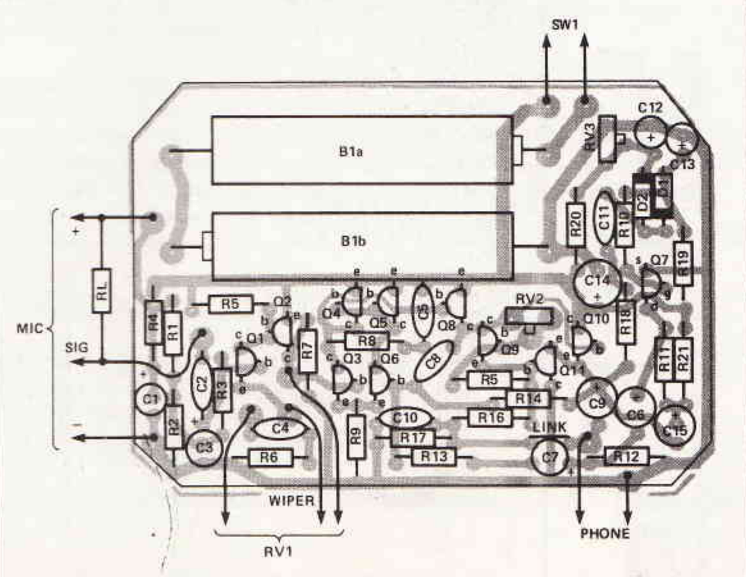
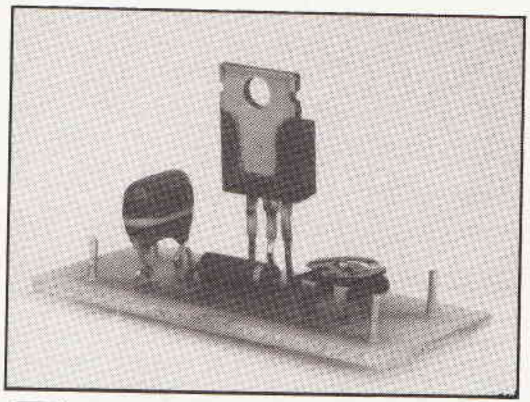


Fig. 6 The component overlay

IN-CAR POWER SUPPLY

For the mobile gadget user, Keith Brindley reveals a variable voltage battery eliminator which doesn't cost the earth and saves £££££s on gadget batteries

1st CLASS



If you're a typical caravanner, camper or motoring tourer, you'll take at least one battery-powered appliance with you on your wayward trips. Even if you just take a simple tranny you'll be well aware of the need to make stops to buy new cells to listen to the weather forecast. If you carry a ghettoblaster to annoy the people in the next van with them crazy jungle rhythms you'll know that these stops are often frequent and expensive!

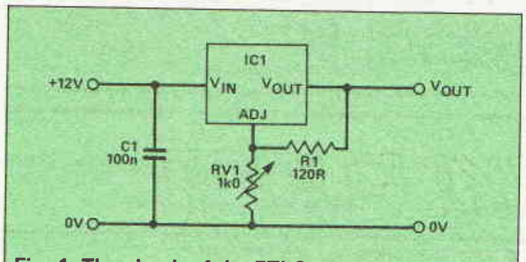


Fig. 1. The circuit of the ETI Caravanner's Battery Eliminator

Now wouldn't it be a good idea if someone would come up with a battery eliminator, just like a normal mains-powered one, except to run off your car or caravan's internal 12V battery? That is, of course, what this month's *1st Class* project is. Not content with giving you a design which eliminates the need for a battery in a single appliance, we've given you a completely variable voltage battery eliminator, for use with virtually any appliance.

This is all made possible by using an easy-to-obtain integrated circuit voltage regulator which allows use of a simple variable resistance to control output voltage. So the 12V battery voltage is regulated down to anything from about 1.2V up to 11V. Maximum output current of the device is some 1.5A sufficient for all but the heaviest users of current.

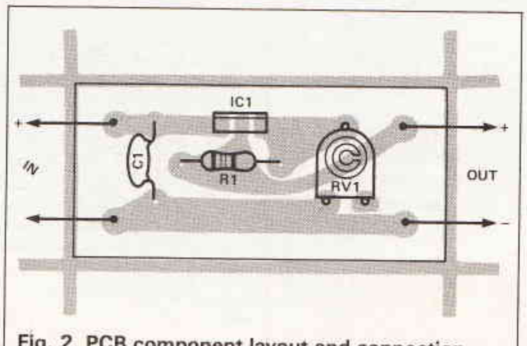


Fig. 2. PCB component layout and connection details

Most battery-powered equipment should be accommodated by this project. Portable stereo cassette players generally need around 3V, tranny radios around 6V, ghettoblasters around 9V. Consult your equipment manual to see what voltage is needed. Current consumption of your equipment isn't likely to be more than the project's capability — if it is, you must use up batteries at such a rate of knots you'd be well advised taking a portable mains generator with you instead of a battery eliminator!

Construction

As usual, we offer you two methods of construction -- PCB or stripboard. Details of construction don't vary much between them. Insert the passive components (that is, resistor R1, capacitor C1 and preset resistor RV1) first followed by integrated circuit IC1. The only component which you need to ensure goes in the right way round is IC1. Useful extras are circuit board pins, which allow you to make later wired connections to the board easily. However, these are not essential.

If you're using PCB, Fig. 2 gives details of component layout and connections. If you're using stripboard, layout and connection details are given in Fig. 3.

HOW IT WORKS

The circuit of the project is given in Fig. 1. There's a lot to it, isn't there? Capacitor C1 filters the incoming voltage, to remove spikes or interference coming down the line. These could be present if the battery is under charge from the alternator in a moving car or from a mains-powered battery charger. Resistor R1 and preset RV1 form an adjustable potential divider network which allows variable control over output voltage.

Integrated circuit IC1 is a variable voltage regulator. It is a simple-to-use three-terminal linear device. Technical specifications are pretty good in voltage regulation terms. Some of the specs relevant to us in this project are: maximum output current is 1.5A, maximum input-output voltage differential is 40V and maximum power dissipation is 15W.

The output voltage of the circuit can be expressed simply as being equal to:

$$1.25\left(1+\frac{RV1}{R1}\right)$$

So, with a preset resistance RV1 of 1k0 and a fixed resistance R1 of 120R, the voltage is theoretically variable between 1.25 and 11.6 volts.

Housing is left to the reader. It is not particularly critical. The voltage regulator IC does, however, need to be mounted on an adequate heatsink to dissipate the heat generated. If you're mounting the whole project in a metal case, such as a diecast box, this solves the heatsink requirement quite neatly; simply bolt the IC to the case. This solution has the added benefit of allowing a suitable fixing method for the whole board. Alternative heatsinking can be effected using one of the many commercially available matt black finned heatsinks. These are rated in terms of their thermal resistance in °CW^{-1}.

Technically speaking, to give adequate heat dissipation from the voltage regulator, a heatsink with a thermal resistance of no greater than 10°CW^{-1} should be used. Any greater than this and the device could be damaged by being driven past its maximum junction temperature. Saying that, this calculation for heatsink thermal resistance is made assuming maximum current flow of 1.5A at an output voltage of 9V. A lower current requirement (which will normally be the case) will allow use of a higher heatsink thermal resistance. For example, at a current consumption of 500mA at the same output voltage of 9V, the thermal resistance of the heatsink can be anything up to around 60°CW^{-1}.

The project can be finished off by fitting a plug which matches the input power socket of the equipment, or an adaptor-plug with a variety of connector plugs in a star-arrangement can be fitted allowing the project to be used with equipment with different power sockets.

PARTS LIST

RESISTORS (all ¼W 5%)

R1	120R
RV1	1k0

CAPACITORS

C1	100n polyester

SEMICONDUCTORS

IC1	317T voltage regulator

MISCELLANEOUS

PCB or stripboard. Circuit board pins. Heatsink. Case. Connecting leads. Connecting plugs.

Setting Up

Simplicity itself. Merely connect a voltmeter with at least a 10V range FSD to the project's output (noting and following correct polarity), connect the project to a 12V car battery (again noting and following correct polarity) and adjust preset resistor RV1 until the required voltage is obtained. Now disconnect the voltmeter and connect the project to your equipment.

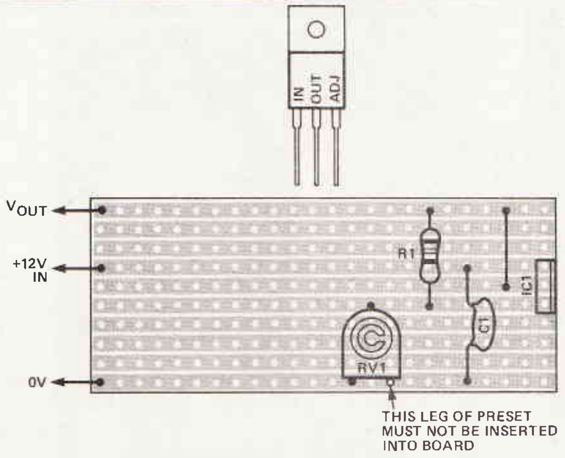


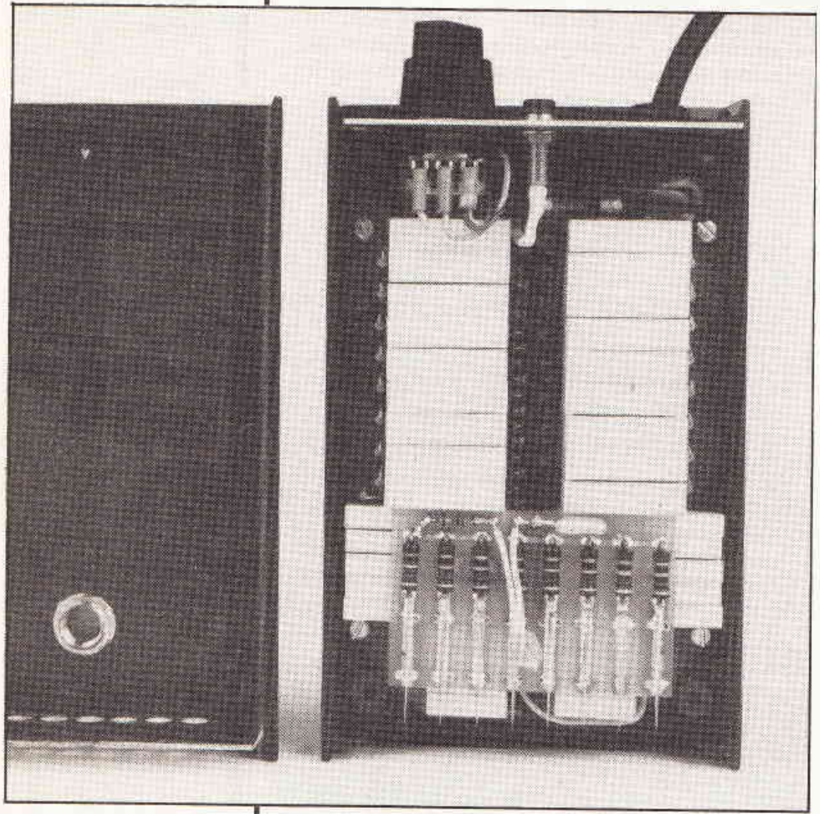
Fig. 3. Stripboard component layout and connection details (there are no track cuts necessary for this project

BUYLINES

Everything is easily obtainable. Integrated circuit IC1 is available from most mail order companies and your local stockist will have them off-the-shelf. The PCB is available from the PCB Service as detailed in the back of this issue.

SON OF VARIAT-ION

Paul Chappell revisits the Variat-Ion ioniser of October 1988 for a few subtle but crucial changes to give even more charged bits for your money



No, it's not another ioniser design! No matter how popular ionisers may be with readers, three months from October's Variat-Ion is a little too soon to be contemplating another model. The thing is, no matter how good a project may be, there's always something that can be done to make it just that little bit better. Usually I resist the temptation to improve projects once they've been published, but for my favourite designs the urge to iron out every last wrinkle sometimes proves too strong for me.

This article describes the modifications and additions I've made to the Variat-Ion since last October. Don't worry if you missed the original circuit — the PCB layout is repeated here to show the alterations, so you could build the whole project from that.

Air Ions

Having spoken at length about ions in the air in the first article I don't intend to repeat it all here. Suffice it to say that the purpose of an ioniser is to add negative charge to the molecules of the air, turning them into negative ions (neg-ions for short). The reason for wanting to do such a bizarre thing is that breathing ion-starved air makes you feel 'under the weather', while breathing ionised air makes you feel on top of the world. Or so people say.

Neg-ions are produced naturally and are around to a greater or lesser extent everywhere you go. After a storm the air is full of them. At the seaside or on a mountain top there are ions to spare. But in cities, inside modern houses and office blocks, there are hardly any.

The Variat-Ion not only re-charges the air with ions, it super-charges it. Every second it produces five times enough ions to make mountain-top levels. Give it an hour and you'll think your living room is a mountain by the seaside after a thunderstorm!

Circuit Changes

The Variat-Ion is already about the ultimate as ionisers go, so no major changes have been made — it's mostly a matter of tidying up a few loose ends. The circuit diagram is shown in Fig. 1. The connections to the output level pot RV1 and to the neon are more sensible and there is no longer any need for a connection between the two — all wires now go to the PCB. The on-off switch pads have been removed since nobody wants to turn the ioniser off at all! If you are the exception to this, you can always wire a switch into the live wire of the mains input lead, so there's no loss in removing the connections from the board. The PCB layout and the new connections are shown in Fig. 2.

Something you'll also notice from Fig. 2 is that there are more resistors than before. Seventeen more to be exact. In the original project resistors of 1kV proof were specified but these are not too easy to obtain. the new resistors (R4a to R20a, all 10M) connect in series with the old resistors, reducing the stress on them so that ordinary carbon film types can be used. R3 has only half the voltage of the other so it doesn't need an extra one in series. The increase in total

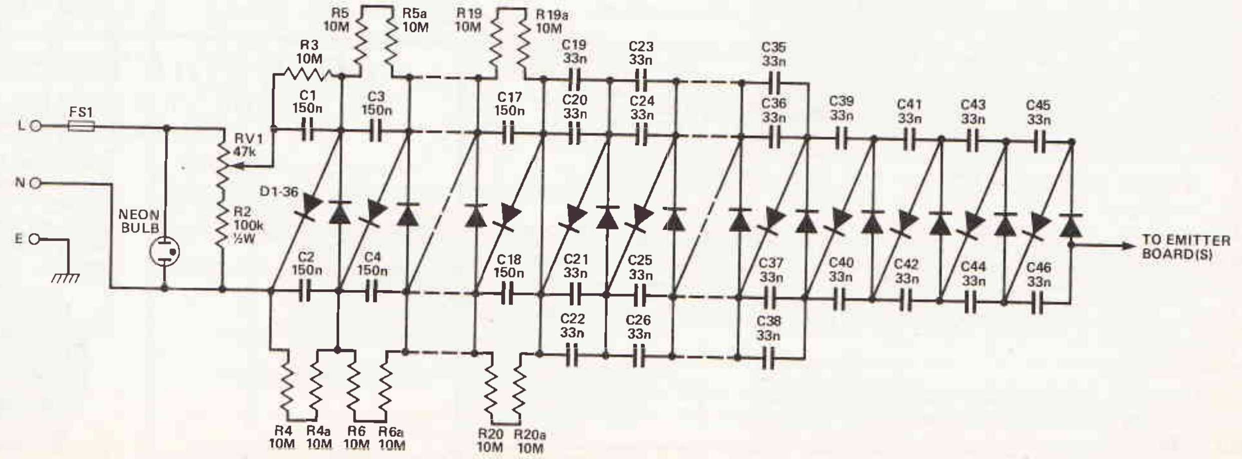


Fig. 1 The circuit diagram of the updated Variat-Ion ioniser

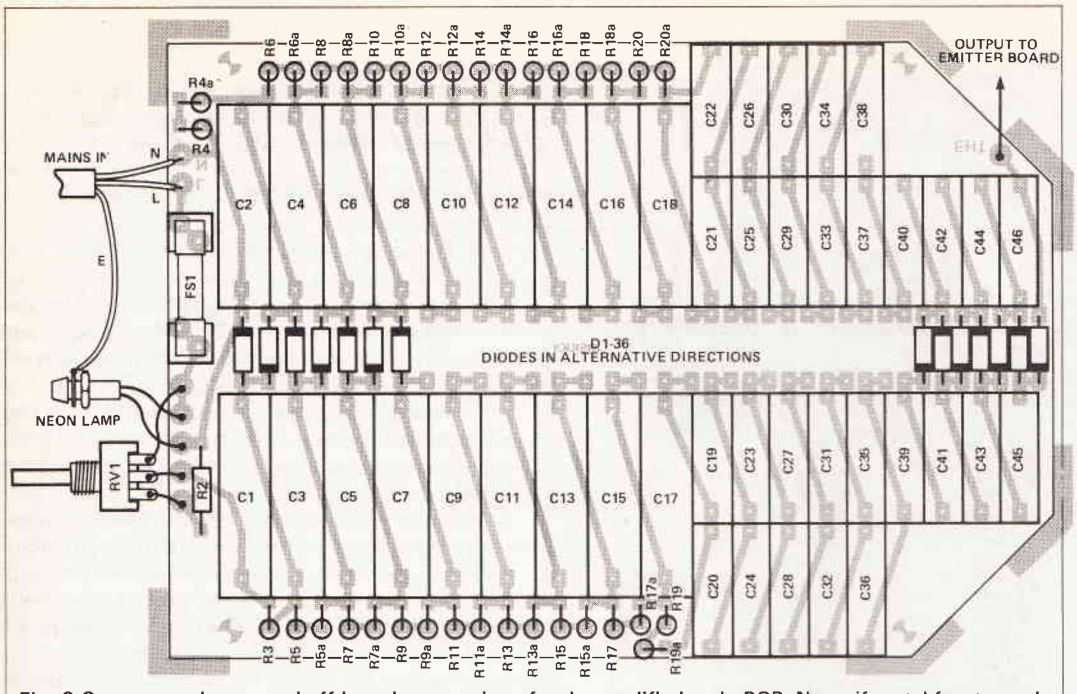


Fig. 2 Component layout and off-board connections for the modified main PCB. Note: if metal front panel is used, it must be earthed. The earth wire is connected to a OBA solder tag which is slipped over the body of the neon lamp and clamped to the front panel by its mounting nut

resistance across each section will also increase the efficiency of the ioniser a little, so the change is worth making.

That's all you need do to lift the main board from almost perfection to absolute perfection so it's on to the emitter section.

Internal Emitter

In the original article I suggested using a internal emitter if the ioniser was to be used by youngsters, for safety reasons. My own reason for building one was slightly different: by using an internal *and* an external emitter together, the Variat-Ion produces even more ions than before!

The circuit of the internal emitter board is shown in Fig. 3 and the component layout in Fig. 4. Resistors R28-R35 are all ½W types to take advantage of their higher working voltage. They allow each emitter point to establish its own working voltage (within reason) which makes for even greater efficiency. The board has its own ion counter and eight emitter points.

The unusual thing about the PCB is that all components mount on the copper track side of the

PARTS LIST

RESISTORS (all ¼W 5% unless specified)	
R1	Not required
R2	100k ½W
R3-R20	10M
R4a-R20a	10M
R27	10k
R28-R35	2M7 ½W
RV1	47k lin. pot.
CAPACITORS	
C1-C18	150n class X2
C19-C46	33n class X2
C48	47n 250V
SEMICONDUCTORS	
D1-D36	1N4007
MISCELLANEOUS	
PCB. Neon bulb. Needles.	

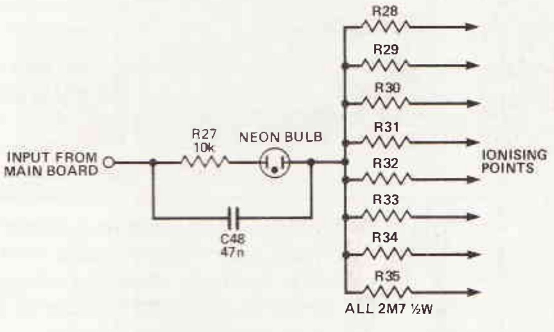


Fig. 3 The circuit of the internal emitter section

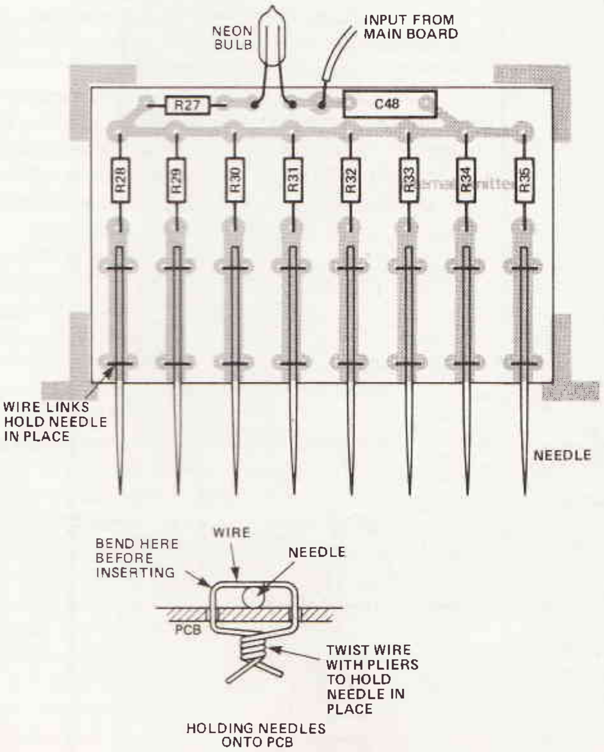
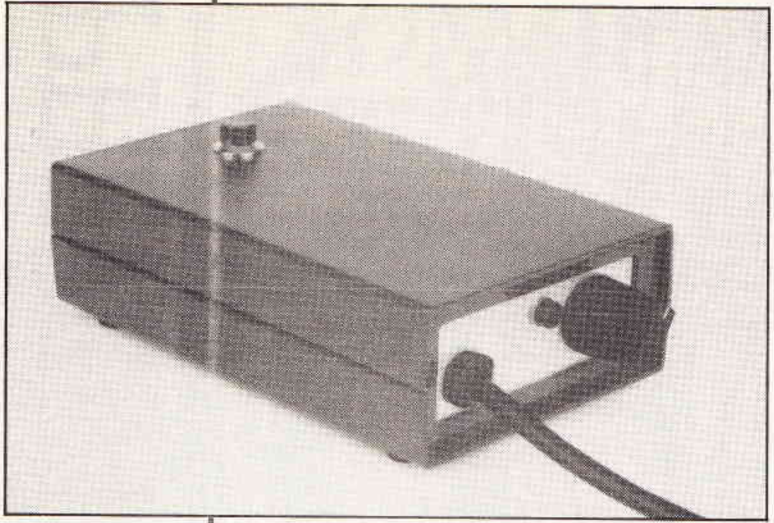


Fig. 4 Component layout for the internal emitter board. Note that components are on the *track* side of the PCB



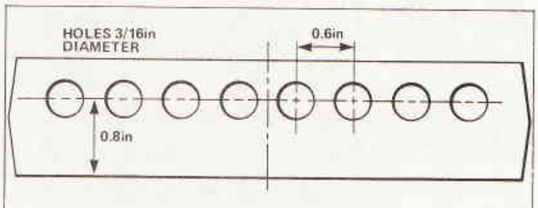


Fig. 5 Drilling diagram for the rear (plastic) panel

board. Bend the component leads and post them through the holes as usual, but solder at the top and cut the leads flush with the plain side of the board underneath. This is to leave a nice, flat surface so the PCB can rest on top of the 33n capacitors at the 'hot' end of the main board.

Insulate the neon leads and leave them fairly long, since it will have to reach at least to the top of the case, and further still if you decide you don't want the lamp to be immediately above the neon's board position.

The wire to join the emitter board to the main circuit is threaded through from the usual side — the plain side — and soldered on the copper side. When the board is in place it will run between the rows of capacitors on its way to the EHT output. Three inches of wire will be more than enough.

When you come to solder the needles, there are two ways to go about it. If you are supremely confident of your own manual dexterity you can do it like this. Wrap a rubber band around the needle end of the board at about the level of the first line of wire-line holes. Slip the eight needles under the band, one on each 'finger' and directly in the centre of it. Rest the PCB on top of the 33n capacitors on the main board and push it against the 150n capacitors so it's as far back as it will go. Slot in the rear panel of the case and adjust the needles so that the point of each is the same distance from the panel (about 1/16in). Now you can carefully remove the board from the case and solder the far end of each needle. Remove the rubber band, solder the front of each needle and you're done.

If you're a little less confident, the needles can be held more firmly in place with wire links through the holes provided. There's a trick to putting in the links — if you just loop them through the holes, no matter how hard you pull from the other side of the board they won't grip the needle. The wire will break first.

The trick is to bend the wire in two 'corners' before putting it through the holes so that it begins by lying flat on the top of the needle. Now when you tighten it (by twisting the ends at the back of the board) it will grip. The wires can be left in place and soldered along with the needles — cut off the twisted ends at the flat surface of the board afterwards.

When the components and needles have been mounted, clean off any dirt and flux residues with an IPA based board cleaner (isopropyl alcohol or isopropanol if you're a modern chemist, it's all the same). After cleaning the board thoroughly top and bottom, spray on a few coats of anti-corona compound, leaving it to dry between each coat. It's very tedious I know but a bit of patience will make all the difference when you turn the ioniser on. You'll be glad you took the trouble. If you place the board on top of the capacitors while the final anti-corona coat is not quite firm, it will glue it in place for you!

The final soldering job is to connect the input lead of the emitter board to the EHT output of the main board. When you glue (or stick with anti-corona spray) the emitter board to the capacitors, let the wire lie between the two rows. Once the glue is dry you can solder the free end of the lead to the main board and put a spot of Araldite over the joint to insulate it.

The drilling diagram for the plastic back panel is shown in Fig. 4. The holes should be 0.3in apart, since that's the spacing of the PCB 'fingers', and a little over 0.8in up from the bottom of the panel. On the prototype I made the holes just over 3/16in diameter — it doesn't allow prying fingers to get in but leaves the ions plenty of room to get out!

If you are making the enclosed version, the only thing left to do is to fix a lens for the neon bulb onto the lid of the box. The one in the photograph is from an incandescent lamp holder — I removed the bulb fitting and just used the lens and metal fixing parts. An alternative would be to cut off the lens of a spare panel neon, or to use the lamp as a whole if you can get at the series resistor to short it out or replace it with a 10k job. I fitted the lens about one inch away from the emitter end of the case but it's quite a stretch for the neon bulb so you might prefer to put yours a little further back.

That's about it for the internal version. You do have to put the case back together but I expect you guessed that yourself. For the two emitter version, all you need to do is to connect both emitter boards to the output of the main circuit — don't forget to insulate the joint with a dob of Araldite if you have to solder to an already sprayed board. You can use both ion counters if you put the two neons one on either side of the emitter brush (or whatever you're using).

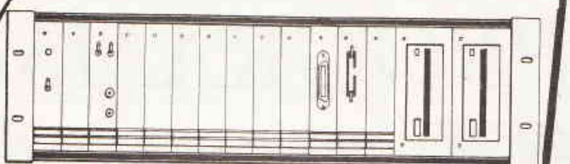
That's about it for ionisers for the moment but don't think you've think you've heard the last of it yet! Experimenting with different types of emitter has inspired me to make an ion meter which can check the output of any ioniser and also sniff out the ion levels around your house. It will be along very soon, so keep an eye on ETI (or an ion ETI if you like excruciating puns) for the project.

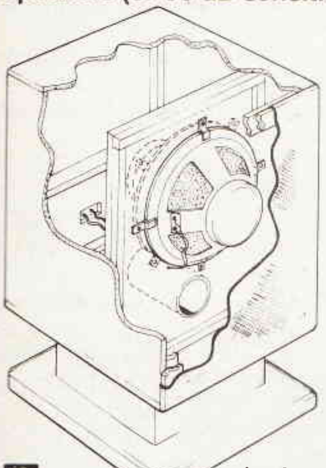
BUYLINES

A complete parts set for the Variat-Ion (also known as the *Mistral*) is available from Specialist Semiconductors Ltd, Founders House, Redbrook, Monmouth, Gwent for £29.32, inclusive of postage and VAT. This set includes the original external emitter board and the modified main board.

There are no parts on the internal emitter board that should cause you the slightest difficulty. If you'd like to get them all in one place, a complete set including the PCB and even the needles is available from Specialist Semiconductors for £3.90 inclusive. Otherwise, the PCB is available from our PCB service and the components from your usual supplier.

A copy of the October 1988 article which described the construction of the project and a lot of info on air ionisation in general can be obtained from our photocopy service.





ETI
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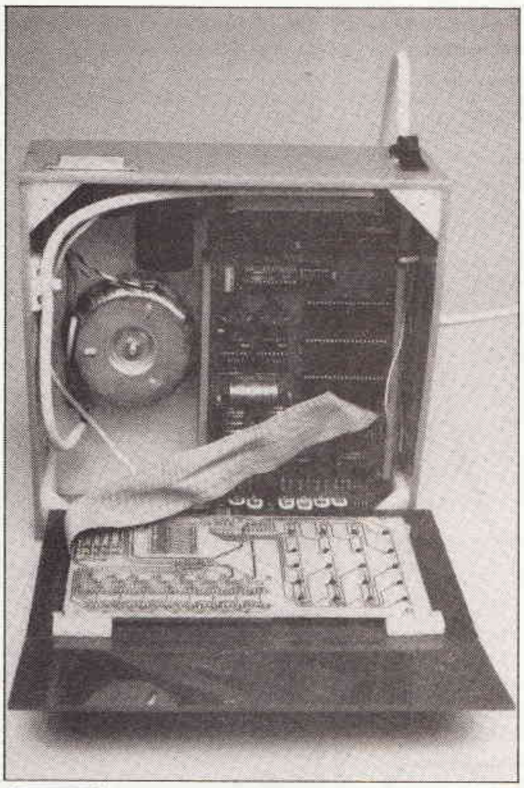
Be it Known
FREE

ETI STAND-ALONE EPROM PROGRAMMER

Mike Bedford unveils the hardware of his new liberated programmer upgrade



This ETI Stand-alone EPROM Programmer has a long and proud ancestral history. The original design back in 1983 was able to program just about any EPROM around at the time but interfaced exclusively with the Tanbus system. This limited its appeal to Tangerine users (and some experimental users of other 6502 and 6809 based computers) but it was nevertheless an enormously popular project.

When technology progressed and memories enlarged, a MKII unit was produced to deal with EPROMs up to the 27512 and 27513. Although even larger EPROMs are available these days, their use is pretty unusual in a non-commercial situation (this means you) and we do not intend to put the price of this unit through the roof by catering for mega-memories here.

Instead this new design upgrades the Universal EPROM Programmer to interface to virtually any computer system, using only an RS232 link. The project takes the MKII programmer as a starting point and adds local intelligence to implement programming, reading, verifying, editing, copying and data transfer. This also makes EPROM duplication or copying after minor changes to the data possible without any recourse to the host computer.

This stand-alone version can also include the EPROM emulator card from ETI July 1984 which can emulate EPROM sizes up to the 2764.

Table 1 shows the specifications available from the complete unit and Fig. 1 illustrates its operation in block diagram form. The programmer and emulator boards are all from the aforementioned projects as listed in the references at the end of the article. Any alterations are noted in the construction details later on.

Similarly the processor card requirements are easily fulfilled by the MCS Single Board Controller that was featured in ETI March 1985.

The main problem with the processor board is that it is no longer available from the original source. Any readers who have an unwanted board from previous projects or equipment might like to sell it

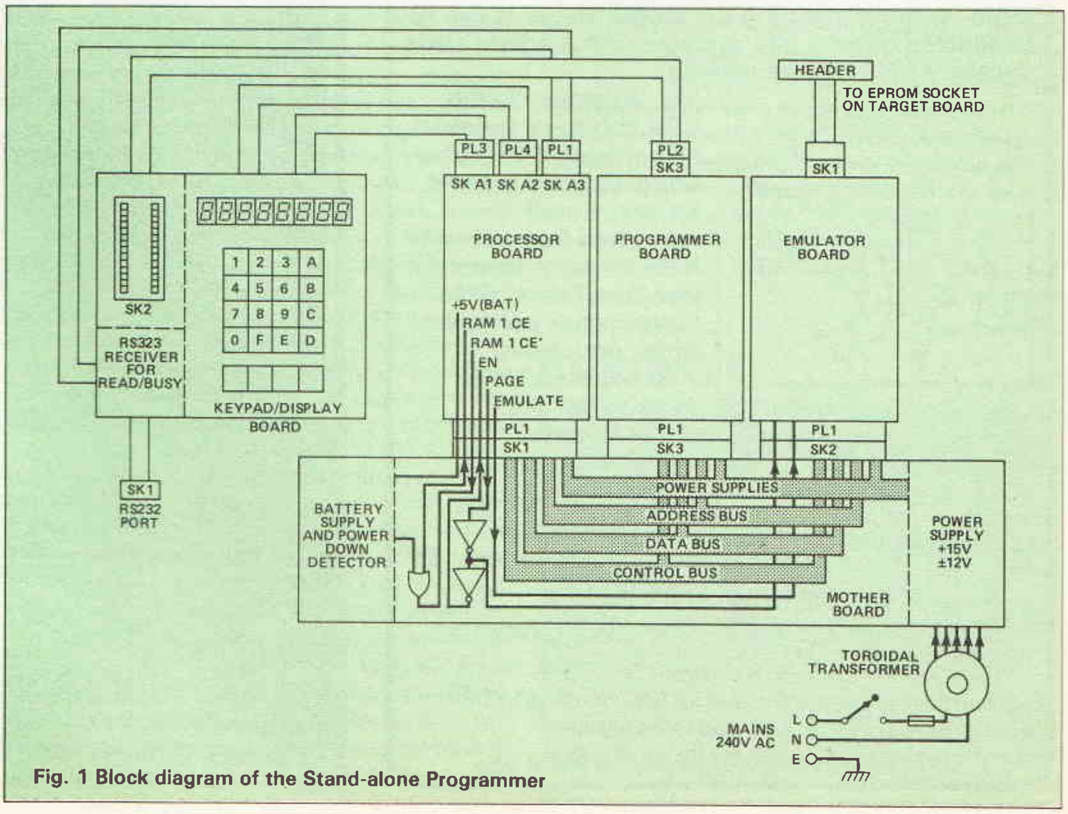


Fig. 1 Block diagram of the Stand-alone Programmer

through our Free Ads to eager constructors.

Readers in possession of MicroTan, Tanex and TanRAM units would be able to modify these with a small mother board to provide equivalent functions.

The last possible source of boards would be a future ETI article describing modifications to an existing 6809 processor board. If enough readers show interest in such a board this could be published in the near future.

Conforming to the Tanbus specification, the SBC processor board interfaces easily to the programmer and emulator cards. Up to 32k on-board RAM (after allowing for EPROM and scratchpad RAM) allows EPROMs up to 27256s to be fully programmed even without the emulator card in the system. Figure 2 shows the memory map of the processor card for this project.

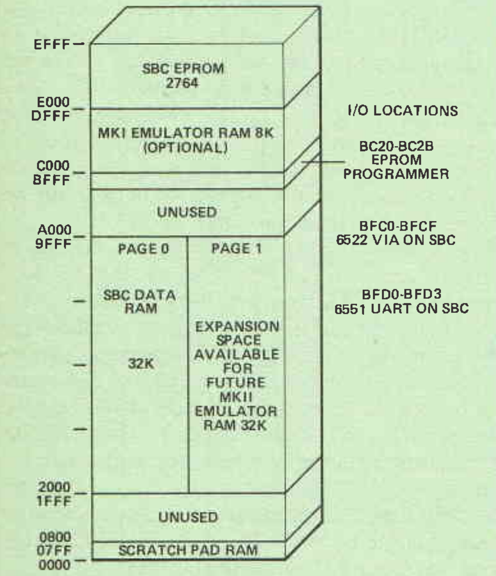


Fig. 2 The memory map of the Programmer

The user controls the programmer by means of a small keypad with dedicated keys, the feedback being through an 8-digit 7-segment LED display. A VDU, although more versatile, would be expensive and also inconvenient.

The mother board and power supply are only lumped together in Fig. 1 since it was convenient to fit both on the same PCB. The mother board provides little more than a bus network for the other cards.

Keypad and Display

Firstly let's get the EPROM ZIF socket out of the way — it appears on this board only since it is handy to have it mounted near the keypad and display. It is connected by a ribbon cable to the programming board.

Similarly part of this board takes a ready/busy signal from the D-type RS232 connector and converts it to a TTL signal, passed as DSR to IC4 on the processor board (which alone provides a limited RS232 interface with only RxD and TxD at RS232 levels).

Neither of these sections of board affect the operations of the keypad and display in any way. These operations are fully described in *How It Works*.

The component overlay is shown in Fig. 3. It is suggested that sockets are not used for ICs since the board will be against the front panel of the enclosed unit and may prevent a flush fit. For the same reason the disc ceramic capacitors should lie flat.

The construction of the board should cause no problems. The ribbon cables take time but are difficult to connect incorrectly. Fitting SK2 after its associated ribbon cable makes the operations less fiddly.

The key caps recommended in *Buylines* are unlegended and can be labelled in transfer lettering followed by a coat of matt-finish varnish. The labels can be seen in Fig. 4.

Mother Board

The mother board essentially consists of three DIN Euro-connectors wired in parallel to provide connection between the processor, emulator and programmer cards.

As always things are not quite that simple and a few extra signals are routed to the appropriate places on pins not used in the Tanbus specification. These signals are as follows:

- The page selection signal from the VIA on the processor via an inverter to the BE signal on the emulator and via a buffer back to BE on the processor.
- The emulation memory access signal from the VIA on the processor to the emulator.
- A chip enable signal for the non-volatile RAM, from the processor through a gate and back again.

This gating on the mother board prevents false writes at power up and down.

The power supply generates +5V at about 3A (for the three logic cards and the LED displays) and ±12V at low current for the RS232 drivers on the processor card.

The component overlay is shown in Fig. 5. Construction is extremely simple and should cause no problems. However, thorough testing of all outputs is recommended since the other boards will not react kindly to a fault here. Check soldering and tracks to ensure that nothing goes wrong at a later date either.

Although the board is simple, the transformer requires some work. The kit transformer (see *Buylines*) is supplied without secondary windings and with instructions generally in French or Flemish, which isn't very helpful (except for our French and Flemish readers).

The first secondary to be put on is the 8.5V which requires 90 turns of 18swg enamelled copper wire. The supplied bobbin is too large to pass through the transformer centre so wind an adequate length (10 metres) onto a narrow bobbin about 9in long constructed from very stiff cardboard or similar.

One end of the wire should be firmly taped onto the core with insulating tape, having first soldered a length of multi stranded insulated wire to it to act as the lead. Winding can now take place — straightforward but tedious. About 1½ complete layers of windings are required with a layer of the provided transparent tape tightly wound over the first layer.

The wire is then cut off, another length of wire for a lead is soldered to it and the end is firmly taped down. A further layer of the transparent tape should now be applied prior to starting the second secondary 240 turns of 24swg (about 25m).

The winding process is the same as before but a length of multi stranded wire needs soldering on as a lead after the first 120 turns. When both the windings are complete two layers of transparent tape should be used to finish off the transformer.

Daughter Boards

The three daughter boards are all fully described in previous projects from ETI, available as photocopies (see *References*). To avoid repetition, nothing much will be said here about them at component level.

EPROMS SUPPORTED

2758	2564	27256*
2516/2716	2764	27512*
2532	2764A	27513
2732	27128*	
2732A	27128A*	

FUNCTIONS PROVIDED

Read EPROM into memory
Programme EPROM from memory
Test EPROM for blank/checksum
Verify EPROM against memory
Input data from RS232 port
Output data to RS232 port
Copy data from memory to memory
Search memory for string
Fill memory with constant value
Edit memory
Split data into even/odd for 16bit

PROGRAMMING ALGORITHMS

Standard 50mS pulse
Fast 10mS pulse**
Intelligent algorithm**

RS232-C WORD FORMATS

7 Data, No parity, 1 Stop
7 Data, No parity, 2 Stop
7 Data, Even Parity, 1 Stop
7 Data, Even Parity, 2 Stop
7 Data, Odd Parity, 1 Stop
7 Data, Odd Parity, 2 Stop
7 Data, Mark Parity, 1 Stop
7 Data, Mark Parity, 2 Stop
7 Data, Space Parity, 1 Stop
7 Data, Space Parity, 2 Stop
8 Data, No Parity, 1 Stop
8 Data, Even Parity, 1 Stop
8 Data, Odd Parity, 1 Stop
8 Data, Mark Parity, 1 Stop
8 Data, Space Parity, 1 Stop

RS232-C HANDSHAKING

Not required on input
XON/XOFF or RDY/BSY on output

DATA FORMATS SUPPORTED

Motorola S1 S9
Intel loader
* Cannot be emulated
** Dependant on availability of algorithm on selected EPROM type

Table 1 Universal Eprom Programmer/Emulator specification

SBC – Construction

LK1	A
LK2	B
LK3/4/5/6	only LK6 to be made
LK7	made
LK8	not made
LK9	made
LK10/11/12/13	only LK13 made
LK14	a-x
LK15	b-x
LK16	a-x
LK17	a-x
LK18	a-x
LK20	made
LK21	A
LK22	B
LK23	already made on PCB
LK24	A
LK25	not made

It is intended these links should be made by pin strips and link blocks, but if the SBC board is for no purpose other than as a component part of this project soldering short lengths of wire directly to the board is fine.

A few more links are needed:

- Pin 27b on the edge connector to pin 12 on DIL socket A1
- Pin 20b on the edge connector to pin 12 on DIL socket A2
- Pin 25b on the edge connector to pin 24 of the RAM in F2 (this one pin of the RAM should be kept out of its socket and wired directly). Note that it is pin 24 of the 24-pin RAM not pin 24 of the 28-pin socket into which it plugs.

The track cut and wires run to edge connector pins 21b and 22b as shown in Figure 5.

Table 2 Links on the processor board.

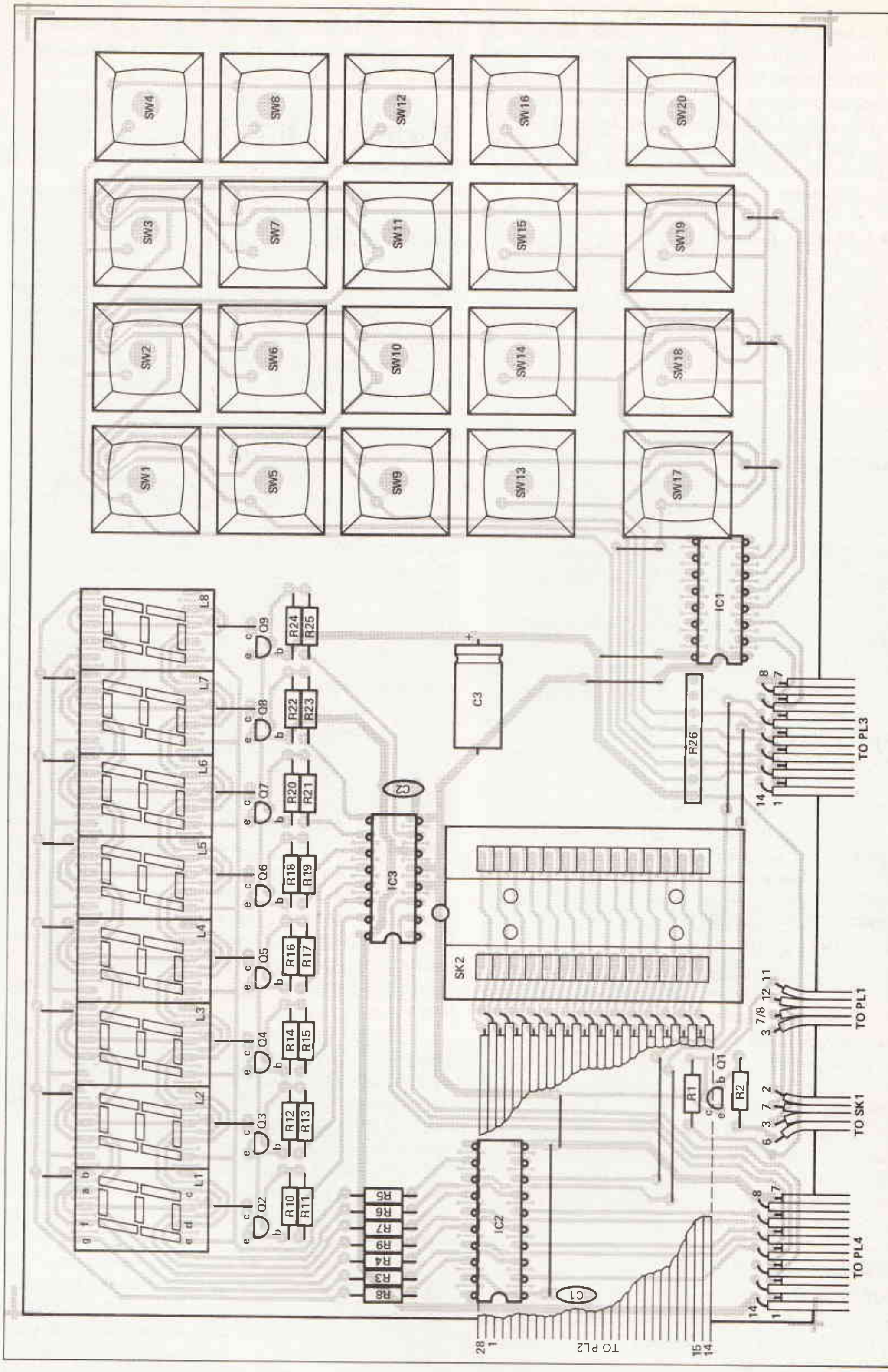


Fig. 3 Component overlay of the keypad and display board

The only aspect which requires consideration is the configuration of user selectable features and in particular the memory map. In order to allow a full 64K of user memory (required in addition to firmware, scratchpad RAM and I/O) a two page organisation is used, page switching being controlled by an output channel on the 6522 VIA.

Page 0 is resident on the main processor card whereas page 1 is available for further development (namely a MKII emulator card planned for the future). The firmware makes the pages appear as a single 64K area of RAM.

The processor card in its original form makes no provision for non-volatile (battery backed up) RAM memory. In this project, however, such a provision would be very useful to avoid having to redefined the RS232 baud rates, RS232 data and parity bits of data format each time the unit is switched on. A slight modification to the processor board and a small amount of circuitry on the mother board to provide a battery supply to one chip and gating of its *chip enable* on power down to prevent false writes makes such a facility possible.

Construction of the processor cards is assisted by the manual, if you have one, and the original article (see *Buylines*). However, you should not use the manual's parts list as a number of features are not used. The parts list here shows all that is required, and the list of links in Table 2 should also be included.

The data for programming the memory mapping

PROM (numbered N3 in the manual) is shown in Listing 1. The final column is the actual data to be programmed to the locations in the second column.

Construction details of the optional emulator card are available in the original article (see *References*). To configure the emulator RAM at &C000 (see memory map in Fig. 2) wire the links on the DIL header as shown in Fig. 7a. Construction of the programmer board is again covered in its original article. The only part specific to this project is selection of the correct address within the I/O area as &BC20. The links on the DIL header should be configured as shown in Fig. 7b.

Putting It All Together

Now it is time to fit all the boards together. Don't forget to make sure the PSU is giving the right voltages in

PARTS LIST

Keypad and Display Board

RESISTORS (all ¼W 5%)

R1,2	4k7
R3-9	150R
R10-25	1k0
R26	10k SIL 7 commoned resistor pack

CAPACITORS

C1,2	100n ceramic
C3	100μ 16V axial electrolytic

SEMICONDUCTORS

IC1	74LS139
IC2	74LS240
IC3	74LS138
Q1	BC184L
Q2-9	BC327
LED1-8	0.5in 7-segment red LEDs, common anode

MISCELLANEOUS

PL1,3,4	14-pin DIL header
PL2	28-pin DIL header
SK1	25-way D-type socket
SK2	28-pin DIL ZIF socket
SW1-20	switch modules plus blank keycaps (see Buylines)

PCB. 14 and 28-way ribbon cable. Wire.

Mother Board and Power Supply

RESISTORS (all ¼W 5% except where stated)

R1	330R 2%
R2,5	10k
R3	68R 2%
R4,6	1k5
R7,8	4k7

CAPACITORS

C1	1500μ 15V electrolytic
C2,3	2200μ 25V radial electrolytic
C4	1μ0 35V tantalum
C5	100n ceramic
C6,8	220n ceramic
C7,9	470n ceramic

SEMICONDUCTORS

IC1	74LS04
IC2	4071
IC3	78H05
IC4	7812
IC5	7912
Q1	BC214L
Q2	BC184L
BR1	4A bridge rectifier
BR2	1A bridge rectifer
D1	1N4001

MISCELLANEOUS

FS1	20mm 1A mains fuse
SK1,2,3	DIN 41612 connectors, 64-way A+B sockets
SW1	panel mounting mains switch
T1	50VA toroidal transformer kit

PCB. 20mm fuse clip. 10m 18swg enamelled copper wire. 25m 24swg enamelled copper wire.

Processor Board

RESISTORS (all ¼W 5%)

R3,5,11,12,14	4k7
R4	1k0
R13	470R
RP1	4k7 SIL pack, 7 commoned
RP3	1k0 SIL pack, 4 separate resistors
RP4	1k0 SIL pack, 7 commoned

CAPACITORS

C1,7-14	100n ceramic
C2,15	10n ceramic
C3	100p ceramic
C5	100μradial electrolytic

SEMICONDUCTORS

B1	6522
C1	74LS393
C2	74LS04
D1	6551
D3	6502
D4	75150
E1	2764 programmed with firmware
E2	74LS244
E3	74LS244
F1,H1,K1,L1	2064 or 6264 8K x 8 static RAM
F2	6116P 2K x 8 CMOS static RAM
F3	74LS139
G3	74LS00
H3	74LS266
J3	74LS12
K3	74LS10
L3	74LS08
M3	74LS138 *NB This chip upside down
N2	74LS245
N3	74S288
Tr1	BC184 (not BC184L used elsewhere)
D1-3	1N4001
XTAL 1	8MHz crystal
XTAL 2	1.8432MHz crystal

MISCELLANEOUS

DIN 41612 Connector, 64-way A+B plug. 3 x 14-way DIL sockets plus those required for ICs. 0.1in pin strips and jumpers for links if not hard wiring.

Overall Components

Mother board and power supply
Keypad and display board
MKII EPROM programmer board
Processor board (Single Board Controller)
MKI EPROM emulator board (optional)
Case
Fuse and fuseholer
Mains switch
3-way mains connector block
Grommet
Mains cable and plug

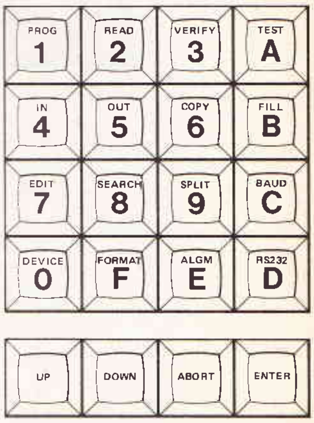


Fig. 4 Layout and legends for the keypad

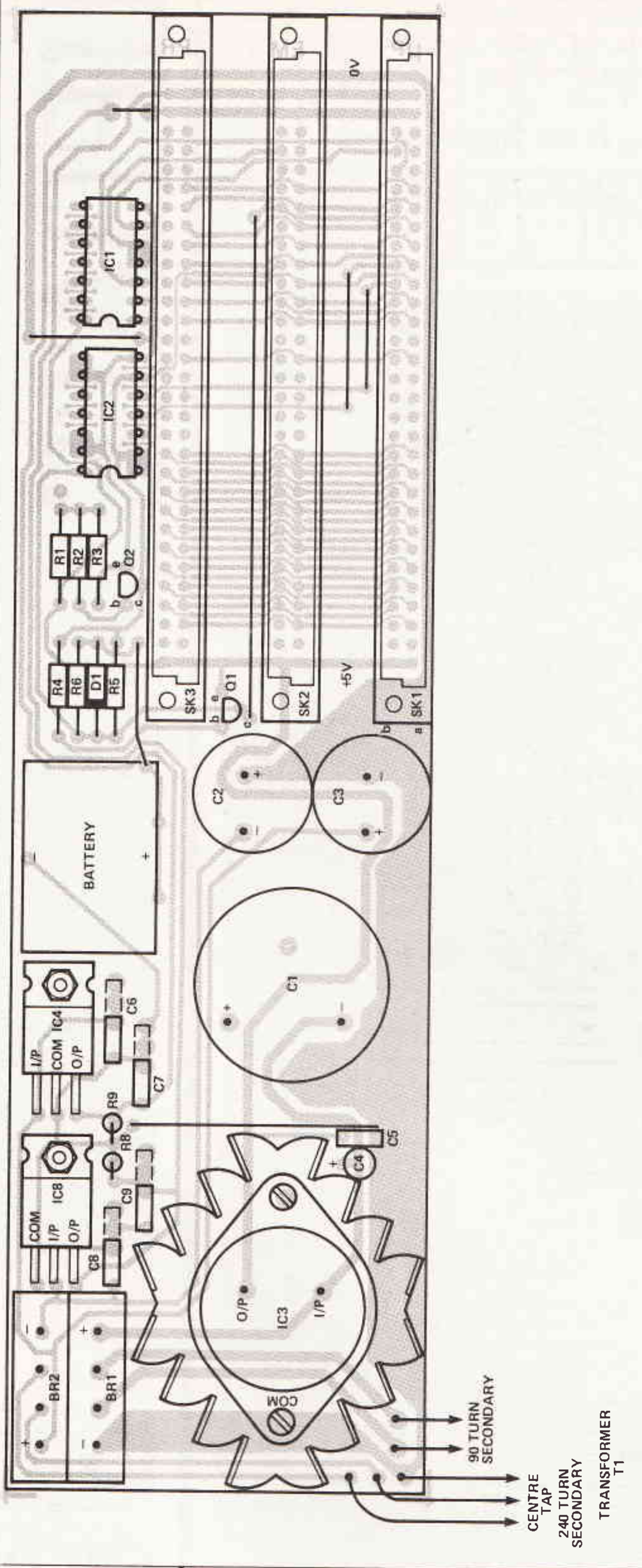


Fig. 5 Component overlay for the mother board and power supply

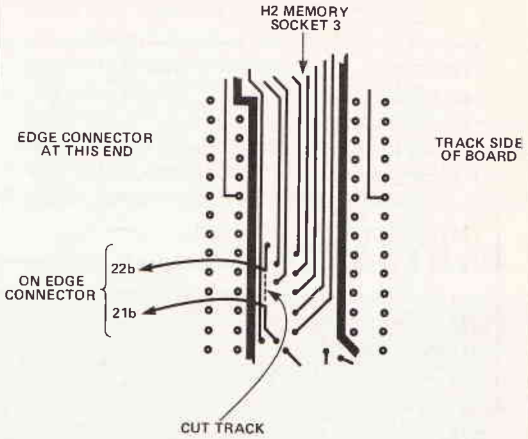


Fig. 6 Tracking modification for the processor board

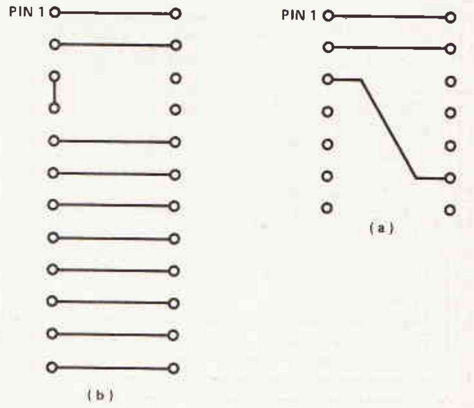


Fig. 7 (a) Links for emulator memory at &C000
(b) Programmer board links for start address at &BC20

Processor Address Range (Hex)	Prom Address	Prom Data Bits								Hex Data
		7	6	5	4	3	2	1	0	
0000 – 07FF	00	0	0	0	0	1	0	1	0	0A
0800 – 0FFF	01	1	0	0	0	1	0	0	0	88
1000 – 17FF	02	1	0	0	0	1	0	0	0	88
1800 – 1FFF	03	1	0	0	0	1	0	0	0	88
2000 – 27FF	04	0	0	1	1	1	1	0	0	3C
2800 – 2FFF	05	0	0	1	1	1	1	0	0	3C
3000 – 37FF	06	0	0	1	1	1	1	0	0	3C
3800 – 3FFF	07	0	0	1	1	1	1	0	0	3C
4000 – 47FF	08	0	1	0	0	1	1	0	0	4C
4800 – 4FFF	09	0	1	0	0	1	1	0	0	4C
5000 – 57FF	0A	0	1	0	0	1	1	0	0	4C
5800 – 5FFF	0B	0	1	0	0	1	1	0	0	4C
6000 – 67FF	0C	0	1	0	1	1	1	0	0	5C
6800 – 6FFF	0D	0	1	0	1	1	1	0	0	5C
7000 – 77FF	0E	0	1	0	1	1	1	0	0	5C
7800 – 7FFF	0F	0	1	0	1	1	1	0	0	5C
8000 – 87FF	10	0	1	1	1	1	1	0	0	7C
8800 – 8FFF	11	0	1	1	1	1	1	0	0	7C
9000 – 97FF	12	0	1	1	1	1	1	0	0	7C
9800 – 9FFF	13	0	1	1	1	1	1	0	0	7C
A000 – A7FF	14	0	0	0	0	1	0	0	0	88
A800 – AFFF	15	0	0	0	0	1	0	0	0	88
B000 – BFFF	16	0	0	0	0	1	0	0	0	88
B800 – BFFF	17	0	0	0	0	1	0	0	1	89
C000 – CFFF	18	1	0	0	0	1	0	0	0	88
C800 – CFFF	19	1	0	0	0	1	0	0	0	88
D000 – D7FF	1A	1	0	0	0	1	0	0	0	88
D800 – DFFF	1B	1	0	0	0	1	0	0	0	88
E000 – E7FF	1C	1	0	0	0	0	0	1	0	82
E800 – EFFF	1D	1	0	0	0	0	0	1	0	82
F000 – F7FF	1E	1	0	0	0	0	0	1	0	82
F800 – FFFF	1F	1	0	0	0	0	0	1	0	82

Listing 1 SBC memory mapping Prom Data.

the right places before slotting the cards into the mother board.

- Plug the processor card into SK1 on the other board.
- Plug the programmer card into SK2 on the mother board.
- Plug the emulator into SK3 on the mother board.
- Plug PL1 from the keyboard/display board into socket A3 on the processor card.
- Plug PL2 from the keyboard/display board into socket SK3 on the programmer card.
- Plug PL3 from the keyboard/display board into socket A1 on the processor card.
- Plug PL4 from the keyboard/display board into socket A2 on the processor card.
- Wire up the circuitry associated with the mains side of the toroidal transformer.

It should now work — assuming you've dealt

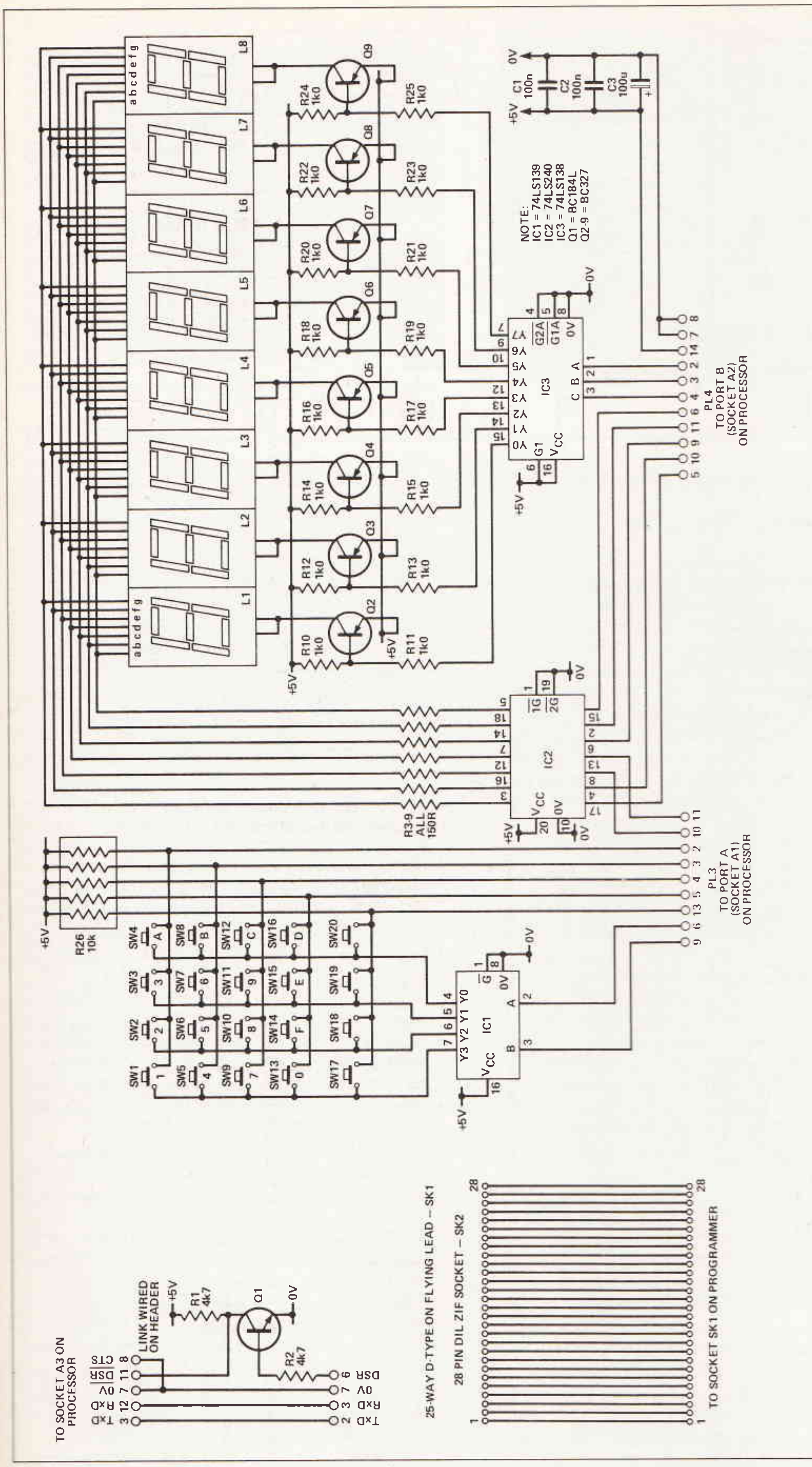


Fig. 8 Circuit diagram of the control panel

with the system ROM software to be described next month. However, building the unit up to be a robust and acceptable unit takes a little more time. The photographs show how the prototype was constructed and only a couple of handy hints are needed here.

Mount the keyboard/display board on pillars or long bolts from the base — that way the screws are kept off the top panel.

A couple of perspex pillars with notches across the three daughter cards will help to stop them shifting in the vertical plane and becoming loose.

It is worth slipping some thin sheets of insulating material between the cards to prevent any shorting. The clearances throughout this project are pretty small — this was to fit in a specific case which has since been rather inconveniently discontinued.

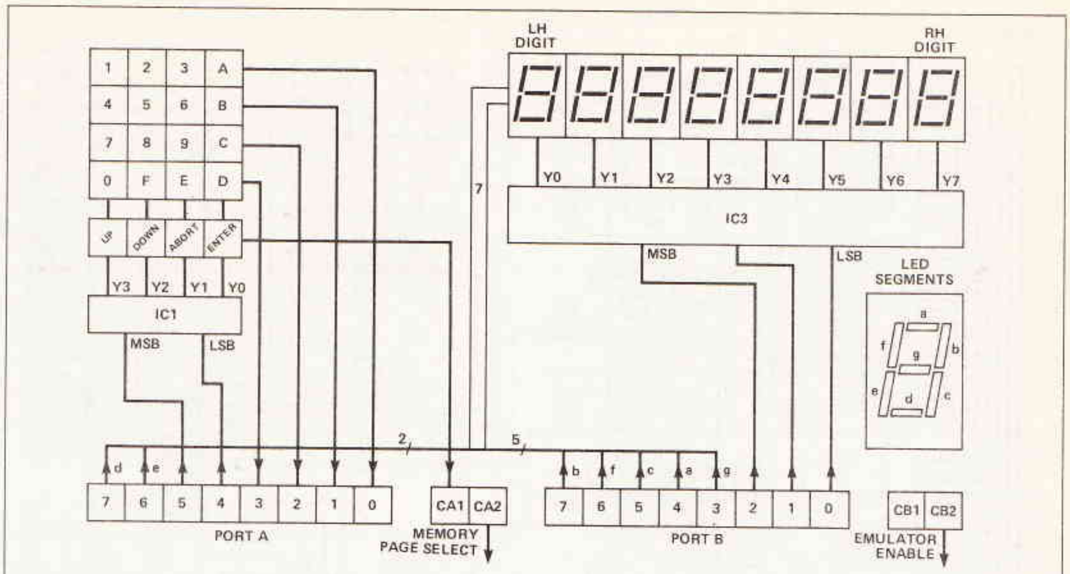


Fig. 9 Processor board 6522VIA bit designations

HOW IT WORKS

Looking first at the keypad/display board (Fig. 8) the circuitry around Q1 is simple. An RS232 signal (±12V) is input on SK1/6 to the base of Q1. Clearly the +12V state will turn the transistor on giving a TTL low output whereas a -12V RS232 signal will turn the transistor off hence giving a TTL high output via R1. This signal is applied to the DSR input of the UART on the processor board.

The keypad is read by the 6522 VIA on the processor board through pins 13, 5, 4, 3 and 2 of PL3 each of which monitors one of the five rows of keys (Fig. 9). When all the keys are open the signals will all be held high by pull-up resistors (RP1). In order to detect depressions, the four columns of keys have a low level applied to them in turn. This is achieved by use of ICl which gives a low at one of the four outputs depending on the binary value on the two inputs which are driven from the VIA. Once a low has been detected on one of the row inputs it is a simple task for the software to deduce which key was pressed from the column currently being driven.

The LED display is multiplexed so that only one of the eight is driven at any one time. The speed of multiplexing fools the eye into seeing all eight illuminated at the same time.

The LEDs used have a common anode – a device is selected by applying a positive supply to this common connection. The switching is achieved by PNP transistors Q2-9 driven by IC3. This chip gives a low level at one of its eight outputs depending on the binary value on its three inputs. The inputs are driven from the VIA via PL4.

Once the required LED has been selected, the appropriate segments are illuminated by applying a TTL low to their cathodes via current limiting resistors R3-9, again driven from the VIA via PL3 and PL4, through the buffer IC2 which provides the required current sinking capacity.

Mother Board

Essentially the mother board (Fig. 10) consists of three 64-way sockets wired in parallel hence providing the address, data and control busses and power supplies for the three cards.

The processor card has been slightly modified to put two of its 6522 I/O channels onto its edge connector. These signals are *Emulate* and *Page*.

Emulate is connected on the mother board to the emulator board and controls whether the memory on this card is available to the processor on the processor card or as emulation memory to the processor on the target development board.

The *Page* signal is used to control which of the two 32K blocks of user memory is actually present in the memory map. When this signal is a logic zero it is fed back to the BE signal on the processor card via the two inverters in IC1 (giving a non-inverted signal) hence enabling the memory on this card. The signal routed to the BE pin on the emulator passes through one inverter and will therefore be a logic high under these conditions hence disabling the memory. Clearly output of a logic high as the *Page* signal will enable memory on the emulator card only. The reason for using this two inverter configuration was to prevent the VIA output being loaded by more than the single TTL load which it is specified.

When the +5V supply is present at a proper level, the voltage at the junction of R1 and R3 will be sufficient to turn on Q2 which in turn switches on Q1 thereby allowing the +5V supply to be present on the +5V (BAT) line. Under these conditions the battery B1 will also trickle charge through current limiting resistor R6.

When the +5V supply is switched off, Q2 and hence Q1 will be switched off preventing the battery from discharging through the power supply. Instead, B1 now supplies the +5V (BAT) line through D1, this line being used to power the non-volatile CMOS RAM on the processor card during power down for data retention.

For such data retention it is also important to prevent glitches which occur on the bus during power up/down from corrupting the data in the RAM. A modification to the processor card brings out the CE signal for the RAM in question to the edge connector. This signal is gated by IC2a to prevent it going low except when the +5V supply is at its correct level. The gated CE signal is passed back to the RAM via the edge connector.

The chip which carries out this gating obviously has to be supplied by +5V (BAT) which limits it to a CMOS type. In adherence to usual CMOS practice the inputs to unused gates are held at a definite logic state to prevent them floating (and possibly switching on both output transistors simultaneously exceeding the power dissipation). The reason some are tied to 0V and the other to another output is purely to simplify the PCB artwork.

The remainder of the mother board is the power supply. The transformer provides secondaries of about 8V5 and 11V5-0-11V5 on load, the off load values being higher by about 13%, the regulation factor of this transformer.

The outputs of these two secondaries are full wave rectified by BRl and BR2 respectively giving DC peak voltages of about 10.5V and 31V. The 10.5V supply is then smoothed by C1 and regulated to +5V by IC3. The level of the secondary voltage used was chosen to minimise the size of both the smoothing capacitor and the heat sink on IC3. The size of the heatsink depends on the current dissipated in the regulator and accordingly the voltage dropped across it. On the other hand, a high secondary voltage reduces the necessary value ane thereby size of the smoothing capacitor. This compromise keeps both components to a reasonable size.

The requirements for the -12V supply were nowhere near as stringent as only a low current will be drawn from it. The smoothing capacitors are therefore quite small and the regulators dissipate very little power. This part of the circuit is very similar in principle to the +5V supply, the only difference being the way in which the supplies are referenced to the transformer secondary centre tap in order to provide a dual polarity supply.

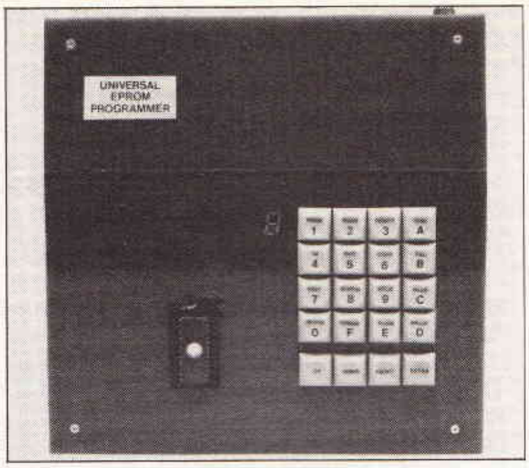
REFERENCES

The original EPROM Programmer appeared in ETI August and September 1983.

The MKII, from which the processor board of this project is taken, appeared in four parts from May to August 1985, but the July and August articles covered software only and are not relevant to this new design.

The EPROM emulator board is from the *Versatile EPROM Emulator*, in July and August 1984. The processor board is described in the article *Single Board Controller*, published March 1985.

To reduce the cost of ordering each article as a photocopy separately, ETI's Photocopy Service can supply copies of the MKII Programmer, the Emulator and the Single Board Controller as a single item, price £3. Contact ETI Photocopy Service, 9 Hall Road, Hemel Hempstead HP2 7BH. Ask for the Stand-Alone Programmer Pack.



BUYLINES

Most of the buying information for items in past projects is still valid.

However, as mentioned at the beginning of this article, the processor Single Board Controller is not available from either the original source or the ETI PCB Service.

The ROM labelled E3 on this board will be available from Gordon Bennett — details with the software next month. The other programmed part, the 27S288 memory mapping PROM N3, requires programming. If readers do not have the equipment — and if you're building a programmer this is quite likely — a blowing service is available from PLS, 16 Central Raod, Worcester Park, Surrey KT4 8HZ. Tel: 01-330 6540.

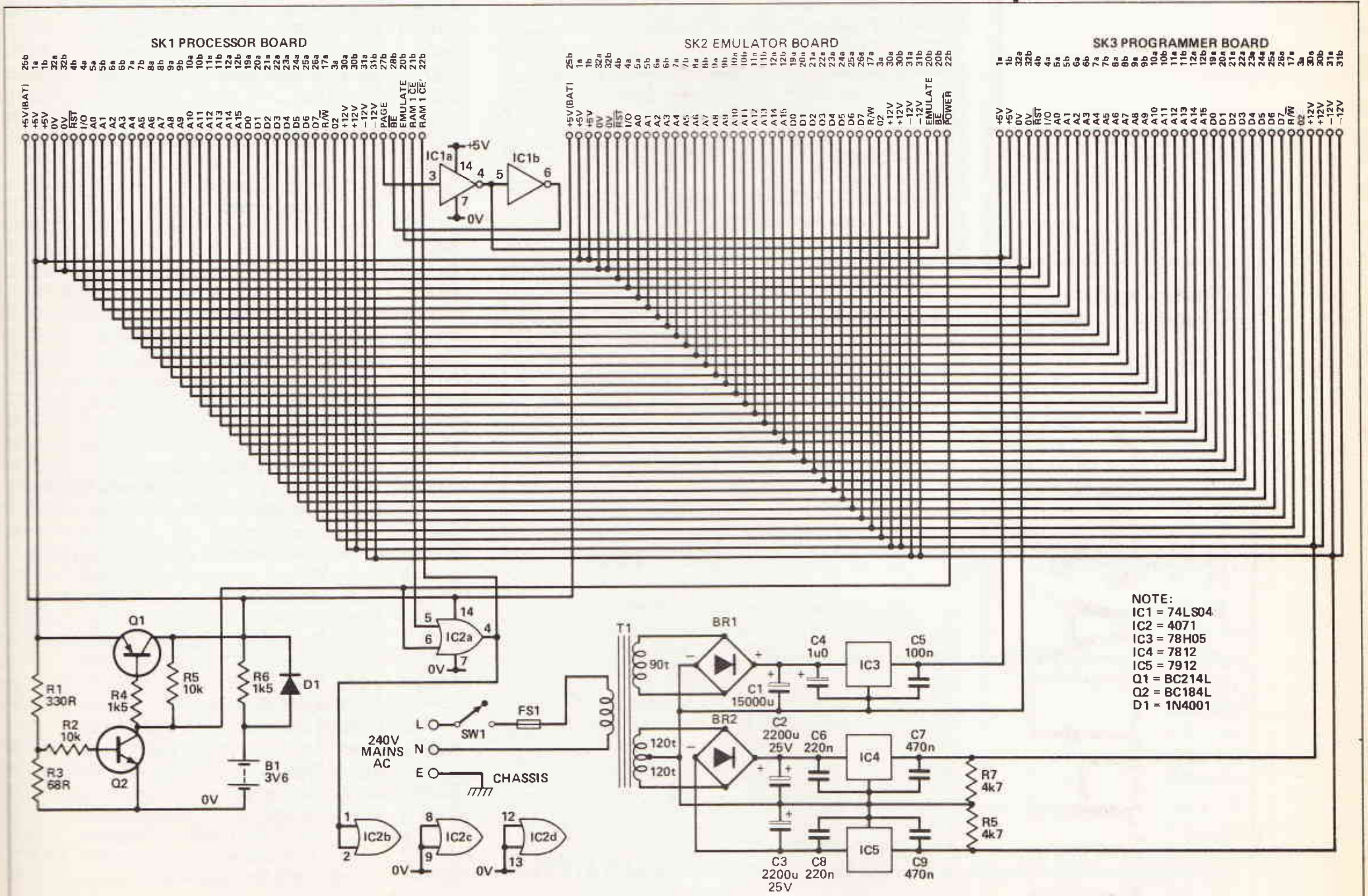
The keyswitches and keycaps for the keypad board can be obtained from Verospeed (Tel: (0703) 644555) as parts 63-40781E and 63-40791L respectively.

C1 on the mother board must be from Electromail (Tel: (0536)204555), part 164-348. The heatsink for IC3 is quite critical in terms of size. One suitable solution is available from Rapid Electronics (Tel: (0206) 272412).

The transformer is from Electronics and Computer Workshop (Tel: (0245) 262149) as part KT050. Most suppliers can only supply 18swg wire (for the secondary) in 2oz reels which isn't enough. Larger reels can be obtained from The Scientific Wire Company (Tel: 01-531 1568).

The battery B1 is 3V6, 0.1Ah. One suitable source is Farnell (Tel: (0532) 636311) if you have an account or Trilogic (Tel: (0274) 684289) if you don't. Part number 148-817.

Next month we'll give the details of the system ROM and describe operation and programming functions.



NOTE:
IC1 = 74LS04
IC2 = 4071
IC3 = 78H05
IC4 = 7812
IC5 = 7912
Q1 = BC214L
Q2 = BC184L
D1 = 1N4001

Fig. 10 Circuit diagram for the mother board and power supply

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E8202-5	MM Stage Disc Pre-amp (Tilsbrook)	G
E8206-5	Logic Lock	F
E8208-1	Playmate Practice Amp (3bds)	K
E8212-1	ELCB	F
E8301-2	Analogue to digital conv ZX81/Spectrum)	E
E8305-3	Dual Audio Power Supply, Linsley Hood	G
E8305-3	Balanced Input Preamplifier	F
E8307-2	Flash Trigger-sound or FR	F
E8308-1	Graphic Equaliser ⅓ Oct	M
E8308-2	Servo Fail-safe	C
E8309-1	NICAD Charger/Regenerator	F
E8310-3	Typewriter Interface — EX42	F
E8311-1	Mini Drum Synth	F
E8311-8	Moving Coil Pre-Pre-amp	F
E8312-3	Light Chaser EPROM Controlled (2 Bds)	K
E8402-1	Speech Board	M
E8402-2	Modular Pre-amp Disc Input Mono	F
E8402-3	Modular Pre-amp Stereo Output	F
E8402-4	Modular Pre-amp Relay, PSU	F
E8402-5	Modular Pre-amp Tone Main Mono	F
E8402-6	Modular Pre-amp Tone Filter, Stereo	F
E8402-7	Modular Pre-amp Balanced Output	F
E8402-8	Modular Pre-amp Headphone Amp	F
E8404-2	Mains Remote control Receiver	F
E8405-1	Auto Light Switch	F
E8405-2	ZX81 EPROM Programmer	N
E8405-3	Mains Remote Control Transmitter	H
E8405-4	Centronics Interface	F
E8405-6	Drum Synth	F
E8406-1	Oric EPROM Board	O
E8406-2	Spectrum Joystick	E
E8406-3	Audio Design RIAA Stage	G
E8406-4	AD Buffer/Filter/Tone	H
E8406-5	AD Headphone Amp	F
E8406-6	AD Preamp PSU	K
E8406-7	AD Power Amp	H
E8406-8	AD Power Amp PSU	J
E8406-9	AD Stereo Power Meter	F
E8406-10	AD Input Clamp	C
E8407-1	Warlock Alarm	M
E8408-2	EPROM Emulator	N
E8408-3	Infra-red Alarm Transmitter	E
E8408-4	Infra-red Alarm Receiver	F
E8409-1	EX42 Keyboard Interface	F
E8409-2	Banshee Siren Unit	F
E8410-1	Echo Unit	F
E8410-2	Digital Cassette Deck	N
E8410-3	Disco Party Strobe	H
E8411-5	Video Vandal (3 boards)	N
E8411-6	Temperature Controller	D
E8411-7	Mains Failure Alarm	D
E8411-8	Knite Light	D
E8411-9	Stage Lighting Interface	F
E8411-10	Perpetual Pendulum	E
E8412-1	Spectrum Centronics Interface	F
E8412-4	Active-8 Protection Unit	F
E8412-5	Active-8 Crossover	F
E8412-6	Active-8 LF EQ	F
E8412-7	Active-8 Equaliser	F
E8501-3	Digital Delay (2 bds)	T
E8502-1	Digital Delay Expander	N
E8502-2	Data Logger	J
E8503-1	Combo Preamplifier	F
E8503-2	THD Meter mV & oscillator boards (2 bds)	K
E8503-3	THD Meter Mains PSU	F
E8504-1	Framestore Memory	M
E8504-3	Framestore Control	N
E8504-4	Buzby Meter	E
E8504-5	CCD Delay	F
E8505-5	Stereo Simulator	F
E8506-1	Audio Mixer Main	J
E8506-2	Audio Mixer PSU	F
E8506-3	Audio Mixer RIAA	D
E8506-4	Audio Mixer Tone Control	D
E8506-5	EPROM Prog MKII	O
E8507-1	Noise Gate	H
E8508-1	RCL Bridge	N
E8508-2	EX42/BBC Interface	E
E8508-3	EPROM Emulator	L
E8509-1	Spectrum EPROM card	F
E8509-2	Direct Injection Box	E
E8510-9	Sunrise Light Brightener	K
E8511-1	MTE Waveform Generator	H
E8511-2	Millifaradometer	H

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E8511-3	Cymbal Synth	J
E8511-5	Chorus Effect	H
E8511-7	Enlarger Exposure Meter	F
E8511-8	Switching Regulator	E
E8511-9	Second Line of Defence	M
E8512-1	Specdrum Connector	F
E8512-2	MTE Pulse Generator	H
E8512-3	Specdrum	L
E8601-2	Walkmate	L
E8601-3	MTE Counter-timer	M
E8602-1	Digibaro	O
E8603-2	Programmable Logic Evaluation Board	H
E8603-3	Sound Sampler Analogue Board	R
E8604-1	JLLH PA PSU	H
E8604-2	Matchbox Amplifier	C
E8604-3	Matchbox Amp Bridging Version	C
E8604-4	MTE Analogue/Digital Probe	M
E8605-1	Microlight Intercom	E
E8605-2	Baud Rate Converter	M
E8605-3	Baud Rate Converter PSU Board	C
E8605-4	Portable PA	H
E8606-1	MIDI-CV Converter Board	H
E8606-2	MIDI-CV Converter PSU	D
E8606-3	Troglograph	F
E8606-4	80m Receiver	H
E8606-5	Sound Sampler	R
E8607-1	Direction	E
E8607-2	Upgradeable Amp, MC stage (Stereo)	G
E8607-3	BBC Motor Controller	F
E8608-1	Digital Panel Meter	G
E8608-2	Upgradeable Amp, MM stage (mono)	H
E8609-1	Mains Conditioner	E
E8609-2	Experimental pre-amp	F
E8609-3	Upgradeable amp, Tone board (mono)	H
E8609-4	Upgradeable amp, Output board (mono)	F
E8610-1	Audio Analyser Filter Board	L
E8610-2	Audio Analyser Display Driver	K
E8610-3	Audio Analyser Display	H
E8610-4	Audio Analyser Power Supply	F
E8611-1	Audio Switcher (2 bds)	H
E8611-2	PLL Frequency meter (4 bds)	Q
E8611-3	Upgradeable Amp PSU	J
E8611-4	Call meter, main board	O
E8611-5	Call meter, interface board	N
E8612-1	Bongo Box	J
E8612-2	Biofeedback monitor (Free PCB)	E
E8701-1	RGB Converter	F
E8701-2	Mains Controller	D
E8701-3	Flanger	H
E8701-4	Audio Selector main board	M
E8701-5	Audio Selector PSU	H
E8701-6	Tacho-Dwell	F
E8702-1	Ratemeter main board	K
E8702-2	Ratemeter ranging board	F
E8702-3	Photo Process Controller (3 bds)	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	ETIFaker patch box	H
E8704-3	24Hr Sundial	E
E8705-3	MIDI Keyboard keyswitch boards (3 bds)	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
E8712-1	Heating Management System	O
E8712-2	SWR Meter	H
E8712-3	Dream Machine (free PCB)	D
E8801-2	Passive IR Alarm	H
E8801-3	Deluxe Mains Conditioner	G
E8801-4	RGB Dissolve	L
E8802-1	Electric Fencer	E
E8802-2	Telephone Intercom	L
E8802-3	Transistor Tester (2 bds)	L
E8802-4	Spectrum Co-processor CPU	N
E8803-1	Co-processor RAM board	N
E8803-2	Beeb-Scope (3 bds)	O
E8803-3	Jumping Jack Flash	E
E8804-1	Spectrum Co-processor Interface Board	N
E8804-2	Combo-lock	E
E8804-3	Kitchen Timer	E
E8805-1	Virtuoso 2U PSU	M
E8805-2	Virtuoso 3U PSU	N
E8805-3	Bicycle Speedometer	F
E8805-4	Dynamic Noise Reduction	E
E8806-1	Universal digital panel meter	L
E8806-2	Universal bar graph panel meter	K
E8806-3	Virtuoso power amp board	N
E8806-4	Virtuoso AOT board	G
E8806-5	Metal detector	E
E8806-6	Bicycle dynamo backup	D
E8807-1	Bar Code Lock (2 bds)	N
E8807-2	Analogue Computer Power Board	L
E8807-3	Bell Boy	F
E8807-4	Logic Probe	C
E8807-5	Updated FM stereo decoder	J
E8807-6	Breath Rate display board	F
E8808-1	Breath rate main board	H
E8808-2	Breath rate switch board	C
E8808-3	Telephone recorder	D
E8808-4	Analogue computer main board (2 bds)	M
E8809-1	Spectrum EPROM Emulator	M
E8809-2	Frequency meter (2 bds)	P
E8809-3	Travellers' Aerial Amp	E
E8810-1	Gerrada Marweh Bikebell	E
E8810-2	Peak Programme Meter (2bds)	N
E8810-3	Variat-Ion ioniser	K
E8810-4	TV-to-RGB converter	E
E8810-5	Electron RGB buffer	C
E8811-1	NiCd Charger	E
E8811-2	Chronoscope (3 bds)	P
E8811-3	Digital Transistor Tester	G
E8812-1	Doppler Speed Gun (2 bds)	K
E8812-2	Small Fry Mini Amp	D
E8812-3	Thermostat	E
E8812-4	Burglar Buster free PCB	D
E8812-5	Burglar Buster power/relay board	E
E8812-6	Burglar Buster alarm board	C
E8812-7	Burglar Buster bleeper board	C
E8901-1	EPROM Programmer mother board	M
E8901-2	Variat-Ion updates main board	H
E8901-3	Variat-Ion emitter board	E
E8901-4	In-car power supply	C
E8901-5	Granny's hearing booster	E

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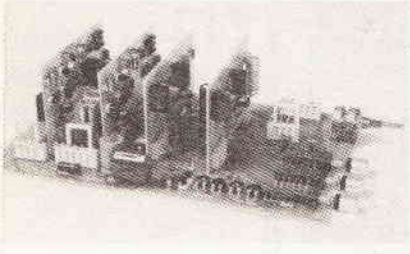

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DC VOLTAGE	RESOLUTION	ACCURACY
200mV	100μV	
2V	1mV	
20V	10mV	±(0.25% of reading + 1 digit)
200V	100mV	
1000V	1V	

Input Impedance 10M on all ranges. Overload Protection 1000V dc or peak on all ranges

DC CURRENT	RESOLUTION	MAX FS ACCURACY	VOLTAGE DROP
200μA	100nA	±(0.5 % rdg + 1d)	0.25V
2mA	1μA	±(0.5 % rdg + 1d)	0.25V
20mA	10μA	±(0.5 % rdg + 1d)	0.25V
200mA	100μA	±(0.75% rdg + 1d)	0.25V
2000mA	1mA	±(2 % rdg + 5d)	0.75V
10A	10mA	±(2 % rdg + 5d)	0.30V

Overload Protection mA Input 2A/250V fuse 10A Input Unfused up to 15A for 15 seconds

AC CURRENT	RESOLUTION	ACCURACY	FREQ RANGE
200mV	100μV		
2V	1mV		
20V	10mV	±(0.5% rdg + 5d)	45Hz-500Hz
200V	100mV	on all ranges	on all ranges
750V	1V	±(1% rdg + 5d)	

Conversion Calibrated for rms of sine wave. Input Impedance 10M shunted by 100pF on all ranges except 200mV range. Overload Protection 1000V dc or 750 rms ac continuous except 15 sec max above 300V on 200M range

AC CURRENT	RESOLUTION	MAX FS ACCURACY	VOLTAGE DROP
200μA	100nA	±(0.75% rdg + 5d)	0.25V rms
2mA	1μA	±(0.75% rdg + 5d)	0.25V rms
20mA	10μA	±(0.75% rdg + 5d)	0.25V rms
200mA	100μA	±(0.75% rdg + 5d)	0.25V rms
2000mA	1mA	±(2 % rdg + 5d)	0.75V rms
10A	10mA	±(2 % rdg + 5d)	0.30V rms

Overload Protection mA Input 2A/250V fuse 10A Input: Unfused up to 15A for 15 seconds

RESISTANCE	RESOLUTION	ACCURACY	MAX OPEN CIRCUIT V
200Ω	100mΩ	±(0.5 % rdg + 3d)	2.8V
2KΩ	1Ω	±(0.3 % rdg + 1d)	2.8V
20Ω	10Ω	±(0.3 % rdg + 1d)	500mV
200KΩ	100Ω	±(0.3 % rdg + 3d)	500mV
2MΩ	1KΩ	±(0.75% rdg + 5d)	500mV
20MΩ	10KΩ	±(3 % rdg + 5d)	500mV

Max allowable input 500V dc or rms

CONTINUITY TEST
Resistance range. Buzzer sounds at approximately less than 200Ω

DIODE TEST
Test voltage: 2.8 Volts. Maximum test current: 3mA

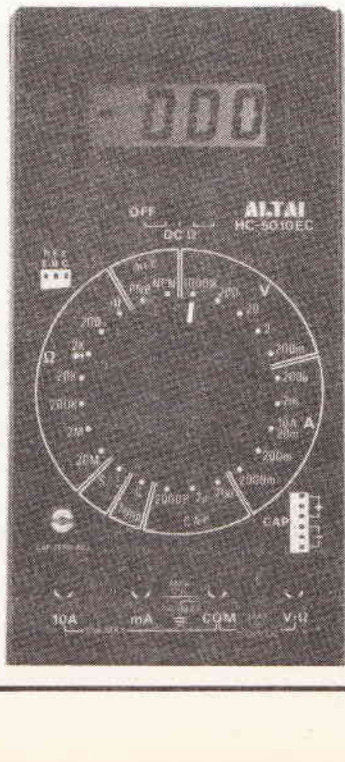
TEMPERATURE	RESOLUTION	ACCURACY
–20°C to 1370°C	1°C	±(3° + 1d) up to 150°C ±3% of rdg over 150°C

Sensor Type K (NiCr – NiAl)

CONDUCTANCE	RESOLUTION	ACCURACY
200nS	0.1nS	±(1.5% rdg + 10d)

CAPACITANCE	RESOLUTION	ACCURACY
2000pF	1pF	±(1.5% FS + 5d)
2μF	0.001μF	±(2 % FS + 5d)
20μF	0.01μF	±(2 % FS + 5d)

hFE TEST. Test condition: 10μA 2.8V. hFE gain 0-1000(npn pnp)



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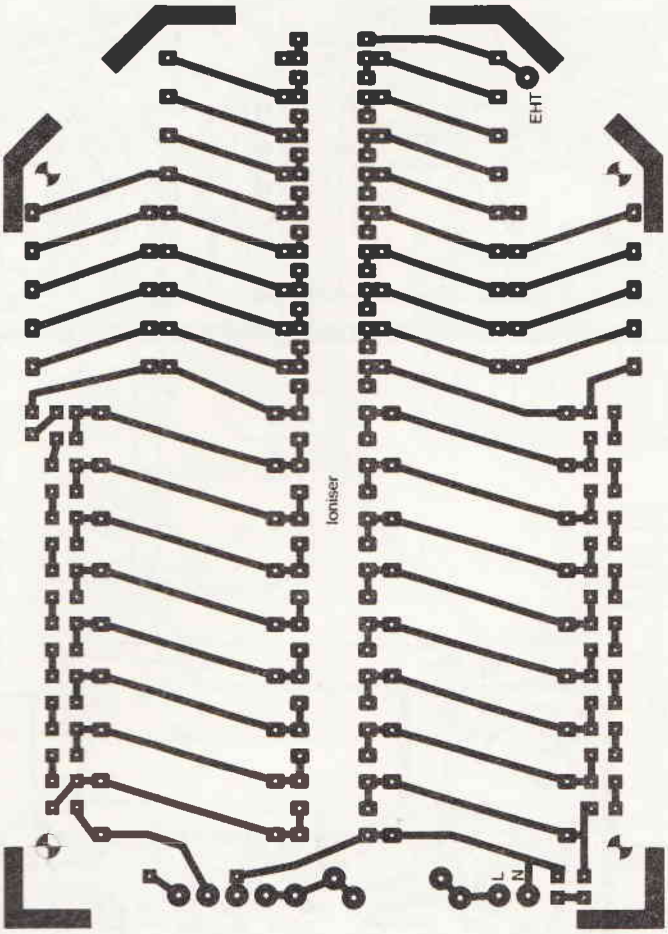
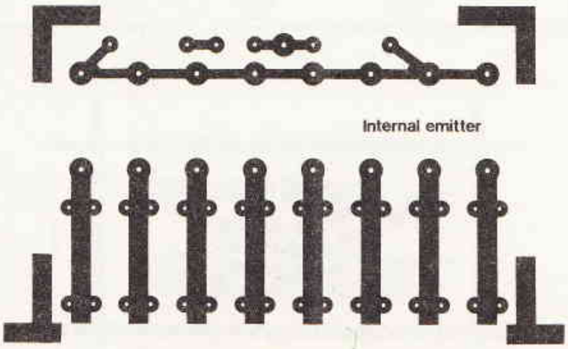
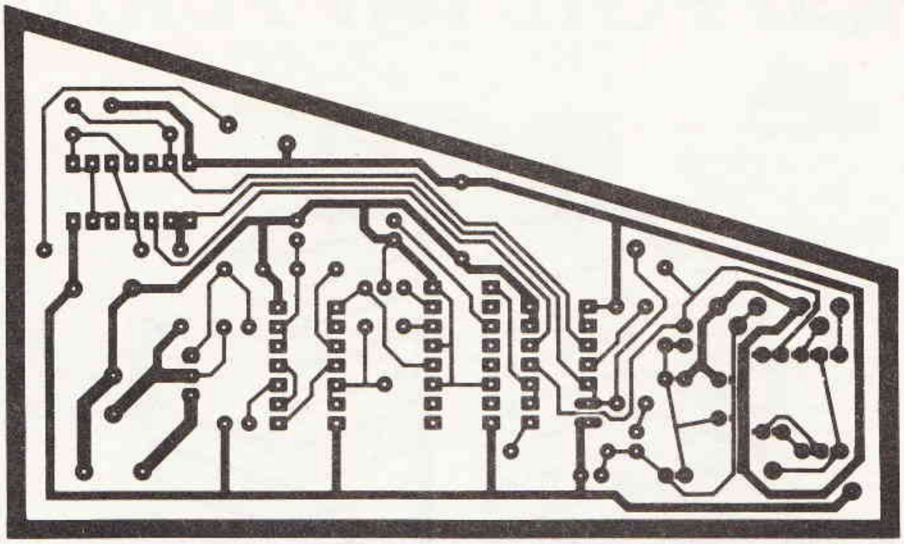


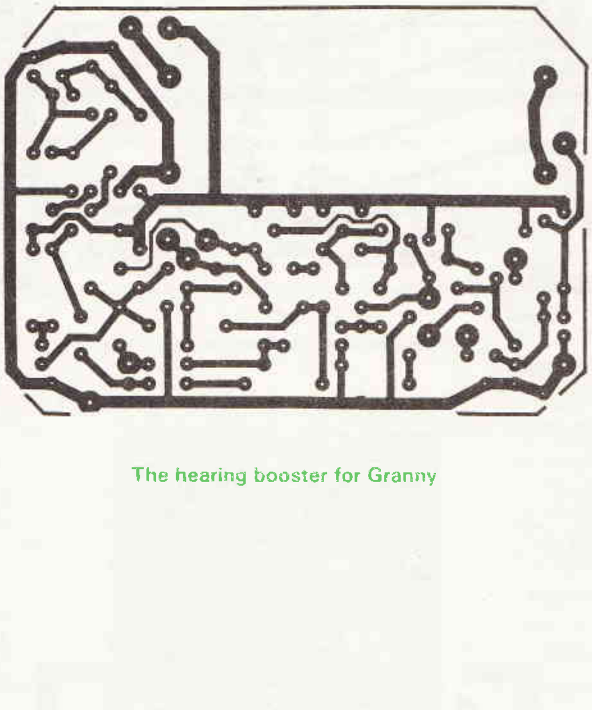
The updated Variat-Ion Ioniser main board



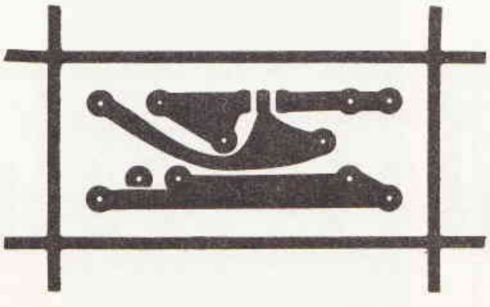
The updated Variat-Ion Ionsier emitter board



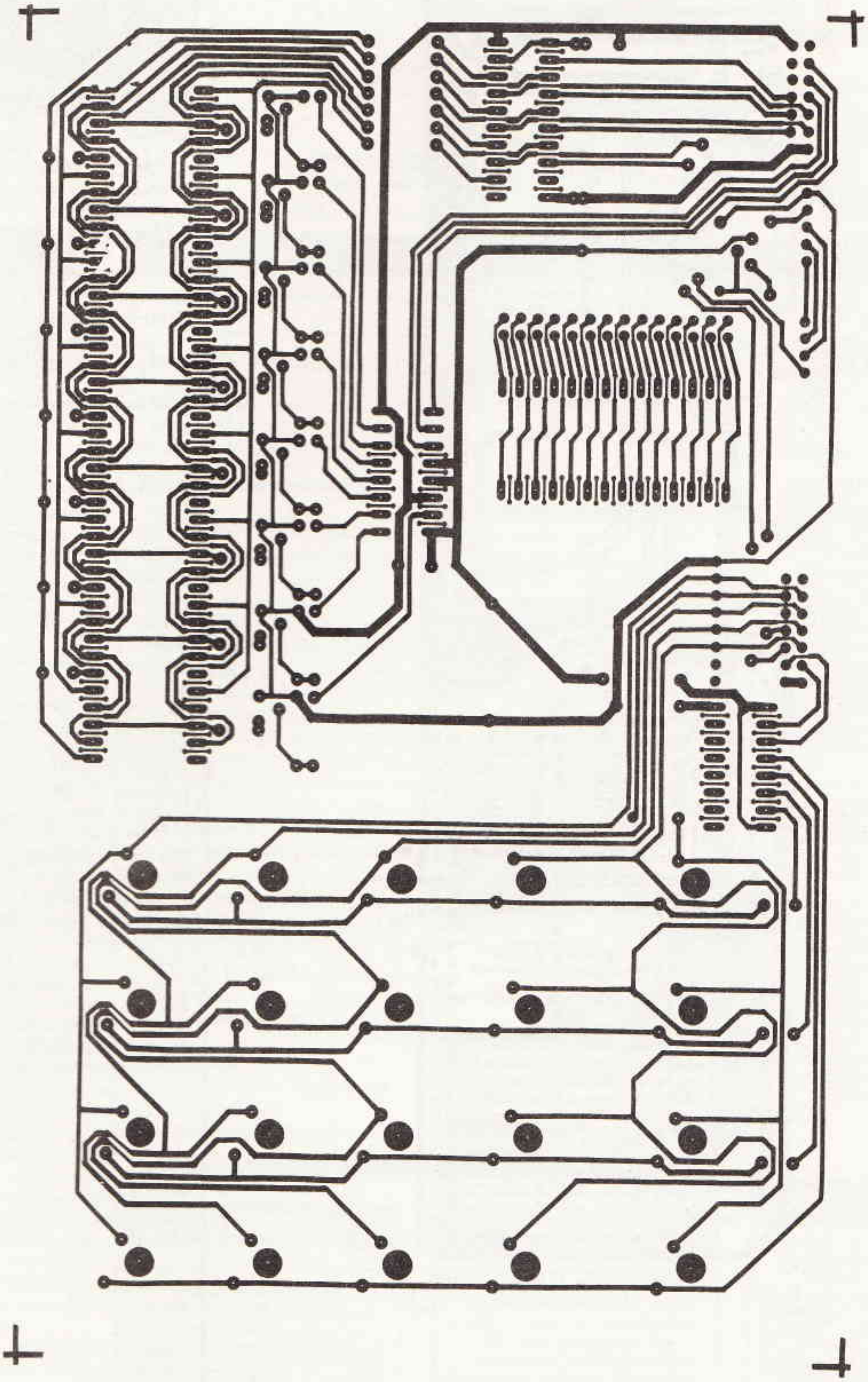
The Rev-rider foil pattern



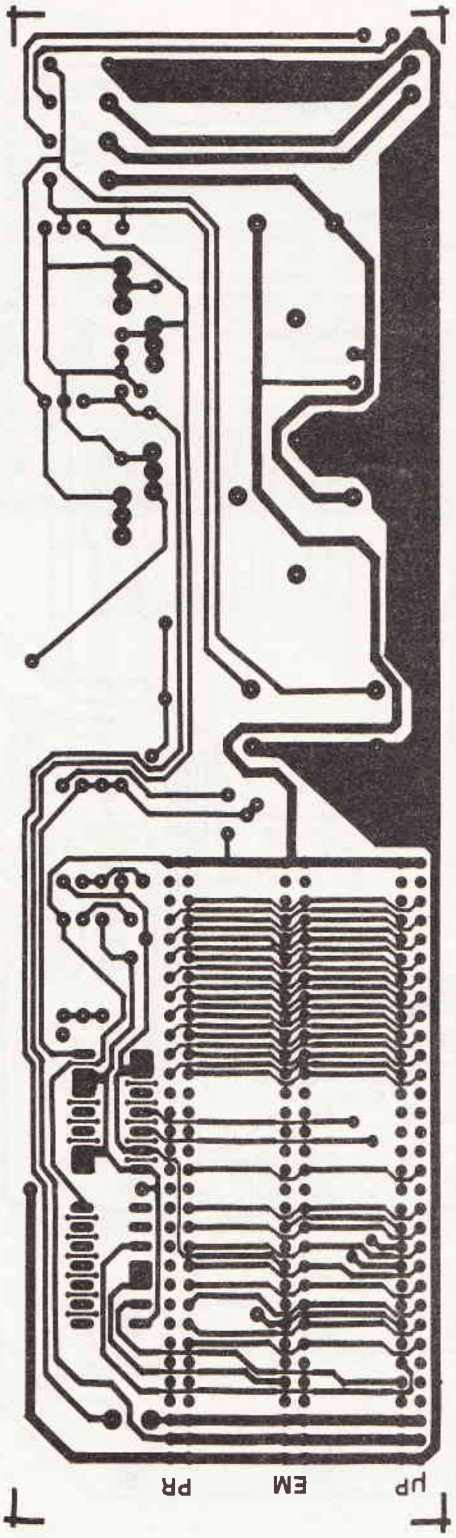
The hearing booster for Granny



The In-Car power supply board



The EPROM Programmer key/display board



The EPROM Programmer mother board foil

OOPS!

Heating Management System (December 1987)
A 4116 is not a suitable alternative to the 6116 specified. A 4016 RAM chip will suffice. In Fig. 1 the junction of R1/D5 should connect to D1-4/C1 and not cross. The zener diodes above the temperature sensor ICs (IC16-19) should be deleted. C4 should be 220n and not 220μ. C7-10 should be 10μ. Q2-7 should be 2N3904 and not BC3904.

RGB Auto-Dissolve (January 1988)
In Fig. 5 there are marked two D6's. The right hand one should be D5 (they are both 1N4148's anyway). In the text the reference to zener diode D5 should read ZD1.

Power Conditioner (January 1988)
There is confusion between the values of R7 and R8 in the Parts List and Fig. 1. These should be: R7-27k, R8-10k and not as given in the Parts List. In addition, ZD1 is incorrectly orientated in Fig. 3. The positive terminal should be at the southern end.

Passive Infra-Red Alarm (January 1988)
Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

Transistor Tester (February 1988)
The foil pattern for the main board was printed reversed left-right on the foil pages. R14 is incorrectly given in Fig.1 as 330k. It should be 330R as in the Parts List.

Spectrum Co-processor (March 1988)
Mogul Electronics, given in the Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Dynamic Noise Reduction (May 1988)
The LM1894 is no longer available from the sources listed but it can be obtained from the author. Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

QL Output Port (Tech Tips May 1988)
Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pins 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.

QWL Loudspeakers (August 1988)
Some dimensions were missing from Fig. 7. The bass driver port centre should be 3¾in above the base of the baffle panel. The notches in the side of the tweeter cut-out are ½in wide. The top plate is missing from the cutout diagram (Fig. 6). This is 7 × 4⅝in.

EEG Monitor (September 1987)
The wiring for the switch SW1 in Fig. 5 shows all the wires for selecting Alpha and Beta waves swapped. A_1 should read B_1, A_2 should read B_2 and so on. The easiest remedy is to swap the front panel labelling shown in Fig. 6 so that the switch labelling reads Theta, Beta, Alpha.

Chronoscope (November 1988)
In the overlay diagram for the counter PCB (Fig. 3) the polarity of C12 is shown the wrong way around. SW1a-d is shown as SW1-4. In Fig. 4 the cathodes of LED 8 and 9 are the righthand and lefthand pads respectively. The cathodes for LED 6,7 are marked as the wrong pin. In the text section on Battery Operation, Q1 should read T1. In Fig. 5 SW2 is incorrectly labelled SW5.

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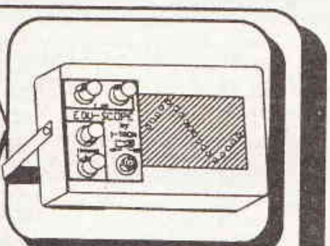

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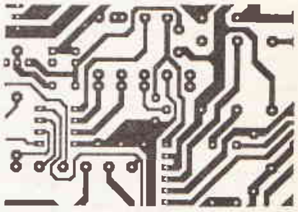

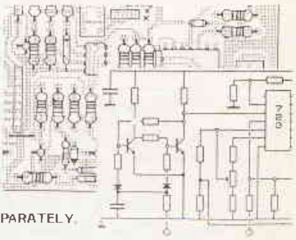

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BLUEPRINT

This column is a service to readers to provide electronic designs to order. Many a project never gets further than the drawing board because of difficulties with one small part. If you are stuck for a circuit or a technique, let the ETI expert help you out. Send your requirements, with as much detail as possible, to ETI Blueprint, 1 Golden Square, W1R 3AB.

This month's querant, N. Allen of Leamington Spa, wants to make a high speed NiCd charger with automatic shutoff. The interesting point about this is that he wants to detect the end of charge by measuring the battery voltage rather than by timing it. The apparent purpose of this is to fast charge batteries used to race radio controlled model cars. In this situation the batteries may not be completely discharged before charging commences so a timed fast charge would have to be set to put in a lot less than a full charge to avoid the risk of the batteries making a loud noise!

However, it is important to charge the batteries as much as is safe, to prevent them from giving out partway through a race. Consequently some means of detecting end of charge is required.

Constant Current

The useful characteristic of NiCd batteries for this purpose is that the voltage falls slightly when the maximum permissible fast charge point has been reached. The voltage follows the law shown in Fig. 1 (supplied by Mr Allen). The peak voltage of the batteries in use is between 9.3V and 10.5V and the source of charge current is a car battery whose voltage may be between 11.5V and 14V.

Mr Allen says the charger provides a constant current by passing the charge current through a power transistor which is switched on and off at 50Hz by a 555 astable circuit. The mark/space ratio is adjusted to control the current. The purpose of this method is to minimise heat dissipation.

With a peak NiCd battery voltage of approximately 10V and a nominal car battery voltage of 12V, there would appear to be limited heat dissipation in a constant current charger. If, for example, the charging current is 4A, then the dissipation would be 8W typically, 18.8W worst case. Even 18.8W is within the capabilities of a 2N2955 (I am assuming a re-entrant regulator configuration) mounted on a 2.2°C/W heatsink in free air.

Dissipation

However, the method described has a worse drawback than of simply being overcomplex for the requirement. It won't save on dissipation. Assuming that the on state current of the power transistor is limited by a resistor then the total dissipation will be the same for the same average charging current. After all, if the charge current is 8A for half the time or 4A for the whole time, the energy dissipated (current voltage time) is the same.

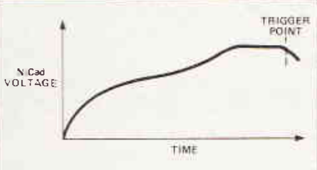


Fig. 1 The characteristic of a charging NiCd

If the dissipation must be reduced then the energy should be stored in an inductor and transferred from inductor to NiCd. This sort of system is one example of a switched mode power supply. Alternatively a linear constant current source could be used. In either case there are design problems associated with providing a high regulated current when the car battery is at 11.5V and the NiCd is at 10.5V.

If a linear constant current source is used, it would be good practice to drop a significant part of the voltage across a resistor. Otherwise, a fault which switched the transistor fully on for only a few milliseconds could destroy it, as many tens of amps would flow.

Omission of any resistor would of course cause hundreds of amps to flow in such a fault, until the fuse flew or the wires melted or the NiCds exploded.

The one fairly sure way to defeat this problem would be to use a flyback converter to increase and invert the car battery voltage. Another less complicated way would be to run the car engine when charging the NiCd.

Endpoint Detection

Now to the actual question asked — how to detect a 20mV fall in battery voltage. From the graph of battery voltage supplied (Fig. 1) I would assume that the 20mV fall in battery voltage occurs over a period of approximately one minute.

The first idea of how to detect the battery voltage change is shown in Fig. 2. This is a differentiator circuit and it gives an output voltage proportional to the rate of change of input voltage. The only time the battery voltage should fall and give a positive output from this circuit is when it has reached its end of charge point.

Interference

Unfortunately this circuit suffers from sensitivity to interference, as illustrated by the end part of the input and output waveforms. It also suffers from a more serious problem in this application. Because the rate of change of battery voltage is very slow (I have assumed 0.33mV/s) a very long time constant is needed. For example, a low leakage capacitor of 2.2μF and a resistor of 1000M would be suitable.

The second idea, shown in Fig. 3, is to use a peak hold circuit followed by a comparator and compare the battery voltage with its peak value to date. The crucial factor here is the rate of drift of the peak hold circuit. For reliable functioning it should not drift at more than half the rate of change of voltage of the battery.

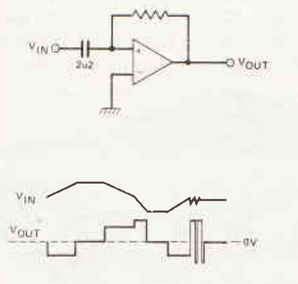


Fig. 2 A differentiator circuit to detect the voltage peak and its sensitivity to interference

Most of the drift on the peak hold will be caused by the bias current of the op-amps. The chosen op-amp, the LF353, has a maximum input bias current of 200pA. Two op-amp inputs are connected to the hold capacitor, so the total maximum bias current is 400pA. The voltage change on a 2.2μF capacitor over one minute with this current is 10.9mV, which would seem just acceptable.

However, the flat part of the charging curve shows a lower rate of change of voltage than the detection area. It is important that the capacitor should not charge by more than approximately 10mV during this period or the switch off may occur earlier than it should. Of course, if the capacitor is discharging during this period, then it will be kept up to the correct voltage by the action of the peak detector circuit but the bias current may flow in either direction.

To take account of this, an optional extra resistor, R2, is added in parallel with D1. This should only be added if tests show that the charging switches off without it. The purpose of the resistor is to balance the effect of the bias current when there is a voltage of 10mV across it, thus ensuring that a maximum error of 10mV exists.

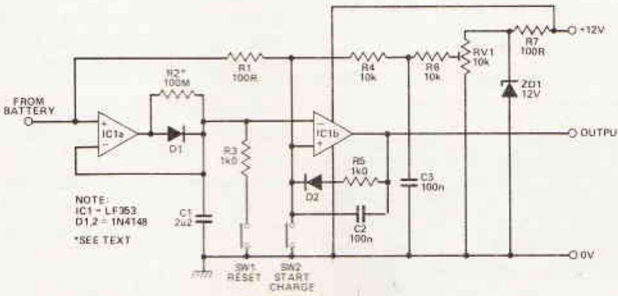


Fig. 3 The circuit diagram of the end-of-charge detector

Finally

Several other points should be noted in passing. First of all, the peak hold circuit will hold the peak voltage for a very long time so it must be manually reset with the reset switch provided each time a new battery is charged. An adjustable offset voltage is provided via RV1 to bias the comparator into the correct state (output low) while the battery voltage is increasing. It will switch high when the voltage starts to decrease.

C2 has been added to the comparator because it has little DC positive feedback at the start of switching and extra AC positive feedback guarantees that once it starts to switch it will complete the process.

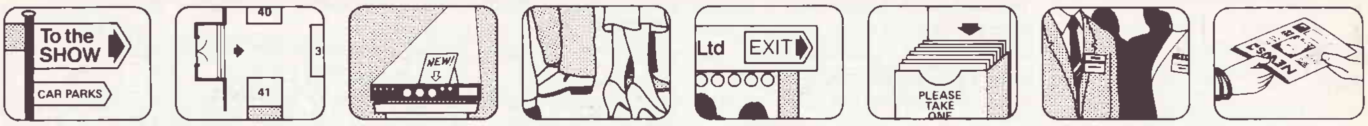
The circuit shown here is based on a genuine constant current charge regime. If a pulsed system is used then the input to this circuit must be preceded by an RC filter which reduces the ripple due to the pulsed charging to less than 5mV.

In the unlikely event that leakage through D1 proves to be a problem, the junction of a 2N3819 junction FET typically has lower leakage than a 1N4148. However, with 20mV across it at the crucial period, the leakage of the 1N4148 is unlikely to be a problem.

I think this wraps it up for the end of charge detection circuit, though perhaps the charger itself would benefit from reconsideration.

Andrew Armstrong

BBC RADIO SHOW REPORT



Good idea, the Radio Show. An enormously wide consumer appeal — *everyone* listens to the radio. Get a lot of easy publicity (on the BBC as well!) so the punters can be charged £5 a ticket and the exhibitors £125 a square metre. Watch the sterling flood in. Well done the BBC, another winner.

Pity then that the hall had to be so small. Pity that there were just 71 listed exhibitors — 28 of whom would have a hard time explaining their connection with radio. Pity that many of the BBC programmes being recorded had a strictly limited audience and were ticketed such that anyone arriving later in the day didn't stand a chance of getting in. All a bit of a letdown really.

The BBC Radio Show ran for nine days at the beginning of October. The whole kaboodle was put together by the ever-inventive BBC Enterprises, taking as its excuse the 21st anniversary of Radios 1,2,3,4 and the local radio network. A giant birthday party, a two million pound extravaganza, a radio listener's paradise.

The pre-publicity was substantial and imaginations were fired throughout the industry. A huge sound-and-light 'Story of Radio' was promised. On a Sunday morning two weeks before the show, I was surprised to encounter a nine foot high chipboard radio on the pavement outside Broadcasting House. 'Radio Show?' I asked a porter struggling with a lifting trolley. 'Radio Show', he confirmed with resignation.

So arriving at Earls Court for the preview day I was disappointed to be led away from the large ground floor exhibition hall (taken up by the National Concrete Convention) to the much smaller upper hall.

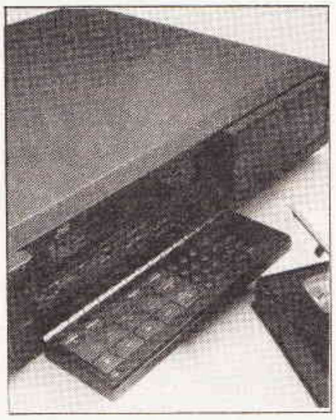
It took all of two hours to see everything and that included 20 minutes being given a demonstration of Grundig's Fine Arts hi-fi system with DAT and RDS tuner (both of which even they admitted were severely limited in use at present).

To be fair to Grundig, some other products are well worth a look, particularly the new car audio range. Apart from a well publicised RDS radio-cassette, most models have the sensible addition of an automatic switch to mono if the signal strength is too low for clear stereo sound.

Also new is the concept of SCV — 'Speed Controlled Volume'. Does your car get louder the faster you go? Do you fret and curse as the engine drowns out your favourite drive-time hit? No, nor do I but obviously the designers at Grundig do, and a jolly innovative feature it is too. One day all in-car audio will be made this way.

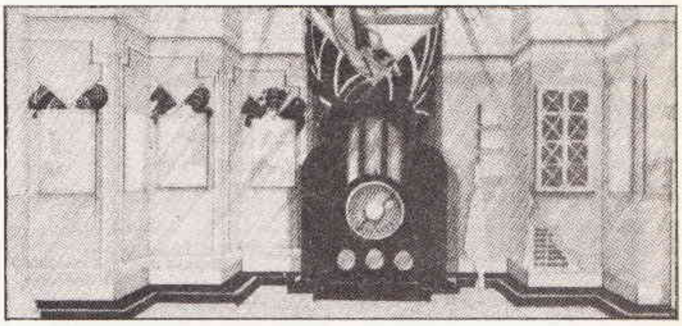
Pioneer built itself an impressive black monolithic palace of a stand — spacious, airy and impeccably staffed. The leading product was the CLD-1200, a combined laser disc, CD and CD-video player.

The CDVs creeping onto the market can handle about six minutes of audio-visual plus about twenty more minutes of normal CD audio. This duration limit on CDV is severely limiting and will almost certainly stop any mass take-off of CDV machines, particularly since Hi-Fi sound on VHS video is now commonplace and quite comparable to CD quality at £10 for 90 mins thank you very much.



Sensibly, the Pioneer machine can take 20cm and 30cm Laser Discs as well. A 30cm disc can give 60 minutes of sound and vision — this might survive if (and only if) mass production can bring the disc prices low enough. Something of a chicken and egg problem but then so was compact disc not so long ago.

One area well covered at the Radio Show was hi-fi loudspeakers. Wharfedale, Goodmans (read Mordaunt-Short and Tannoy), Celestion, BOSE and Acoustic Research all took



stands. Of course a barn like Earls Court is hardly the place to judge sound reproduction but there was much to see and more to read.

Linn premiered its Helix LS150 speaker as well as its award-winning Nexus LS250, a ported two-way design (as is the Helix) with polypropylene baffle. Separate wiring of bass and treble sections is possible.

KEF was also present and correct with its coincident-source C series of speakers (see September *Playback*). These have the Uni-Q Driver with a soft-dome HF unit actually inside the LF driver. Such a system should be able to avoid many problems in predicting response.

JVC had a proud demonstration of S-VHS, the late arrival about to set the home video industry alight. The line resolution is vastly improved and the results are clearly visible. With the VHS symbol behind it, the new standard has an assured future in the UK — unlike the developing Super Beta although this is likely to be even better (when it gets here).

It is reasonably safe to assume the exhibition organisers had little communication with programme makers when allocating the stands. The main Radio Show stage was surrounded by hi-fi and loudspeaker companies — the resulting ambient noise for the stage was appalling. During actual broadcasts demonstrations were halted but rehearsals were badly handicapped.

All the broadcasts were great fun, as broadcasts generally are. The live concert by T'Pau on Thursday night was accompanied by brilliant visual mixing on the 49-screen displays at either side of the stage. Sound was well mixed at both orchestral and rock events.

But the shows were too few and far between to represent value for money, particularly when you remember that you can go to all these events free simply by writing to the BBC Ticket Unit or calling in at the Paris Studios.

And the Story of Radio sound-and-light exhibit? Eleven rooms with loop tapes of a few minutes in length, almost loud enough for you to hear properly if there are other people in the room and certainly loud enough to spill into the other rooms.

The first few rooms represented a decade each, starting in 1930 (the emotional part of the war), through the 40s (the happy part of the war) and the 50s (most of the chipboard radios were here) to the 1960s (although this room was ambiguous in being Radio 1's Roadshow room as well). The entire local radio network was dismissed in a single corridor, followed by the room for Radio 2 — apparently presented as a network purely for drivers.

Radio 3 came out with the most tasteful display which consisted of a flag-decked piano and pseudo promenade concert stage. Radio 4 chose Desert Island Discs as its sole representative (did you know that Morgot Fonteyn's island luxury was a skin diver's mask?). That's about it for the Story of Radio.

Oh — apart from the final room entitled 'Whatever Next?' In here was the grand public launch of the Radio Data System. Most people didn't seem very interested. The whole room was centred on a glass cabinet housed in the tip of an inverted pyramid hanging from the ceiling. In the cabinet was an impressive sparking plasma globe . . . which had unfortunately packed up by the fifth day leaving an almost-as-impressive empty case.

A few other exhibits relieved the monotony — regular news broadcasts from the BBC newsroom, PPLs competition to win a radio hat, Ensoniq's keyboard stand, Schweppes giving free orange away throughout the show. The best thing of all was the exhibition guide, which included a well-written and lavishly illustrated feature on the history of radio.

The stand that best captured the mood of the whole event, the stand that probably shifted the most merchandise, the stand that took prime position right by the Story of Radio exit — was the BBC Enterprises Shop.

Such was the BBC Enterprises Show. There was talk of making this an annual event. That remains to be decided. I don't think I'll be too much bothered either way.

Jez Ford

OPEN CHANNEL

The recent successful launch and landing of the US Space Shuttle starts my monthly wanderings. Regular and long-term readers will remember (hands up who doesn't) my last comment on space launches, regarding the problems which could mount up in world communications systems if the shuttle (and in fact the European launch rocket Ariane as well) were to be grounded for any great length of time.

Both vehicles are used to take communications satellites up to the geostationary orbit height. At the time neither of the systems were operational and so no European or North American satellites were getting off the ground, except carried piggy-back by rockets of a deeply hued red colour. Ariane's problems were surmounted a little while back and now the shuttle is all systems go again, so it seems we're back in action. A fact we should all be most pleased about.

One of Ariane's launches which is most interesting to us is the one which was scheduled for November 8. Ariane Flight 27 took up perhaps the most famous satellite of all time — Astra. By the time this issue of ETI hits the streets, Astra will be transmitting live and will be operating to a full service by February. Astra is, of course, the first European satellite launched specifically for the purpose of transmitting broadcast television signals for public reception — known as direct-to-home reception. Direct-to-home reception requires that medium-to-high-powered satellites (with a power of 45-100W per transponder) be used, simply to allow small dish aerials of around 60 centimetres or so to pick up the signals back on earth. Astra's 16 operational transponders are each of 45 watts.

Meanwhile, a satellite provider which already has a number of satellites in orbit transmitting television signals (specifically, low-powered — only 20W — non-public and requiring large dish aerials of around a metre or so in diameter), Eutelsat, seems to have realised the need for direct-to-home reception, and is forging ahead with plans to launch a number (at least four, maybe more) of medium-powered satellites of 50W transponder power. The race hots up.

CT2

The second generation of cordless telephones, called CT2, can be used as much more than the mere cordless telephones which many of us use and love in our homes. Some readers may have heard of the Telepoint wide-area system, whereby users with a CT2 phone are able to make telephone calls from anywhere within the country, provided they are within sight of a Telepoint base station terminal.

The Telepoint base stations are to be quickly brought into operation in most city centres and areas of public gatherings, such as shopping arcades, public transport stations and so on. Ferranti's Zonephone forms the basis of the Telepoint standard which looks as though it is about to be adopted as the European standard this year (1989, that is).

The reason behind this strong British influence on a pan-European standard is that all the UK manufacturers have got their act together regarding CT2 equipment, with the result that a common air interface standard has been agreed. This means that equipment from all UK manufacturers is compatible, being able to make calls to a single standard range of base stations.

Telepoint could be an important new communications medium, if pricing strategies are carefully worked out. For instance, if the phones are around the £150 range depending on facilities, they provide a very cheap mobile communications method. Far cheaper than a cellular radio telephone.

Devotees of cellular telephones would, no doubt, point out two disadvantages. First, a CT2 phone cannot receive a telephone call. That is true, but to many people that is no *real* disadvantage. Besides, the situation can be sidestepped marginally, by the user carrying a pager, too. Once a message has been received via the pager (say, a telephone number to call) the user contacts whoever is paging him.

Word has it that some species of CT2 phones will feature an in-built pager, for this very purpose.

The second CT2 disadvantage is that the phone cannot make a call unless in the vicinity of a base station. Nobody can argue against that but as long as base stations are provided in sufficient quantities throughout the country and are always in similar spots (say, always in the High Street of each city or always in Motorway service areas) users can rely on being able to make a call when they get to such a specified place.

However, if the price of a CT2 phone is twice this then the situation changes as users see the benefits of cellular telephones. More than twice, and potential users will think again.

Currently, the Department of Trade and Industry is considering applications from a number of potential Telepoint service providers. Up to four operators are to be licensed to manufacture base stations for use on the system. I hope to report on the outcome of the DTI's consideration next month.

Keith Brindley

PLAYBACK

Specmanship has ceased to be an important arbiter of sound quality as far as the specialist audio market is concerned.

It is quite common for our home-grown amplifiers, for example, to suffer relatively high levels (0.1-0.5%) total harmonic and intermodulation distortion while the Far Eastern competition still seems hell-bent on pursuing THD down to infinitesimal levels.

Furthermore these specialist amplifiers are generally thought to *sound* better than much of the mass market competition, despite their being inferior in the technical arena.

Xenophobia

Now, this is simply an observation based on experience — it is not intended as an exercise in xenophobia. However, it does begin to hint that the Far Eastern manufacturers are caught between two stools as other markets, such as Continental Europe, seem to place greater store in the traditional *measured* performance of such products.

All this may seem to add further evidence to the suggestion that objective/subjective correlation is something of a misnomer. In fact quite the reverse is true but it requires the acceptance that distortion *per se* is not necessarily a bad thing.

Designers in this country (who may be building for a very restricted marketplace) generally accept that it is nigh-on impossible to construct a perfectly linear amplifier for £200 or £300. As such many of them succeed in *manipulating* those distortion mechanisms that are present to their advantage. The attitude is: if you can't beat it then use it!

Enhancement

Most of us are familiar with the sonorous presentation of many valve amplifiers despite the fact that they should sound like a bag of nails — THD often approaching 5% or 10% at the frequency extremes. The fact that certain forms of distortion are subjectively more acceptable than others is nothing new but the concept of deliberately introducing such aberrations so as to *enhance* the perceived sound quality is altogether more recent.

Naturally, those designers who have a feel for such electronic trickery are not exactly shouting about their methods but distinct trends do seem to be emerging. I was fortunate enough to be able to gauge public opinion on this matter at the recent Penta Hi-fi Show where three nominally identical power amplifiers were put up for audition.

Each amplifier was subject to subtle, detail modifications that altered the distortion complement rather than the distortion level to any great degree. In fact THD and IMD were kept below 1% across the 20Hz-20kHz bandwidth, amplifier 1 having the least distortion while amp 3 incurred the most.

Noise, power output, channel separation and output inpedance were identical across the trio of amplifiers.

Around 150 people took part over two days and the results were wholly consistent — amplifier 2 coming out on top. Interestingly this amplifier did not enjoy the lowest distortion of the trio but the mechanisms were contrived to produce entirely even-order harmonic and IM residues. A broad carpet of harmonic (2nd to 10th) and IMD summation products (2nd to 8th order) persisted, lending the amplifier a smooth and relaxing sound even though it was clearly less *accurate* than amplifier 1.

Amplifier 3 was universally rejected, its harmonic and IM compliment being entirely odd-order. Interestingly, amp 1 produced a low and consistent level of 2nd and 3rd harmonic distortions with principally 2nd order sum and difference IMD — the kind of result usually obtained with the reliable and competent mass market amps that abound in great quantity.

Other alterations were made to the regulation and capacity of the power supply feeding amplifier 1, resulting in a linear relationship between the input/output signal and any harmonic/IM artifacts identified in a Ramped Supply Modulation test (a 40Hz driving signal is used, raising the amp from −96dB to full output while observing the relative level of 40Hz harmonics and 50Hz or 100Hz supply modulation components).

Amplifier 2 and 3 demonstrated a non-linear relationship between signal level and IMD when subject to this test and though the artifacts were typically less than −90dB there was a clear loss in subjective detail resolution at low frequencies.

Anomalies

In the event, this proved fascinating for it showed that anomalies at extremely low levels could still influence sound quality, anomalies that are laid bare in the traditional low distortion amps but are masked by the preferable colourations imposed by many specialist designs.

Nevertheless, I feel it will be some time yet before the mass market brigade adopts the principle of contrived distortion.

Paul Miller

BOOK LOOK

Benchmark Books is a new company on the electronics scene and this month's *Book Look* review deals with the company's first two offerings.

Key Techniques For Circuit Design. Designing DC Power Supplies. Both by G. C. Loveday. £6.95 each from Benchmark Book Company, 59 Waylands, Swanley, Kent BR8 8TN.

The author of these works, G. C. Loveday, is in fact one half of Benchmark Books. There are already four books promised for this initial series entitled 'The successful design of electronic hardware' and these first two provide a tempting taste of what is to come.

The two works are both a touch short and a little amateurish in presentation, reflecting the new (and no doubt impoverished) state of the publishers. However, although all the diagrams and (by the look of it) the text are hot off a computer printer, the end result is quite good enough to make reading easy.

These are almost text books. Indeed, they are aimed at BTEC National and Higher National students but they are also essentially non-mathematical (or as non as you can be) and firmly in the practical, real life camp — suitably for home hobbyists as much as schoolroom pupils.

Number One

Key Techniques is a generalised primer for anyone contemplating moving up from the jigsaw assembly of magazine electronics projects to actually creating their own electronic designs.

It follows a near classic formula with five chapters on 'The Design Problem', 'Using Passive Components', 'Using Active Devices', 'Equivalent Circuits' and 'Design Examples'. There is also a handful of questions at the end of each chapter with (grovelling thanks from a thousand teachers) answers at the back.

Everything is explained from basic principles with a methodical stepwise approach which is both clear to understand and easy to emulate when it comes round to designing your own circuits.

This is a basic starter book which will not take you very far down the road to being a fully fledged electronics designer. However, it lays good groundwork which will certainly stand you in good stead.

The style is not too heavy (unlike most text books) but neither is it padded out with useless (if 'friendly') waffle so it does serve both as a course in itself and as a useful back reference for when you get stuck with your own problems.

The book omits the poignant question of conceptual design — how to go from the real life problem to an electronic idea and specification — and concentrates on the move from specification to circuit. However, this is a nearly universal failing of all tutorial books, understandable as it must be the most difficult skill to teach and is usually put down to native talent.

Ideally I should like to see this series greatly expanded with further books following on where this one leaves off. It could just be that Loveday would then have created an electronics course which *genuinely* teaches from beginner to reasonably expert.

However, for the moment *Key Techniques* serves well.

Second Half

Designing DC Power Supplies is a little different in its approach. Here Loveday concentrates on a relatively narrow subject with far more detail.

A wide range of different power supply types are dealt with (with the notable exception of switch mode types — understandable as they provide enough material for several books on their own).

Transformers, rectifiers, regulators, reference supplies and protection circuits are all covered along with sensible design methods and testing procedures.

Although the style is similar to *Key Techniques*, with concise and clear explanations and short problems at the end of each chapter (again, answered at the back), the overall impression is that this book is less of a course book and more of a reference work for looking up a particular type of supply when it is required. Again, there is little on the basic problem analysis side to help you determine which type of power supply is required for any particular project.

Nevertheless, it provides a useful addition to any hobbyist's library at a reasonable price and a good basis on a much underated subject which forms an important part of nearly every design.

With the other two titles already promised for the series *(Designing With Linear ICs* and *Designing Interface Circuits)* and hopefully with yet further titles added in the future, these two works provide an excellent starting point for any enthusiast beginning to produce their own circuits and Benchmark Books promises to be a company to watch.

Martin Tame

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