ETI

ELECTRONICS TODAY INTERNATIONAL

AUDIO • COMPUTING • MUSIC • DOMESTIC

APRIL 1988 £1·40

VIRTUOSO

Super-fi power amp project

CAPACITORS
the inside story

FIRST CLASS
beginners project series starts inside

NEW LOOK!

ETI
ELECTRONICS TODAY INTERNATIONAL

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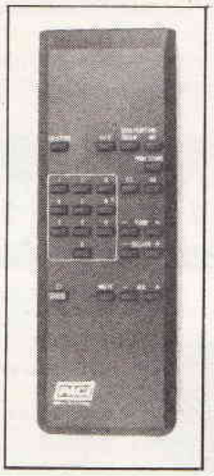

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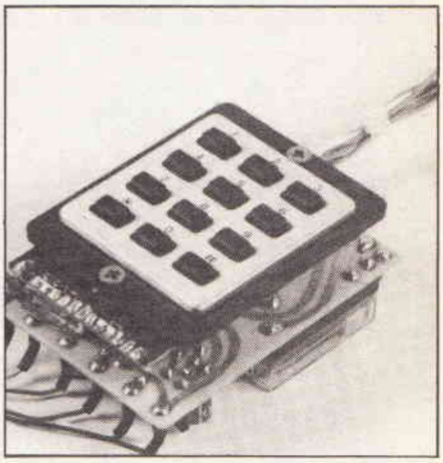
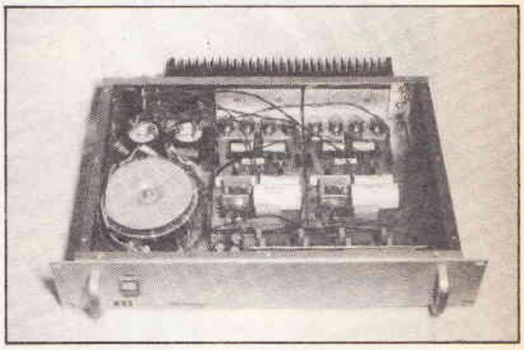
APRIL 1988





NEWS

KEEP YOUR HEAD STRAIGHT

Alignment of VCR heads and spindles can be quickly (but expensively) checked using Tentel TSH spindle gauges available from Crow in Reading.

The gauges, available for VHS or Beta, simulate a cassette and drop into your VCR.

Any spindle-height error is shown by a dial indicator in thousands of an inch. In fast forward or rewind the spindle wobble is indicated.

This is all very useful but rather costly. Both the Beta B3 and the VHS V4 models cost £503 including VAT.

Contact Crow Broadcast Holdings, 10 Arnham Road, Newbury RG14 5RU. Tel: (0635) 523255.

ONLINE INFO

Online Distribution has announced its new catalogue of passive, electromechanical and connector products.

The catalogue has 48 pages with a good smattering of photos and drawings, listing prices and postage costs for components from various manufacturers including Erg, General Hybrid, Harwin and TI.

The catalogue is free from Online Distribution, Melbourne House, Kingsway, Bedford MK42 9AZ. Tel: (0234) 217915.

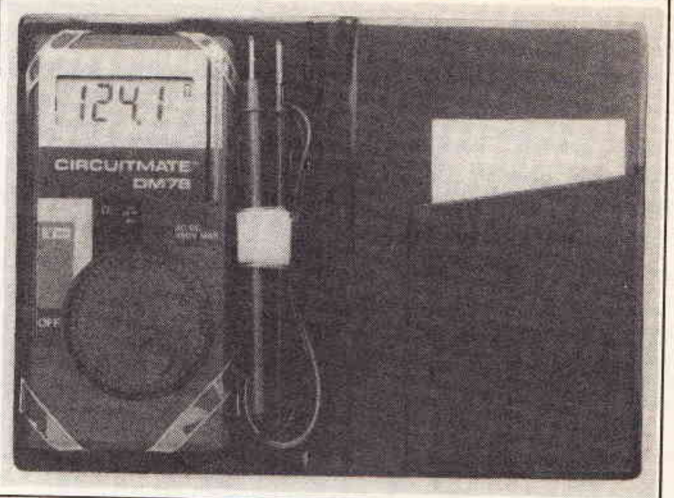
KITS AND PIECES

Dinky design projects and budget component packs are the produce of Imagina-tronics from Surrey.

Among the kits are a matchbox-size 'surveillance' transmitter which broadcasts on FM (but don't tell the Home Office) and a pair of robot wheels with remote control, priced at £4.95 and £16.95 respectively.

For a full list of kits and of the varied and occasionally bizarre budget packs, contact Imagina-tronics, Aberdeen House, The Street, Charlwood, Surrey RH6 0DS.

POCKET THE DIFFERENCE



A digital multimeter that fits in a shirt pocket (they don't say whose) has been produced by Beckman Industrial of Birmingham. The DM78 has a 3½-digit display to cover the ranges for volts (AC and DC) and resistance to 20M, and for diode checks and continuity there is a bleeper. The multimeter auto-ranges to avoid overloading and costs just £24.50 + VAT.

Contact Beckman, 43-48 New Street, Birmingham B2 4LJ. Tel: 01-643 8899.

DIRECTORY ENQUIRIES

The European Consumer Electronics Directory has been published by Euromonitor Publications. The directory is not simply a trade directory and carries no advertising. It covers all EC countries plus Scandinavia.

The directory begins with an overview of European electronics, examining trends of the first half of this decade and giving some fairly generalised predictions for the second half — audio sales to fall, Portugal to go hi-tech and so on. The next 150 pages are the most useful — listing publications, MR companies, trade associations and the main electronics companies of each country.

The last section of the book deals with statistics for each country — mainly dealing with import, export, sales and production of electric consumer durables.

It's a useful tome if you get it free, otherwise the £135 might limit its appeal to PR and MR users. Contact Euromonitor, 87-88 Turnmill Street, London EC1M 5QU. Tel: 01-251 8024.

PC PLOD NABS PC PIRATE

The first ever jail sentence for software piracy has been passed by Exeter Crown Court on Tos International and Gerhard Martens of Torquay.

Tos International (international even in convictions — Martens is also wanted by the West German police) has been selling all the leading spreadsheet and WP packages through computer papers and magazines, with counterfeit manuals obtained from the recently raided Golden Triangle in Hong Kong.

The Devon and Cornwall Constabulary worked in collaboration with FAST (Federation Against Software Theft), the organisation set up by the computer industry to help catch pirates. FAST spent two days identifying the seized software and found that the pirated disks originated from Taiwan. 'It's reassuring that the courts recognised the seriousness of this case,' said Bob Hay, co-ordinator of FAST. 'It will serve as a deterrent to others.' For FAST information contact FAST, 8 Southampton Place, London WC1A 2EF. Tel: 01-430 2408.

WALL TO WALL TO WALL TO WALL

The ultimate in surround sound sensation is promised by Sharp in the form of the Optonica SM-A75.

This 16-bit digital delay and five speaker system will transform your home with recreated acoustic environments, claims Sharp.

The SM-A75 has 14 modes such as hall, live or stage (for music) and stadium or ringside (for sport on TV). More intriguing is the 'Sci-Fi' mode — one of three environments to simulate the cinema.

The power output is 40W into 2 channels or 25W into each of 4 channels. The speaker system has two sets of three 4-in speakers in front, a pair of 4-in speakers behind and a super woofer housing a 10in passive radiator and 6in drive unit.

But before you rush out and convert your living room into an acoustic Wembley or White Hart Lane, consider that for the £879 that Sharp are asking you could spend every Saturday until 1993 on the terraces themselves...

Full details from Sharp UK, Thorp Road, Newton Heath, Manchester M10 9BE. Tel: 061-205 2333.

INFO ON LINE

The British Library has finally got its 'Online Search Centre' project off the ground.

Online Search uses the databases of the British Library to provide references on almost any topic selected by the user. Virtually all scientific fields on a global basis are covered by these data bases, including Japanese information.

The British Library cites £45 as the average search cost but this will depend on search-time and the number of references printed.

Only references are produced — the 'experienced specialised searchers' will advise on how to obtain copies of the actual documents.

The Online Search Centre have produced a price list and database guide available free by telephoning 01-323 7477.

BLOWY ON THE PROM

New from Dataman of Dorchester is the Softy 3 Programmer — a PROM programmer, PROM editor, ROM and RAM emulator and development system all crammed into what looks like a desktop calculator.

As a PROM blower the S3 has a built-in library for EPROMs and EEPROMs (25, 27, 28, 87 series and so on) and can blow say an Intel 27C256 in under 20 seconds.

It is also upgradable for handling future PROMs, loaded via the ROM socket (bottom left in the photo).

The whole thing can be remotely controlled by 2-way RS232 interface, with baud-rates up to 9600.

As a memory emulator the S3 accesses typically in 100ns, providing a direct replacement for EPROMs, EEPROMs and RAMs up to 64K.

Inside the dinky 7in by 4in case the CMOS architecture has 4K of BIOS ROM masked into the microcontroller, with 8K RAM program area and a 64K buffer for user data.

The S3 retails at £495 + VAT. Contact Dataman, Lombard House, Dorchester DT1 1RX. Tel: (0305) 68066.

CUT-PRICE CONIFER COMPACT CLASSES

A new range of compact discs is now in the shops priced at a remarkable £3.99.

The discs are from Conifer Records and feature classical and easy listening material — the sort of collections you might find by the checkout in Tesco.

With the vast majority of CD titles still retailing at £11-odd it seems likely that the Conifer 'Compact Selection' will start a range of budget CDs rather than initiating a price war with the giants.

If budget labels can produce popular collections (such as K-Tel and Pickwick did in the 70s on LP) then CD might free itself from the 'yuppie-product' label so often ascribed to it, boosting consumer demand for players still further.

The Conifer Compact Selection is available from Boots record departments and other chain stores.

FLIP-TOP AVOMETERS

A new range of analogue/digital Avometers is now available from Megger Instruments in Dover.

The new multimeters feature a folding case design with a lid that pivots behind the control section. This enables a much larger display to sit neatly above the controls, and the display can be set at any convenient viewing angle for the user.

The display has 4¾ digits plus an analogue-style scale with 60 divisions and 'zoom' facility.

The cheapest meter in the range is the M2035 (on the left in the picture). It measures amps, ohms and volts with autoranging protection. A diode test and continuity beeper is also included.

At the top end of the range the M2042 provides true RMS values for AC measurement (with or without additional DC) and can zoom up to a factor of 500.

As with all Avometers the prices reflect the quality. The M2035 costs £330 + VAT, the M2042 costs £525 + VAT.

Full details from Megger, Archcliffe Road, Dover CT17 9EN. Tel: (0304) 202620.

SPIES IN AMERICA

An American study claims that many employers 'spy' on their workers by programming VDU terminals to report on employee performances — input speed, sales rates and so forth.

'The Electronic Supervisor' was produced by the Office of Technology Assessment (run by Congress) and concludes that millions of Americans are routinely monitored in this way.

Many American companies openly admit this form of 'private personal assessment' and justify it as 'good business management'.

The report goes on to suggest that as employees rush to improve their efficiency, inferior service may result and stressful illness can occur in the overstretched employees.

One wonders quite how the British trade unions would react to discovering such big brother tactics on their home soil.

As there is nothing in American law that prohibits monitoring in this way the unions over there can only campaign to get the practice outlawed.

Here at home, the TUC would be interested in hearing if the notion crosses the big pond to invade the privacy of the honest British worker.

HELP WANTED

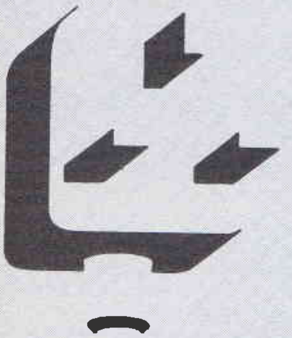
Talking Books for the Handicapped would greatly welcome any volunteers who would be able to service the Library's specially-designed tape machines or to produce homemade induction loops for listeners with hearing aids.

The organisation is based in London but operates nationwide.

If you could help please contact The National Listening Library, 12 Lant Street, London SE1 1QH. Tel: 01-407 9417.

NEWS

POWER TO THE PEOPLE



Privatisation of the electricity industry should be abandoned rather than create a British Telecom/Gas style private monopoly, concludes the Government's own report from the Centre for Policy Studies.

The report (entitled 'Current Choices') examines in detail six methods of privatising electricity and consigns four of these to the waste bin.

The first is the option urged by the CEGB, to privatise the whole industry as a single entity subject to minimal regulation, as with British Gas.

The report rejects this as failing to introduce any form of competition, incompatible with the competitive privatisation of British Coal and as unlikely to draw commercially-orientated management into the industry.

The second option is to keep the supply industry whole but allow competition in the building and running of new power stations.

The report rightly suggests that few investors would relish the prospect of putting £1½billion into a 1800MW station that would take at least seven years to build, only to face competition from the still-existing and massively entrenched CEGB.

Effectively then, this second option is the same as the first.

Next to hit the binliner is the proposal from the Electricity Council. This involves creating two separate monopolies, one for distribution and one for generation.

The distributing monopoly could (if it wished) compete in power generation.

However the report points out that the new CEGB would hold all the expertise and experience of building and operating power stations. The distribution monopoly simply wouldn't bother or would make little headway if it did.

The fourth monopoly option is to split the industry into regional boards. Each board would have a local distribution monopoly and would generate most of its own power, purchasing the remainder competitively. The boards would however favour their own power stations and competition would be minimal.

This option would create several buyers of coal and would enable coal to be privatised.

The report firmly informs the Government that 'it would be a grave mistake to adopt any of these options'.

The alternative is competitive privatisation. The CEGB is broken up into separate generating companies which compete to supply electricity to five Regional Distribution Utilities (RDUs).

This would produce competition at every stage except the final regional distribution, would enable coal privatisation, would bring in new management (ten companies starting up), should need minimal regulation and should enable considerable cost savings.

The main drawback with this option is that it would take years to implement, and the Government will not wait that long.

The report therefore puts forward what appears to be the only choice for a fast privatisation.

Private Transition to Competition (PTC) creates the same RDUs for distribution but keeps the CEGB as a monopoly wholly owned by those RDUs.

This new CEGB is debt-financed and so cannot make a profit giving the RDUs an incentive to get competitive generation moving as fast as possible, eventually leading to complete competitive privatisation over a longer period.

This is a radical reorganisation and will worry a good many people, not least the unions involved. The TUC is firmly against any form of privatisation at all.

For the consumer, prices would be expected to drop but since each RDU would be a regional monopoly the consumer might suffer corner-cutting and artificially high prices without recourse to any regulatory body.

Nuclear power presents problems that are totally irreconcilable with privatisation, even the CPS report admits that.

And would the Electricity Council cease to exist or become an advertising agency for the combined industry?

The industry and its dependants nervously await the Prime Minister's decision.

'Current Choices — Good and Bad Ways to Privatise Electricity' is available for £4.90 from CPS, 8 Wilfred Street, London SW1E 6PL.

DIARY

Components In Electronics 88 — March 8-10th
Islington Business Centre, London. Conference and exhibition. Contact Nutwood Exhibitions on (0705) 264333

Senior Management Seminar On Surface Mount — March 16th
The Royal Automobile Club, London. Seminar by Coopers and Lybrand for DTI. Contact Katy Parkinson on 01-831 2858

The Status Of Nuclear Fusion Research — March 17th
IEE, London. Lectures by Dr D C Robinson. Contact IEE on 01-240 1871

Video, Audio And Data Recording — March 21-24th
University of York. Contact Institute of Electronic and Radio Engineers on 01-240 1871

CADCAM 88 — March 22-24th
NEC, Birmingham. Contact EMAP International Exhibitions on 01-404 4844

Electro-Optics & Laser UK — March 22-24th
NEC, Birmingham. Exhibition running alongside the Optics-Ecoosa '88 conference at the Birmingham Metropole Hotel. Contact Cahners Exhibitions on 01-891 5051

Internepcon Production Show — March 22-24th
NEC, Birmingham. Contact Cahners Exhibitions on 01-981 5051

Into 88 — March 22-24th
NEC, Birmingham. Products, advice and services for industrial training. Contact EMAP International Exhibitions on 01-404 4844

Offshore Computer Show — March 22-24th
Aberdeen Exhibition and Conference Centre. Contact Offshore Conferences and Exhibitions on 01-549 5831

Computer Recruitment Fair — March 25-26th
Rainbow Rooms, London. Contact Intro Ltd on (0491) 681010

Computing In The Next Generation — March 25-27th
Annual conference of the British Computer Society's Young Professionals Group. Contact Julia Allen on 01-637 0471 for the venue

Computers In Retail & Retail Technology Exhibition — March 29-31st
Metropole Exhibition Centre, Brighton. Contact Focus Events on 01-832 1717

HF Radio Systems And Techniques — April 11-13th
The IEE, London. Conference organised by the IEE and The Institute of Mathematics and its Applications. Contact IEE on 01-240 1871

Safe Nuclear Power — April 12th
Scarborough Lecture Theatre, University of Durham. Lecture by C Smitton. Contact IEEIE on 01-836 3357

Scottish Computer Show — April 12-14th
Scottish Exhibition Centre, Glasgow. Contact Cahners Exhibitions on 01-891 5051

Computer Recruitment Fair — April 15-16th
New Century Hall, Manchester. Contact Intro Ltd on (0491) 681010

Computer Recruitment Fair — April 22-23rd
Watershed, Bristol. Contact Intro Ltd on (0491) 681010

Softeach 88 — 23-24th April
Heathrow Penta Hotel, London. Contact Softsel Computer Products on 01-568 8866

ATE 1988 (Automatic Testing & Test Instrumentation) — April 26-28th
Metropole Exhibition Centre, Brighton. Contact Network Events on (0280) 815 226

British Electronics Week — April 26-28th
Olympia, London. Contact Anne Jackson on (0799) 26699

Miltest 1988 (Military Testing Equipment) — April 26-28th
Olympia, London. Contact Network Events on (0280) 815 226

Second Power Sources And Supplies Conference — April 26-28th
Olympia, London (at British Electronics Week). Contact Anne Jackson on (0799) 26699

Electronics And The Stock Exchange — April 28th
IEE, London. Lecture by D C Marlborough. Contact IEE on 01-240 1871

Electronics And The Space Program — May 4th
IEE, London. Lecture by J Egan. Contact IEE on 01-240 1871

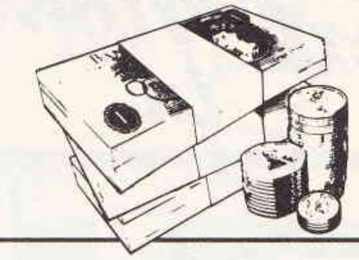
TITLE 88 (Technology In Tourism & Leisure Exhibition) — May 17-19th
Business Design Centre, London. Contact PLF Communications on (0733) 60535

Computer North — May 24-26th
G-Mex Exhibition Centre, Manchester. Contact Cahners Exhibitions on 01-891 5051

Engineering Products And Technology North — May 25-26th
Exhibition and Conference Centre, Doncaster. Contact Trinity exhibitions on (0895) 58431

Information Technology And Office Systems Exhibition — June 7-10th
Barbican Exhibition Centre, London. Contact BED Exhibitions on (09328 65525

FAME & FORTUNE



That's what an incredibly small number of people have achieved by contributing articles to ETI. The rest of us have had to make do with total obscurity and enough money for a couple of pints. Nevertheless it's all worthwhile and we need your contributions now!

FEATURES

If you know what you're talking about and it hasn't all been said before, we want you to add to our wide ranging and informative features. If you have a great idea for a feature or two, send in a brief resumé. If you don't have the ideas but you think you have a commanding knowledge of a suitable subject area we want to hear from you too.

PROJECTS

ETI has built its reputation on novel, worthwhile projects well designed and accurately presented. If you have recently designed and built a world-beater we want to hear from you. In the first instance send us a brief description of your masterpiece along with a circuit diagram.

Whatever you can contribute to ETI, take the plunge now. We can offer a modicum of fame and a very reasonable fortune.

Write in to:
The Editor
ETI
1 Golden Square
London W1R 3AB

Next Month in ETI

ELECTRONICS TODAY INTERNATIONAL

Next month's ETI features even more ingenious projects and instructive features. The comprehensive news section keeps you up to date with the best new products as well as with the movements of the world and its stomach. As Napoleon said – "Not tonight Josephine, I'm trying to get this co-processor going".

It was in the early 1930s that ETI exploded onto the newstands of depression-ravaged Britain, although it only sold its first copy in 1972. That copy was bought by a Mr. Sinclair of Cambridge and he's never looked back. "I laughed so much I crashed my C5 into the Hoover factory" he said, though no one bothered taking much notice.

Other world leaders say:

"I cried until I got an Oscar" – Sally Fields.

"I'm glasnost 'vailable in Russia" – Gorbachov & Vladivar.

ETI is read in 44 different countries, and all by Mr. G. Smith of Croydon. "Next month I hope to read it in Malawi" he said in an exclusive satellite linkup with *Watch with Mother* "but I'm having trouble getting a copy."

Lucky readers who do find a copy will discover the May issue packed with a fully computerised bicycle speedo, the ETI universal panel meter, a lucid dream machine, the next part of the Virtuoso Power Amp, the final part of the Spectrum Co-processor, more on capacitors and much, much more besides.

Make 9th April your May Day with ETI

The articles listed are planned for the next issue but may not appear due to circumstances beyond even our control

READ/WRITE

LETTERS

When studying the ETI Concept (October 1987) and the Heating Management System December 1987) I noticed the of 1N4148 diodes across relay coils.

I consider this to be fundamentally incorrect as this type of diode is not suitable for this type of service.

I have experienced failures (about 100) doing a similar function. I think designers have forgotten one of the fundamentals. When using transistor drives, especially on gates (ICs), their switching times can be extremely fast.

If I remember my theory correctly, the peak inverse voltage (PIV)=di/dt. So with a coil current (di) of say 0.06A and a switching time of say 100ns then PIV=600000V. Only 1N4007 diodes are appropriate.

Finally, the article Home CADMAT (October 1987) was rather irritating because of the relatively high cost of commercial CAD packages and quality assemblers for the BBC micro or IBM PC compatibles. Has any thought been given to publishing a PCB design program in Basic?

R A J Howard
New Farnley, Leeds

Nice try but although your formula is correct, it's the wrong formula. PIV= di/dt only applies to circuits *without* the diode. The diode is placed across the relay coil to prevent just this voltage build up. *With* the diode, inverse voltage is limited to 0.7V — the forward voltage across a diode.

The reason your diodes were failing was probably due to excessive instantaneous current — not voltage.

To solve *that* problem an 1N4007 would be a good idea although these devices may be too slow to conduct to protect the driver circuit.

The idea of Home CADMAT was to write programs and build equipment of your own rather than rely on the expensive commercial variety. However, we shall look into the possibility of a PCB design program in Basic. Any readers care to contribute?

At last! Other ETI readers are revealing their true colours by coming out in favour of *Doctor Who* (Read/Write, January 1988).

I too was pleased to see the return of the good Doctor to the realms of our FST Trinitrons and equally appalled to see him still accompanied by Bonnie Langford (good though she is at screaming).

The good news is she has left the series. The bad news is the series has ended (three stories — a series?!)

Come on BBC let's have less of Anne Thingy and *Points Of View* and some more *Doctor Who*, immediately.

John 'Cyberman' Graham
Gallafrey.

Yes, yes, but why tell us? Shouldn't you be writing to the BBC (even 'Anne Thingy') and heckling *them*?

By the way, how can impoverished ETI readers afford FST Trinitrons?

I'm glad to see you're taking a look at the world of satellite television. This has long been a subject which has interested me.

However, I feel your introductory look at STV (January 1988) was short of one important aspect of the installation — planning permission.

Planning permission is required for any dish of more than 90cm diameter. Different local authorities take different views on the obtrusive nature of satellite antenna but all tend to take eons to express their views in the form of permission!

It can take months for planning permission to go through and stories of over a year are not uncommon. Some local authorities insist the dish is disguised with shrubs or even painted green!

So be warned, before you part with the readies, you have the local bureaucracy to contend with.

Mark Pinna
Walkley, Sheffield.

Too true. It does seem ridiculous that you can put up a 15 foot greenhouse and paint it pink and the council won't (and can't) do a thing about it but put up a 4 foot aerial hidden behind your garden fence and they go berserk.

As the government is trying to encourage satellite TV for the future (in the form of DBS) it is ridiculous it is now discouraging the forerunning service. Write to your local MP and local councillor.

In the August to December 1986 issues of ETI you published a series of articles on an Intelligent Call Meter project to automatically log the cost of telephone calls.

The project began with a warning which said that although the meter was not BABT approved 'it can be used as the basis of a submission for approval.'

Have any readers submitted one of these devices to BT and was it approved. If it was rejected — on what grounds?

S Green
Smethwick, West Midlands.

Devices can be submitted to the BABT either for 'one off' approval or for approval of design (which includes the entire manufacturing process). So, any reader submitting the ICM for approval would only obtain approval for their own particular model. Only if they go into production (which they cannot without the permission of the author and ETI anyway) can a generalised approval for the ICM be granted, and then only for those produced by the approved method of production.

In other words, you're on your own!

Don't seethe in silence over the woes of the world. Don't keep your mind-blowing praise to yourself. Let us all have a giggle. Keep those letters coming to:

**ETI
1 Golden Square
London
W1R 3AB**

CAPACITY FOR THOUGHT

The capacitor is a much used but often misunderstood component. John Linsley Hood turns your doubts to dust with a two-part look at all things capacitive

CAPACITORS

There is an old joke that a metallurgist is someone who, given a choice of materials, chooses wood . . . The point, I suppose, being that any specialist who knows the snags inherent in his chosen speciality is likely to be more enthusiastic about the potential use of something else.

This is basically how I feel about capacitors.

For some years I was involved in the manufacture of the polypropylene film used in making capacitors, responsible for the electrical evaluation of our own and competitive films of various types to see how well they would perform.

This was quite an interesting project and involved visits to a large number of capacitor manufacturing companies to discuss the use of polypropylene and other films in this particular field.

I don't think that this makes me a capacitor specialist, but at least I have had a rather closer acquaintance with this topic than is normal for electronics engineers. I know a lot of the unpublicised problems.

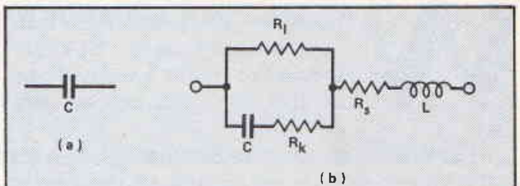


Fig. 1 (a) Circuit symbol (b) Accurate representation of a capacitor

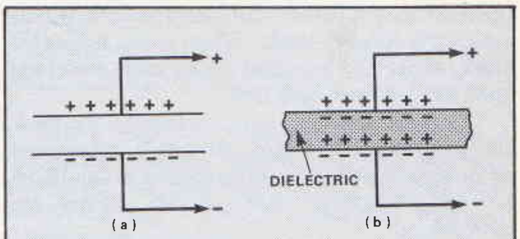


Fig. 2 Physical construction (a) without dielectric (b) with dielectric

So Say The Hi-Fi Buffs

Quite a lot has been written in recent years in the 'Hi-Fi' and electronics press about the differences in sound quality which can be brought about by changes in the type of the 'passive' components used in the audio system, whether these be resistors, capacitors, connecting cables, mains transformers, printed circuit board materials, solder, or even the fixing screws with which the cases are held together.

With most of these claims technically plausible explanations for the observed effects are usually only remarkable by their absence.

The tests on which they are based are also inevitably subjective in their nature and rely on listening trials which, however extensive, can seldom be conducted on an instantaneous 'A vs B' switch-over comparison. Where any length of time elapses between two alternatives, the memory becomes clouded and expectations begin to colour the observations.

There may be basis for the claims, though I feel that these are often exaggerated or incorrectly interpreted by their discoverers — like the change in sound quality (sometimes even for the better, since it lessens 'crossover' distortion) which happens when an amplifier having a poor stability margin is caused to oscillate at some ultrasonic frequency by the unwise connection of high self-capacitance LS leads. I remain agnostic.

Nevertheless, in the case of capacitors and particularly in the case of those used in the feedback loop of an amplifier using negative feedback (NFB), I feel that a good case can be made for care in their choice, since there are effects which are capable of being measured instrumentally as well as being heard.

But there is no blanket answer to the question of which capacitor do I use — it will depend on where you want to use it, what are the particular qualities which are especially needed in that position, how much space you can spare, and how little bothered you are about wasting money.

As for polypropylene (the current favourite of the 'golden-eared' fraternity) the questions I would ask are 'what type, how made and by whom, and how used?' So, let us look at some technicalities.

Normally in circuit diagrams the circuit symbol shown in Fig. 1a is used to depict a capacitor, but in reality it is more accurately represented by the drawing of Fig. 1b, where 'C' is the capacitance at some specified frequency, temperature and applied voltage, 'R_l' is the leakage resistance across the capacitor (which again may be temperature, humidity, frequency and applied voltage dependent), 'R_k' is the equivalent series resistance due to dielectric loss (again not a constant factor), 'R_s' is the straightforward series resistance due to its method of manufacture, and finally 'L' is the inevitable inductance of the component.

Physical construction

In principle, a capacitor is a pair of conductors in proximity to each other but not in electrical contact, such as a pair of parallel conducting plates in a vacuum (as shown in Fig. 2a).

When an electrical potential is applied between these plates, electrons will flow into the negatively connected plate from the negative pole of the applied potential. An equivalent number of electrons will be repelled away from the opposite plate and will flow towards the positive pole of the applied potential. If there is some circuit resistance this will lead to the familiar charging current stage shown in Fig. 3.

If the potential is removed and the wires from the capacitor are shorted together the same process will happen in reverse, so the wires will probably spark as they touch since there is now no longer any reason for the asymmetry of charge on the plates.

The theoretical value of such a capacitor (ignoring the effects of fringe fields at the edges of the plates) is given by the formula:

$$C = AK/11.315d \text{ (pF)}$$

where A is the effective opposed area of the plates, K is the dielectric constant of the material separating the plates (=1 for vacuum or air), and d is the gap separating them — all dimensions being in centimetres.

The practical problems of such a construction are due to the need to prevent the plates from touching and the difficulty of getting any large amount of capacitance.

These can be solved if some insulating material is fitted into the gap, as I have shown in Fig. 2b. If this is thin and has a good electrical strength, the gap d between the plates can be made very small which increases the capacitance for a given effective plate area (see the formula above).

Dielectric For Division

The capacitance will also be increased because the dielectric constant K of the insulating material will be greater than unity.

This comes about because all such insulating materials will 'polarise' to some extent, either by the displacement of orbital electron clouds surrounding the atoms of the constituent material, or by the migration of ions, or by the physical reorientation of polar molecules.

This has the effect of producing equal but opposing charges on the surface of the insulator facing the capacitor plates (Fig. 2b) which lessens the effective spacing between the plates.

Unfortunately, the introduction of a dielectric brings the problem of leakage (though this isn't such a problem with modern materials as it was with the old waxed paper insulated 'tar babies' of my early years in electronics!)

The insulation may break down electrically though there are techniques for reducing this hazard. The dielectric constant may not be constant — certainly it will decrease with applied frequency and will also be affected to a lesser extent by temperature and applied voltage.

Finally the dielectric introduces 'dielectric loss' which is represented by the term 'R_k' in Fig. 1b. This comes about (understandably) because the migrations of electrons or ions or the molecular reorientations (which produce the effect shown in Fig. 2b, and which cause the increase in capacitance) all absorb some energy when they occur, which is every time the applied electrical field is reversed.

The more frequently the polarity of the applied electric field is reversed (the higher the operating frequency) the higher the loss. Materials such as the largely non-polar plastics (polyethylene, polypropylene, PTFE, and polystyrene) don't have very high dielectric constants — which doesn't help very much to make compact high value capacitors. On the other hand very little happens when the field is reversed, so the dielectric loss is very low and the dielectric constant K doesn't alter significantly with frequency (up to the GHz range).

The thinking of the hi-fi purists is largely coloured by considerations of dielectric loss, and 'pp' is reputed to be very low and therefore very good. However, the actual loss factor depends on the purity of the material, on the way in which it is made (including additives included to assist in production and the extrusion temperature). I have listed the major qualities of the most common dielectric materials in Table 1, but as I have indicated these figures can only serve as a guide.

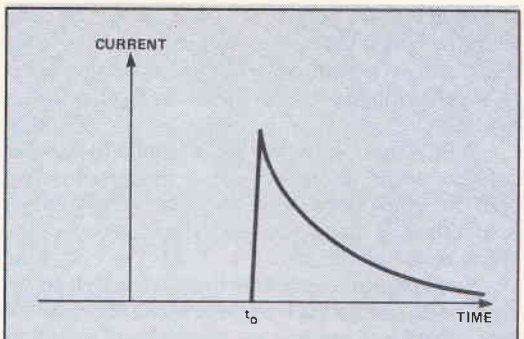


Fig. 3 Typical capacitive charging current pulse

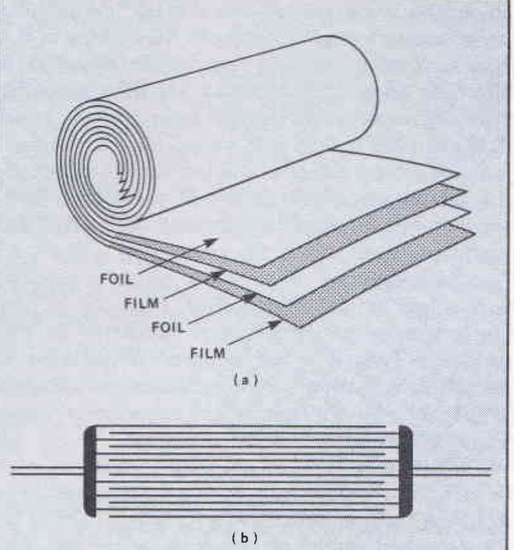


Fig. 4 Foil/film capacitors (a) construction (b) contacts

Non-polar Manufacture

Generally, plastics film insulated capacitors are either of the film/foil type, or of the metallised film construction. In the 'F/F' type, two long lengths of aluminium foil (which should be scrupulously clean and of high purity if the loss factor of the capacitor is not to be worsened) are sandwiched between a pair of slightly longer strips of plastics film and the whole thing is wound up in 'swiss roll' form, as shown in Fig. 4a.

Usually the foils are arranged so they extend a bit beyond the edges of the film strips so that electrical end contacts can be made to them as

Dielectric Material	Dielectric Constant (K)	Breakdown Strength (Volts/mil)	Loss Factor (Tan σ. 60Hz
Polyethylene (High density)	2.3	500-1000	0.0003-0.001
Polypropylene	2.2-2.3	450-650	0.0001-0.0003
Polyester	3.0-3.5	1500-2000	0.001-0.005
Polystyrene	2.5-2.6	500-100	0.0001-0.0002
Polycarbonate	2.97	400-450	0.0001-0.0005
PTFE	2.1	500	<0.0001
Polysulphone	2.82	420	0.008
Mica	5.4	2500	0.0005
Ceramics	30-6000	50-250	0.01-0.4

Table 1 Characteristics of some common dielectric materials

shown in Fig. 4b. Sometimes (as is usually the case with the small polystyrene capacitors) the foils don't overlap the film but a pair of connecting wires is simply trapped in the spiral while it is being wound.

With larger capacitors it is helpful to make a continuous edge contact since this lessens the spurious inductance value, because of the 'shorted turn' effect. It also helps keep the electrical resistance of the plates low.

In all film/foil capacitors the electrical strength and consequently the thickness of the film must be great enough to prevent any possibility of electrical breakdown at the rated working voltage. Such capacitors therefore tend to be bulky for a given capacitance value.

In the case of the metallised film (MF) types, the problem of possible electrical breakdown is solved by using a very thin metallic conducting layer, vacuum evaporated onto the surface of the film so that it leaves a clear strip along each alternate edge. End contacts are then made by spraying a solderable metallic layer onto each end of the sandwich. Such MF capacitors will 'self heal' in that if there is a local breakdown of the dielectric, the instantaneous discharge of the stored electrical energy through the puncture will burn off the metallised layer in that region.

Such internal flash-overs cause a gradual worsening of the loss factor because of the accumulation of combustion products in the windings. They also cause a gradual decrease in capacitance. Both of these problems are lessened significantly by not running the capacitor at more than half of its rated working voltage.

The major problem with 'MF' types however is that the metallised layer is so thin and has a significant winding resistance Rs which cannot be distinguished electrically from dielectric loss. On the other hand they are very small in size.

There has recently been an increased availability of stacked foil capacitors, a number of postage stamp sized pieces of film with either metallised layer or foil plates assembled into a small rectangular stack, and then resin encapsulated with projecting radial connection leads as shown in Fig. 5. These have the advantage of low series inductance and compact PCB assembly, but are otherwise similar in characteristics to the spiral wound versions.

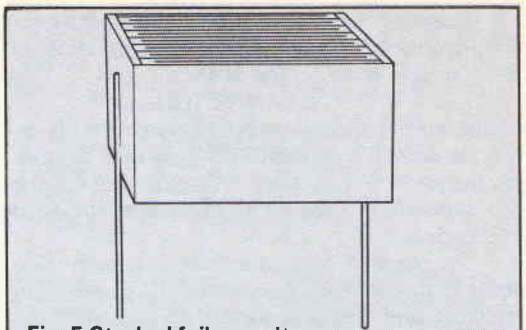


Fig. 5 Stacked foil capacitor

Tantalum And Aluminium Electrolytics

In these capacitor types, a large value of capacitance is obtained by chemically growing a very thin insulating oxide film on the surface of an etched metal plate or a pellet of sintered metal powder, with a conducting electrolyte occupying the gap between this and the other plate. This avoids the problem of electrical failure through breakdown of the insulating layer because if there is a puncture in the oxide film it is promptly repaired by local electrolytic action between the exposed metal and the electrolyte.

The snag is that this action is going on all the time, with continuous small pulses of current evened out by the capacitor itself into a fairly smooth current flow. The electrolyte though quite a good conductor is not as good as a layer of metal, which is why the non-polar capacitors always have a lower series resistance value. The other problems are that the value of the series resistance is dependent on voltage, temperature and frequency, as is the capacitance itself.

Also the polarity of the capacitor must be observed, and if any AC potential is likely to appear across it there must always be a continuous DC bias voltage which is greater than this. This means that electrolytics are not very happily used with zero polarising potentials.

When 'tantalum bead' (sintered tantalum pellet, resin encapsulated) electrolytics first appeared they were greeted with great enthusiasm since they had a lot of factors in their favour. The tantalum oxide dielectric was electrically and chemically very strong, and it had a much higher dielectric constant than alumina. This meant that a much more acidic electrolyte could be used giving lower series resistance, and more capacitance could be packed into a small volume.

In addition because of the strength of the oxide layer, the capacitor would even stand a small (0.5-1V) reverse potential which permitted use in signal lines. Unfortunately the instantaneous (though small) voltage dependence of conductivity leads to a complex behaviour pattern on transient voltage steps, and this can give a rather 'dull' sound when used as the blocking capacitor in a feedback line.

The increase in the cost of tantalum bead capacitors has stimulated research work on their aluminium equivalents with the result that physically small high-capacitance aluminium types are now available which are much to be preferred in audio use such as DC blocking in signal or feedback lines if high capacitance values are essential (though their quiescent working potentials must be carefully chosen).

Even so, non-polar types should always be the first choice, except in routine supply line decoupling duty.

Permanent Polarisation

This is the electrostatic equivalent of permanent magnetisation and is a snag which is exclusive to the plastics film dielectric types of capacitor.

As in steels, the durability of such a permanent polarisation is a function of the hardness of the material. It occurs much more readily in those films which are biaxially stretched during manufacture such as polypropylene or polyester (PETP) since this greatly increases their mechanical strength.

Those films which are made by casting from a lacquer (such as polystyrene, polycarbonate, or polysulphone) or by sintering a powder (such as PTFE) are much more limp physically and much less prone to this defect which can have the effect of building in a permanent series potential within the capacitor dielectric.

Circuit Applications

Next month I shall look in detail at the specific requirements of audio circuits and how best to fulfil them.

ETI

T-SHIRT COMPETITION

Back in the halcyon days of 1980 ETI had a pretty nifty line in T-shirts for sale. Although those garments are long gone, the unclothed masses at the ETI editorial office want to resurrect the tradition and once again see the ETI logo across the chests of millions.

The only problem is we have no design (well, we wouldn't want to use the old one again would we). Since we're not only unclothed but overworked too, we haven't the time (well, OK, we haven't the imagination either) to come up with a good design. That's where you come in.

We are giving away three ETI T-shirts of the winning design and a year's subscription of your favourite mag (this one, silly!) to the creator of the best design for the ETI apparel. The design should be in just one colour, incorporate the ETI logo (as on the cover of this issue) and be suitable to fit on the front of a T-shirt. Although humorous designs would be appreciated, please bear in mind it is illegal to send obscene material through the post!

Get your grey cells working on the problem, draw the design on a large T-shirt shaped blank (like the coupon) and send it with a completed coupon to arrive by 15th April to:

ETI T-SHIRT COMPETITION
1 Golden Square
London W1R 3AB

Name ....
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Address ....
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Size (S, M, L) ....

SATELLITE ACOLYTE

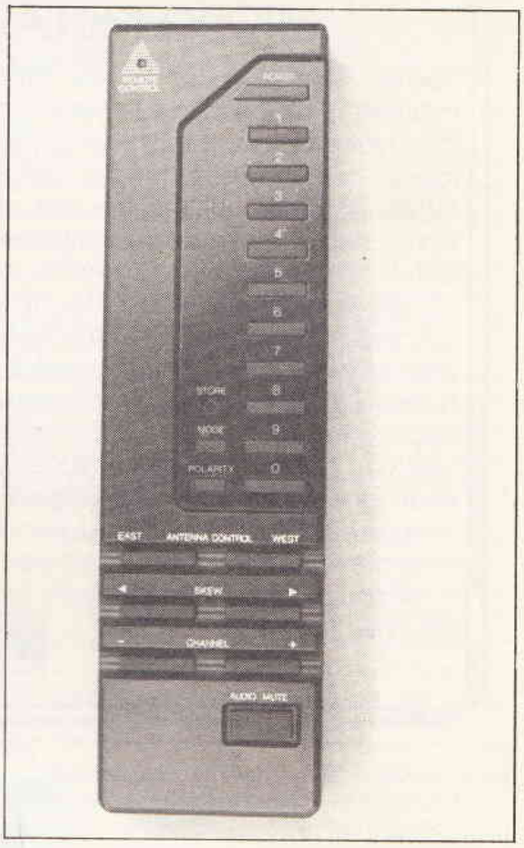
Keith Brindley rounds off his look at satellite TV with a detailed review of his favourite three systems

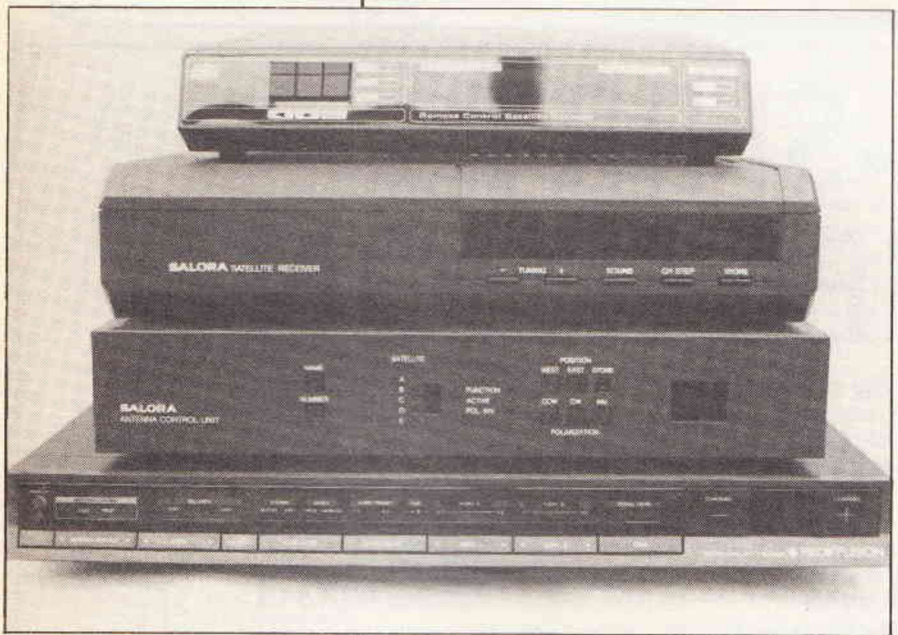
There are so many satellite television receivers around (see February ETI), with so many different features you'd be forgiven if you are confused by all the relevant specifications. It's for this reason that the final part of this series on STV concentrates on only three receivers, with the intention of an objective comparison — although, as you'll see, comparison isn't easy. The three receivers looked at have been chosen simply because they seem to provide the widest range of features and represent some of the best available systems.

They are all 'future-proof' (a term used by many manufacturers to show that their products can be up-graded with add-on boxes to receive scrambled signals and MAC signals). Other equally high quality receivers exist, however.

The three receivers reviewed are the Rediffusion RSR50, the Salora SRV1150 (both well known and highly acclaimed) and the newcomer Pace SR640.

Readers of the many satellite television magazines will already be familiar with the Rediffusion and Salora receivers but the Pace receiver (designed and built by Pace Micro Technology — perhaps better known for modems) will be a stranger. Nevertheless the Pace receiver, as you will see from the following, is a receiver to reckon with.





First, a brief description of the three receivers, listing a few relevant specifications and highlighting their quirks.

Rediffusion RSR50

Last year the RSR50 took the STV fraternity by storm. It was the first receiver which allowed the user to *fully* store all relevant information about individual satellite television channels.

The idea had been around for a while of course, with some receivers able to store information regarding frequency, polarisation, audio sub-carrier frequency and skew, such that the touch of a single button (or at worst, two or three buttons) on the remote control handset would change the channel displayed on the television.

What distanced the RSR50 from the rest is that it allows the user to store antenna position relevant to particular channels too.

When channel changing from one satellite to another, users of other receivers must first adjust antenna position as well as changing to the required channel. RSR50 users merely have to press a single button — the receiver takes care of it all. This feature caught the eyes of the STV press and prompted one magazine to call the RSR50 the 'one to beat in 1987.'

The antenna position-controlling factor means that, whereas most other receivers require a separate antenna controller, the Rediffusion RSR50 is effectively an integral system.

I say 'effectively' because the receiver is not, correctly speaking, a stand-alone unit — a separate power supply is required, containing the transformer and relays required to control the antenna actuator. This power supply is merely for the antenna though, and the receiver still incorporates its own internal PSU, which means it *can* be used alone in a single-satellite installation (without an antenna actuator).

Without all the bulky antenna-controlling electrics, the RSR50 has quite a low profile in comparison with most other receivers and is of such a width, depth and colour as to be extremely handsome sitting on top of your video cassette recorder underneath your telly.

Apart from its good looks the RSR50 also has some specifications worthy of note. First it has a reasonable carrier-to-noise threshold of only 8dB — so even fairly weak signals will produce pictures. Its IF bandwidth of 30MHz allows a good picture resolution for most channels (only Superchannel, Teleclub and RAI-Uno have higher bandwidths — 36MHz — than this).

For transmissions in stereo sound the RSR50 has stereo audible outputs allowing direct connection to a hi-fi system. Video outputs allow similar direct connections to video recorders or TV monitors for higher quality pictures than the UHF output affords.

Whereas most other receivers accommodate descramblers or MAC decoders simply by featuring a baseband output, the RSR50 also has a descrambler 'loop-through' socket. When descramblers are available, only one interconnection will be required, so installation will be a doddle.

The remote control handset is a delight to use. Single-handed operation (either hand) is possible simply by moving your thumb around to reach only a few logically placed buttons. This is the result of two things incorporated into the receiver; first, the stored details for antenna position, channel frequency, polarisation and so on which mean that a single button press changes received channel. Second, the receiver has two main operating modes, the handset buttons meaning different things in each.

Main mode is called memory mode. In this, channels are selected simply by pressing a numbered button — Premiere may be programmed into channel 1, so pressing button number 1 selects Premiere. Logical, huh? Up to 50 channels can be programmed into the receiver and as there are only ten numbered buttons, channels above number 9 require two button presses. In both modes, other buttons on the handset allow control over antenna position, polarity, skew and audio mute.

The other mode is search mode, entered from the handset by pressing the mode button then button number 1. In search, the receiver creates an on-screen graphic displaying the frequency of the received transmission. Handset buttons marked channel– and channel+ allow tuning of this frequency up or down. The numbered buttons can also be used to jump to a desired frequency (the IF frequency range of 950-1750MHz is split into eighty 10MHz steps). Once a channel is located, and all relevant details have been selected, it can be allocated a channel number by pressing the store button (inset into the handset) followed by the desired number.

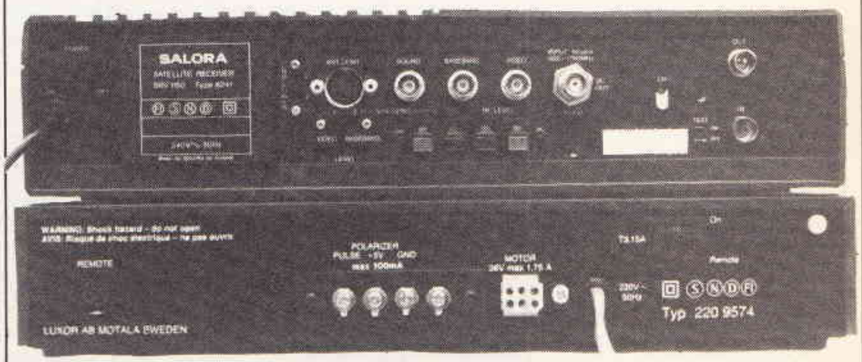
Once back in memory mode (accessed by pressing the mode button twice) that channel complete with relevant antenna position can be selected just by pressing its number.

In operation, there are few things to complain about. A great deal of thought has obviously gone into the receiver in a successful attempt to make it user-friendly, resulting in the two operating modes. Single-button channel selection is a sheer delight and I'm sure many other manufacturers will be rushing to adapt this feature into their products to compete. On-screen graphics are clear and precise and remain synchronised even when no signal is picked up, say when the antenna is tracking between satellites.

The only real niggle with the receiver was the lack of any facility for accurately metering signal strength — useful when installing and setting up the antenna. The integral bar-graph signal level display isn't sufficiently accurate.

Salora SRV1150

This receiver has been around for a little while and as such you might be forgiven for thinking that technology has overtaken it. However, quality-wise you'd be wrong to pass it over. Whereas the Rediffusion RSR50 control-antenna-positions directly, a Salora system actually comprises receiver and a separate antenna control unit (ACU 1160) — this makes a 'feature-by-feature' comparison a little tricky.



In overall specification terms, the Salora system is every bit as good as anything else around. Threshold is 9dB (not quite as good as the Rediffusion RSR50 and a lot poorer than the PACE SR640). On the plus side, an IF bandwidth of 32MHz means that picture resolution is theoretically much better. The argument goes that a picture formed from a signal with a carrier-to-noise ratio less than about 9dB isn't worth watching, so you might as well have a good picture resolution when a stronger signal is available.

The receiver itself is smartly designed but this is slightly offset by the presence of the antenna control unit which, although the same colour, doesn't quite match in style. Back panel connections for video, sound and baseband outputs are provided for direct connection to video cassette recorder or monitor.

Operation of the receiver is straightforward enough. Front panel buttons for tuning (+ and –), sound (one of four preset subcarriers), channel step and store are the only controls provided and once the antenna has been pointed at a satellite, it's a simple job to locate channels and store them ready for watching — much as you'd tune in a UHF television tuner. Setting up the antenna control unit to store details regarding antenna position, channel polarity and skew, is somewhat more involved. Nevertheless, lengthy instructions are provided, albeit translated — presumably from Finnish. Satellites are number from A1 to A6, B1 to B6 through to E6 — a total of 30 satellite positions.

One of the trickiest concepts to come to terms with is the fact you have to allocate different polarity signals into set channel numbers. This depends on a rear panel switch setting. Either odd channel numbers all cause the polarotor to be vertically polarised and even channel numbers cause the polarotor to be horizontally polarised or channels 1 to 16 switch the polarotor for vertical polarisation and channels 17 to 32 switch it for horizontal polarisation.

A compact remote control handset is provided which takes a while to get used to. Channel buttons are numbered in white from 1 to 16, doubling up from 17 to 32. Choosing between hexadecimal groups is done with two other buttons marked 1-16 and 17-32. Buttons for antenna polarity and position are provided, as are buttons used to initiate the satellite selection procedure and to return to channel selection.

Although a parental-lock isn't a feature of the SRV1150, it is possible to lock the antenna position so mean mummies and daddies wishing to frustrate their offspring could lock the antenna into a position where no satellite is sited, effectively rendering the system useless.

Where the system falls down is in general operation. Changing channels on a single satellite is easy enough, a maximum of two button presses will select any channel stored. But, when you wish to change to a channel located on a different satellite, things begin to get tricky. First, by pressing the SAT button on the handset, the satellite selection procedure is invoked. Then the satellite wanted (A1 to E6) is keyed in using the blue lettered buttons on the handset for the letter, followed by its number — at this point the antenna control unit moves the antenna to suit. Then, by pressing the CH button to return the system back to channel selection, the required channel is finally located. Although logical enough, it is a lengthy procedure, all of which could entail a total of six button presses — try doing that after a Vindaloo and five pints of lager!

That really is the system's only fault (if you can call it a fault). It is, however, only apparent when considered beside receivers like the Rediffusion RSR50 and the Pace SR640 because they are so simple to use. Most other receivers are equally as complex, if not more so, than the Salora 1150 system.

Pace SR640

Satellite television receivers are a new venture for Pace and it's interesting to consider why the company has gone down this path. Their first product, the SR640 follows in the Rediffusion RSR50's footsteps in that it has separate modes of operation, making use extremely easy.

Also like the RSR50, it is an integral system rather than just a tuner. It has a similar separate power supply too, although Pace has gone the whole hog with the SR640 and put the receiver power supply in the separate black box. This fact makes the SR640 itself the smallest (to my knowledge) and lightest receiver on the market. Housed in a custom-adapted Vero Proteus instrument case, the receiver is certainly neat.

Specifications are, like the other receivers in our comparison, pretty good. Featuring the lowest threshold of all (6dB) the SR640 will produce a picture where the others haven't got a sufficiently high carrier-to-noise ratio — not that picture quality at a carrier-to-noise ratio of 6dB is worth watching (see March ETI).

On the other hand, an IF bandwidth of only 27MHz means that picture resolution for those channels such as Superchannel, with bandwidths around 36MHz isn't as good as, say, the Salora SRV1150's. However, the trade-off between resolution and sensitivity which Pace seems to have made means that fewer sparklies will occur when a weak signal is received when compared with wider IF bandwidths, lower sensitivity receivers.

Back panel sockets for the usual audio, video and baseband outlets allow direct video cassette recorder or television monitor interconnection.

Only three controls adorn the SR640's front panel, two of which are labelled with left and right going arrows (channel down and channel up — in normal mode) and a mode control which steps the receiver through the three modes — NORM (normal), DISH and TEST.

The remote control handset is quite easy to use. Ten numbered keys 0-9 are used for channel selection and can be used for single-button channel selection (see later), although channels are generally in decades — 1-9, 10-19, 20-29, and 30-39. Two buttons, tune– and tune+ adjust received frequency. Two buttons, decade– and decade+ select which decade of channels are accessed. One button alters polarisation and a number of buttons are used to store antenna position and channels. As well as a single mute button, volume can be turned up or down (a nice feature) with the vol– and vol+ buttons and finally there is a standby button.

The receiver is factory pre-set so that different satellite positions are allocated to each decade of channels, which means that to change to a channel from a different receiver up to four buttons may have to be pressed in sequence. However, users can store channels from different satellites within a single decade if they wish, thereby making single button channel selection possible.

Channel selection takes place in normal mode and users will rarely need to access any other mode. In dish mode, for example, the two arrowed keys on the front panel change function to adjust dish position east and west. Dish mode is also the mode used when channels are to be stored in the receiver. Like the Rediffusion RSR50, all details of a channel including antenna position are stored together with a corresponding channel number so when in normal mode, users can select a channel (and antenna position) merely by pressing the channel's number.

There are three test modes. Test mode 0 produces a black and white UHF test signal used when tuning the television receiver upon installation. The other receivers in this review also feature such test signals, via switches on the rear panels. Test mode 1 converts the digital dish position display on the receiver's front panel into a digital display of signal strength — extremely useful when siting the antenna. Test mode 2 is a skew adjustment, allowing the receiver to adjust the antenna polarotor's absolute vertical and horizontal positions — only undertaken once on installation.

Quirks are few and far between. The only significant hardware problem is the lack of a UHF 'loop-through' facility which, a company spokesman has concurred, is to be included in the near future. Without 'loop-through' UHF, signals from a terrestrial aerial aren't passed through to the following video cassette recorder and television. Either users have to swop UHF leads, or a UHF splitter/combiner is required. The only other minor niggle is the fact that on power-up, the receiver jumps to the first channel of whichever decade it was in on power-down. When using normal factory preset channels and decades this makes absolutely no difference but if you prefer to store different satellite channels on single decades and if you were watching a channel from a satellite other than that stored at the first channel of the decade on power-down, when powering-up again the receiver will reposition the antenna before a picture is obtained. So a wait of quite a few seconds will elapse before anything is seen. This could be prevented with a software change to either power-up the receiver in the channel it was in on power-down or to put the receiver on standby when powered-up.

In Conclusion

Well, we said comparison isn't easy, didn't we? Each receiver in this review has its own pros and cons and deciding which is the best is well nigh impossible. Best value for money has to be the Pace SR640. The Rediffusion RSR50 just pips the SR640 to the post when considering which is easiest to use. Highest quality picture resolution must be the Salora SRV1150 (due to its IF bandwidth) but the SR640 with the narrowest IF bandwidth gives a picture which is sparkly-free with the weakest of signals when the other two show some most irritating interference.

Ah well, you pays your money...

ETI

Features/facilities/ specification	Rediffusion RSR50	Salora SRV1150	Pace SR640
Technical			
Input level	-60 to -25dBm	-60 to -30dBm	
Threshold (C/N)	8dB	9dB	6dB
IF bandwidth	30MHz	32MHz	27MHz
Unclamped baseband output	yes	yes	yes
Baseband level control	yes	yes	no
Video output	yes	yes	yes
Audio: output	yes	yes	yes
subcarrier range (tunable)	5-8.5MHz	—	6-6.8MHz
subcarrier range (preset)	6.5, 6.6/6.65MHz	6.5/6.6/6.625/ 6.65MHz	—
subcarrier range (automatic)	—	—	6.5/6.6/6.65MHz
type	mono/stereo	mono	mono
UHF: modulated tunable output	channels 30 to 39	channels 30 to 39	channels 32 to 40
test signal	yes	yes	yes
'loop-through' input	yes	yes	no *see text
Descrambler 'loop-through'	yes	no	no
Signal: strength display	yes	yes	no
strength metering	no	yes	yes
Polarotor output	pulse	pulse	pulse/IRTE
Actuator control	36 volt + pulse	36 volt + pulse	36 volt + reed
Dimensions (mm): receiver	430(w)×45(h)×350(d)	340(w)×78(h)×230(d)	275(w)×60(h)×290(d)
control/PSU	140(w)×72(h)×150(d)	340(w)×70(h)×270(d)	125(w)×90(h)×125(d)
Operating instructions	adequate	adequate	good
Facilities via remote control			
Polarity	yes	yes	yes
Skew	yes	yes	no
Antenna position	yes	yes	no
Channel select	yes	yes	yes
Channel store	yes	no	yes
Tuning	yes	no	yes
Mute	yes	no	yes
Volume	no	no	yes
Standby	yes	yes	yes
Mode change	yes	—	yes
General			
Operating modes	memory/search	—	norm/dish/test
Parental lock	yes — single channel	*see text	no
Number of programmable channels	50	32	39
Pre-programmed satellites/channels	yes	yes	yes
Scan	yes	no	no
Number of antenna positions	50	30	12
Single-button channel/ satellite select	standard	no	*see text
On-screen graphics	yes	no	no
Antenna position limits	yes	yes	yes
Adjustable polarotor skew	yes	yes	yes
Designed/built	Japan	Finland	UK
Typical receiver/ controller/supply price	£475	£650	£410

STV

COUNT ON IT

Mike Barwise takes a look at the Fairchild 74F525 and finds there's a lot of counter squeezed into this chip

New generations of logic devices within extant generic families usually differ in terms of power and speed. However, sometimes a manufacturer will use the new generation to introduce additional new devices.

Such a device is the 74F525 programmable divider from Fairchild. This is a versatile device which can be used wherever binary programmable digital timing is needed. It is typical of new introductions in logic in that it incorporates the functions of about half a dozen separate conventional chips in one package.

The 74F525 (Fig. 1) consists of a 16-bit down counter, a 16-bit input holding register and some custom control logic which Fairchild has not documented. The device has five modes of operation, three of which have alternate modes. It can act as a triggered digitally timed monostable with retrigger or pause, or as a free-running binary divider. The Fairchild modes are given in Fig. 2.

The Fairchild operational documentation leaves a bit to be desired (I had to phone the USA for control information!). So, I am giving here a control resumé before discussing.

The mode pins M0-2 are set by CIP switches or hard wiring to the literal mode number in positive logic. So all lines low equals mode 0 and all high gives mode 7. The input clock is applied to CP. The inverter between CP and XTAL *must not* be used as an oscillator inverter. It cannot carry the required current. XTAL can be used to carry forward an inverted clock in.

The data inputs are conventional TTL compatible logic inputs into a 16-bit transparent latch. This is loaded by taking $\overline{WE}$ high after the input data is stable, but due to the transparency of the latches $\overline{WE}$ should not be kept idle in the low state unless stable data is available from an external source.

The safest data write is performed by a short negative-going pulse, the data being effectively latched on the trailing (rising) edge.

The RUN/LOAD alternatives of the counter are controlled by the state of XTR. This stands for *external trigger* (a misleading name — it is not a trigger edge signal. It is a *state controlled* mode signal). While XTR is high, the counter *loads* synchronously with the clock, when low the counter *counts*.

The remaining control input $\overline{MR}$ is a master reset. There *must* be a master reset after power-up before any other operation. I do not know what would happen in each mode otherwise but I reckon the results would be pretty unpredictable!

Controlling The 74F525

Whatever the mode of operation you have chosen, the external control sequence is much the same. After power-up, $\overline{MR}$ must be pulsed low. Thereafter it can be ignored, except in mode 7 (continuous divide by n) where it is used to stop and clear the counter.

Next, XTR is taken high and a 16-bit data word (the divisor of *modulo*) presented to the data inputs and held stable while $\overline{WE}$ is pulsed low.

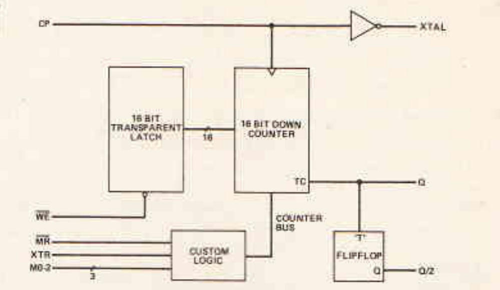


Fig. 1 Block diagram of the 74F525

When XTR is next taken low, counting will begin. When the counter reaches zero (counting down) the outputs Q and Q/2 change state in accordance with the chosen mode of operation.

In all modes except mode 7, XTR must be taken high and low each time a sequence is required. In mode 7, after an initial XTR falling edge, the counter is automatically reloaded by its own rollover through zero. In this mode, the output at Q is a positive-going pulse one clock wide. Q/2 just changes state (toggles) on the rising edge of Q.

The preceding notes show the internal transparent latches are only essential to operation in mode 7. In all other modes they simply avoid the user reprogramming the counter externally between one-shot operations.

Some source of external programming is still needed and this usually takes the form of binary switch inputs or registers programmed by a microprocessor. Assuming for the moment that this is the case, a simple loading/control interface is shown in Fig. 3.

Using The 74F525

Now let us look at the various modes of this clever little chip in more detail. In all cases, let us assume that $\overline{MR}$ has been pulsed and a modulo loaded into the input register already.

In mode 0, the F525 operates as a 'wait for it' delay device. Q goes high n clocks after XTR is lowered. Q/2 toggles state as well but this is not very useful unless you know its state before.

If XTR goes high, the counter reloads and Q is taken low. If Q is still low (because the sequence has not completed) it stays low. Lowering XTR restarts the sequence from the top.

This mode is basic but not very widely applicable. Precision timing is not possible due to the delay of anything up to nearly one clock period between XTR falling and the first active clock. The main use of this mode which comes to mind is as a time-out microprocessor watchdog. Software writes to pulse XTR normally often enough for the counter to not time out. If the CPU loses its way, XTR is not pulsed soon enough and the output from Q is used to either reset the CPU or cause an error interrupt.

In this application DIP switches would be used to set the required modulo. $\overline{WE}$ would be tied

CHIP IN

MODE 0
While XTR is HIGH, the data in the data latches is loaded into the counter upon the next positive-edge of CP. The negative-edge of XTR enables the count-down to begin with the next positive-edge of CP. When the count reaches zero, Q is brought HIGH and Q/2 toggles state. Taking XTR HIGH at any time causes the data in the latches to be loaded into the counter and the Q output to be cleared.

MODE 1
The operation is exactly the same as in mode 0 except that Q is normally HIGH and goes LOW on a count of zero. Q/2 toggles on the negative-edge of Q.

MODE 2
While XTR is HIGH, the data in the data latches is loaded into the counter upon the next positive-edge of CP. The negative-edge of XTR enables the count-down to begin with the next positive-edge of CP. When the count reaches zero, Q is brought HIGH for a single period of CP. Q/2 toggles state on the positive edge of Q. Taking XTR HIGH at any time causes the data in the latches to be loaded into the counter and the Q output to be cleared.

MODE 3
The operation is exactly the same as in mode 2 except that Q is normally HIGH and goes LOW on a count of zero for a single period of CP. Q/2 toggles on the negative-edge of Q.

MODE 4
While XTR is HIGH, the data in the data latches is loaded into the counter upon the next positive-edge of CP. The negative-edge of XTR enables the count-down to begin with the next positive-edge of CP. When the count reaches zero, Q is brought HIGH for a single period of CP. Q/2 toggles state on the positive-edge of Q. Taking XTR HIGH before the counters reach zero causes the data currently in the counters to be held.

MODE 5
The operation is exactly the same as in Mode 4 except that Q is normally HIGH and goes LOW on a count of zero. Q/2 toggles on the negative-edge of Q.

MODE 6
While XTR is HIGH, the data in the data latches is loaded into the counter upon the next positive-edge of CP. The negative-edge of XTR enables both the count-down to begin and Q to go HIGH with the next positive-edge of CP. Q is brought LOW when the count reaches zero. Q/2 toggles on the positive-edge of CP. Bringing XTR HIGH during a count-down will reload the latched data into the counter, but will not affect Q.

MODE 7
The negative-edge of XTR enables the count-down to begin with the next positive-edge of CP. When the count reaches zero, Q is brought HIGH for a single period of CP. Q/2 toggles state on the positive-edge of Q. The positive-edge of CP upon which Q goes low also causes the data in the data latches to be reloaded into the counters. Taking XTR HIGH at any time causes the data in the data latches to be loaded into the counter and the Q output to be cleared. However, after an initial XTR this mode can run continuously until stopped by MR.

Fig. 2 The Fairchild mode descriptions

permanently low and the clock would drive CP.

Mode 1 operates the same except the Q output polarity is reversed. It goes low on time-out.

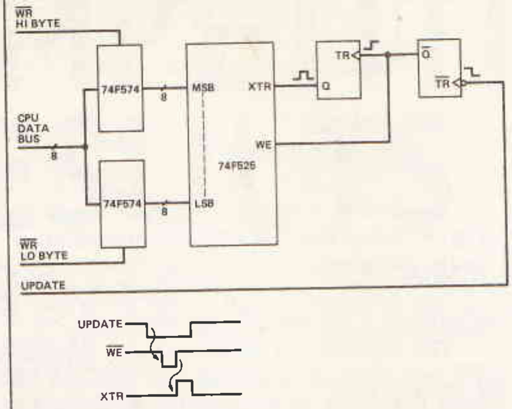


Fig. 3 A simple loading/control interface

Symbol	Parameter	54F/74F T_A +25°C V_{CC} = +5.0V C_L = 50pF Min	Typ	Max	54F T_A, V_{CC} = Mil C_L = 50pF Min	Max	74F T_A, V_{CC} = Com C_L = 50pF Min	Max	Units
t_{PLH}	Propagation Delay			24.0					ns
t_{PHL}	CP to Q or Q/2, Mode 0			24.0					
t_{PLH}	Propagation Delay			22.0					ns
t_{PHL}	Mode to Q or Q/2			22.0					
t_{PLH}	Propagation Delay			19.0					ns
t_{PHL}	XTR to Q			16.0					ns
t_{PLH}	Propagation Delay			24.0					ns
t_{PHL}	$\overline{MR}$ to Q			18.5					
f_{max}	Maximum Clock Frequency	50	65					45	MHz
$t_s(H)$	Setup Time, HIGH or LOW	4.5							ns
$t_s(L)$	D_n to WE	4.5							
$t_h(H)$	Hold Time, HIGH or LOW	2.0							ns
$t_h(L)$	D_n to WE	2.0							
$t_s(H)$	Setup Time, HIGH or LOW	11.5							ns
$t_s(L)$	D_n to CP	11.5							
$t_h(H)$	Hold Time, HIGH or LOW	0							ns
$t_h(L)$	D_n to CP	0							
$t_s(H)$	Setup Time, HIGH or LOW	7.5							ns
$t_s(L)$	XTR to CP	13.5							
$t_h(H)$	Hold Time, HIGH or LOW	0							ns
$t_h(L)$	XTR to CP	0							
$t_s(H)$	Setup Time, HIGH or LOW	33.5							ns
$t_s(L)$	Mode to CP								
$t_w(H)$	XTR Pulse Width, HIGH	14.0							ns
$t_w(L)$	MR Pulse Width, LOW	7.5							ns
$t_w(H)$	CP Pulse Width	4.0							ns
$t_w(L)$	HIGH or LOW	9.0							
t_{rec}	Recovery Time MR to CP	5.0							ns

Table 1 Timing constraints of the 74F525

Modes 2 and 3 are very similar. The only difference is that the Q output is active for only *one input clock period* when the counter reaches zero. This output is therefore more suitable for driving level triggered flip-flops, where only one input may

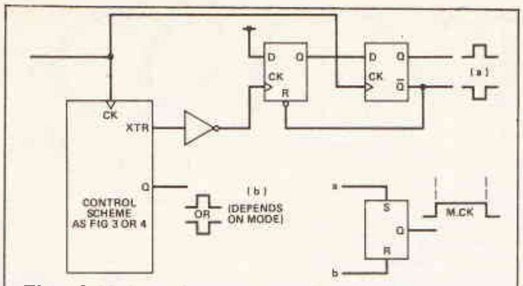


Fig. 4 Using the 74F525 for precision pulse generation

be active at one time for valid outputs.

The addition of a simple one-shot tripped by XTR and clocked synchronously with the F525 allows this mode to be used for precision pulse generation (Fig. 4). For this application, the input of data can be the same as that specified for modes 0 and 1 if binary switches are used but if a micro is used for programming (a good idea!) an additional set of external registers is used.

Modes 4 and 5 are the positive and negative logic variants of a *hold-off monostable.* This acts like a retriggerable monostable in that the period may be extended during the delay but instead of reloading the delay from the registers, the F525 simply freezes the counter when XTR goes high. This has the effect of applying an arbitrary asynchronous extension to the monostable period while XTR is high.

Mode 6 is an internal implementation of my rather clumsy attempt at precision pulse generation using modes 2 and 3. After a falling XTR, Q goes high on the first active clock (the first clock to decrement the counter) and goes low again when the count reaches zero. This is the true digital monostable. It is also retriggerable by taking XTR high and low again *within less than one clock period* (to avoid screwing up the timing precision) without affecting the state of Q.

The timing constraints (Table 1) suggests that retriggering within a clock cycle is only possible at a lot less than maximum system speed. However, the precision of pulse generation (disregarding retrigger) is only as good as your clock source.

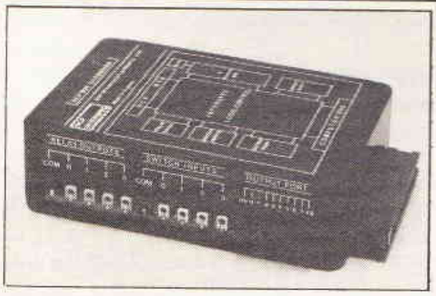
The whole of my three PCB pulse generator (ETI February-July 1987) could be built using only three of these chips in modes 6 and 7 plus a few flip-flops and gates!

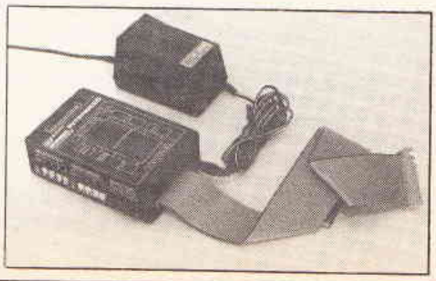
Mode 7 is unique in that it is a free-running mode. Once set up it will continue dividing by the same modulo until either a master reset stops it, it finds a new modulo in its registers or XTR is taken high. It is important to note that in mode 7 the real modulo used by the counter is n+1. The output at Q is a clock-wide pulse and at Q/2 a square wave of twice the period.

If you are going to modify the modulo on the fly, the external registers and the control interface of Fig. 3 are *obligatory.* This interface reloads the external registers, writes the internal registers and then pulses XTR.

The only possibility of a restart glitch is where by chance the internal counter reload happens at the moment the internal registers are being updated. A little additional control can be provided by synchronising the internal register re-write to the leading edge of Q (or the falling edge of the input clock) allowing the update to be performed either sufficiently early or late for this hazard to be covered.

That's about it on the 74F525, but it will almost certainly crop up in the future as a supporting device for other new chips. It might be worth mentioning that it is the perfect solution (in mode 7) for the MF8 switched capacitor filter clock (ETI November 1987). ETI





SS COMPETITION RESULTS

D	H	T	O	O	T	W	A	S	V	V	U	R	E	D	I	L	S	X	E
S	O	L	D	E	R	H	E	A	D	Q	Y	N	H	C	F	H	N	O	M
J	V	M	F	D	G	O	E	D	O	I	D	J	M	R	P	Y	C	I	F
S	Q	A	E	R	I	Z	Q	W	W	O	X	S	O	Y	C	I	Y	H	T
A	P	O	N	A	T	I	M	T	U	I	E	M	K	S	Y	E	H	Y	U
F	C	E	O	O	T	D	P	T	Y	J	I	O	O	T	D	Y	O	C	X
I	I	D	H	B	Y	U	P	T	J	R	T	O	Q	A	I	G	E	Z	Q
L	N	I	P	D	C	U	A	R	R	Q	V	T	C	L	A	O	R	O	U
N	O	V	O	A	T	Z	G	O	I	I	Z	H	A	T	F	W	E	B	T
P	I	S	R	E	O	A	E	T	Z	J	A	I	E	X	E	G	T	H	M
A	M	G	C	R	J	D	X	A	K	M	R	C	V	I	E	R	S	G	T
R	R	L	I	B	O	L	E	L	F	E	T	T	U	J	D	O	V	V	I
O	E	C	M	H	E	N	C	L	A	M	Y	B	V	A	B	T	T	Y	U
T	H	G	T	M	T	S	M	I	O	O	H	P	P	S	A	S	N	O	C
I	T	A	E	I	Y	D	B	C	S	R	O	P	A	R	C	I	E	V	R
C	C	Z	D	O	B	W	F	S	R	Y	S	V	E	D	K	S	R	R	I
A	Q	L	M	N	X	Q	X	O	I	J	L	N	T	X	B	N	R	E	C
P	C	D	T	R	E	F	F	U	B	X	E	H	K	A	U	A	U	S	A
A	U	J	B	I	P	O	L	A	R	Z	M	I	T	X	H	R	C	M	K
C	T	J	M	U	T	S	L	J	C	O	A	X	I	A	L	T	D	X	I

The Specialist Semiconductors kit competition back in the January 1988 issue attracted a large number of entries.

Most readers managed to correctly calculate the current in the given network as 1mA (to the nearest mA). The wordsearch caused a few problems with some entries listing every combination of three letters possible! However, from the entries with the most real words the first out of the hat were from Harry Clough of Hitchin and Mark Thomson of Barnet. Congratulations to the lucky winners and commiserations and thanks to everyone else who entered.

The £75 Specialist Semiconductor vouchers will soon be winding their way to Mr. Clough and Mr. Thomson.

The wordsearch square with most of the real electronic words is given here to show you where you went wrong! Don't forget the T-shirt competition in this issue!

PULLING IT ALL TOGETHER

Paul Chappell shows how the theory of recent months can be put to practical use

CIRCUIT THEORY

Since we've spent most of the past six months looking at phasors and complex algebra, I think it's almost time to give it a rest for the time being. Before taking our leave of the topic, let's just look around and see what we've achieved so far.

One of the problems with explaining the theoretical side of electronics is that most demonstrations of any new idea involve very simple networks far removed from the complexities of practical circuits. The idea, of course, is to show up the new concepts as sharply as possible without becoming involved in irrelevant detail. But the better it works, the more remote the theory seems from real life!

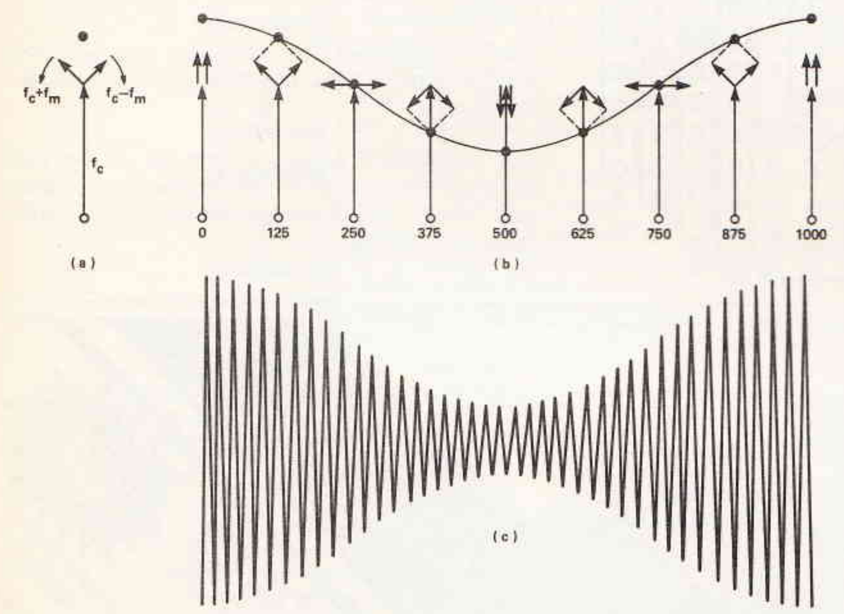


Fig. 1(a) Phasor diagram for amplitude modulation. (b) The phasors in motion. (c) The resulting time domain waveform.

Believe it nor not, if you've followed the articles so far you already have a useful tool at your disposal. It's not a complete and self-contained means of investigating circuit behaviour but then no other single technique can make that claim either. Used in conjunction with your intuition and general electronics knowledge it can help to shed new light on obscure areas and act as an aid to developing new ideas.

In an earlier article I had occasion to mention amplitude modulated radio signals to make the point that an amplitude modulated sine wave is not a sine wave at all, rather a combination of three sine waves. At the time the best 'proof' I could offer was to refer you to the corresponding trigonometric identity.

Invoking mathematical authority is a convenient way to bludgeon disbelievers into submission but it doesn't actually *explain* anything unless you're so familiar with the area concerned that its truth seems self evident. The attraction of the phasor representation is that the truth leaps out at you — you couldn't avoid seeing it if you tried! In Fig. 1a, f_c is the carrier, which corresponds to the frequency you set your radio dial to. Let's say it's at 1MHz. The modulating wave is another size of frequency f_m, which we'll say is 1kHz. This makes f_c+f_m 1.001MHz and f_c-f_m 999kHz so the three phasors of Fig. 1a are rotating at almost (but not quite!) the same speed.

The sum of the three phasors is shown by the dot. The result of adding the three sines in the time domain will be the shadow of the dot on the real axis.

Imagine the phasors are spinning around and you have a strobe light which catches them each time f_c is pointing vertically upwards. Since f_c+f_m is rotating slightly faster than f_c it will move slightly anti-clockwise on each flash of the strobe whereas f_c-f_m will appear to be moving clockwise (although it's really moving anti-clockwise but a little slower). The dot will move up and down, always in line with f_c, taking 1000 cycles of f_c to complete its travel and return to its starting position.

Figure 1b shows the positions after a number of cycles of f_c (or flashes of the strobe) and Fig. 1c shows the shadow of the dot on the real axis — the translation back into the time domain. A 1MHz sine wave amplitude modulated by a 1kHz sine wave! It shouldn't be necessary to draw Figs. 1b and 1c once you get used to interpreting phasor diagrams. Just looking at Fig. 1a should be enough for you to be able to visualise them.

The main attraction of amplitude modulation is that it's so very easy to recover the signals at the receiving end. Figure 2 shows how easy. It may come as a surprise to those of you brought up on a rich diet of ICs and high technology but this little circuit is all you need to pick up most AM broadcast signals. Look, Mum — no batteries!

If you want to experiment with the circuit, L1 and CV1 can be removed from an old radio set (otherwise use about 60 turns of enamelled copper wire on a length of ferrite rod and a variable capacitor of about 300p maximum for a medium wave receiver). D1 should be a germanium diode, C1 about 1n0, and the headphones (which give a nice radio-shack flavour to the circuit diagram) can be a crystal earpiece. In areas of high signal strength, just about anything will do as an aerial — your bedsprings, a length of insulated wire, the TV aerial. Otherwise, 100ft of insulated wire strung between two posts in the garden will do fine. The earth connection can be made to central heating pipes or a rod stuck into the ground — you may find it's not necessary at all.

The coil L1 and variable capacitor CV1 form a resonant circuit which responds enthusiastically to signals close to its resonant frequency and barely at all to anything far removed from this frequency. The resonant frequency is varied by CV1 which allows the set to be tuned. D1 lops off the negative going portion of the AM wave, C1 removes the carrier frequency and you're left with a copy of the modulating signal to be fed to the earphone. C1 is not really necessary, since the mechanical inertia

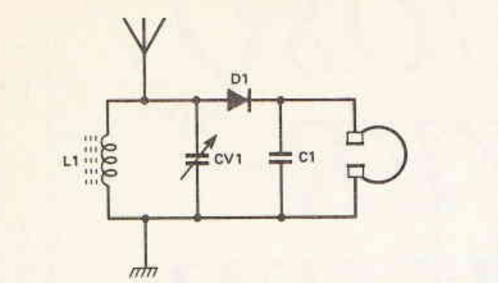


Fig. 2 A modern version of a crystal radio set.

of the earpiece will smooth out the wave well enough but it makes the explanation more convincing!

If we take a closer look at Fig. 1a it soon becomes evident that, apart from the ease of recovering the signal, amplitude modulation doesn't have a lot going for it. For one thing, a large part of the transmitted signal is a constant amplitude sine wave f_c, which contains no information in itself about the modulating wave (which is what we're really interested in). It seems a waste of power to transmit it at all!

Secondly, the information contained in one side frequency is simply repeated in the other. If we know f_c+f_m and f_c, we should be able to reach f_m without much trouble, so why double the bandwidth and and send f_c-f_m as well? The broadcast bands are crowded enough as it is!

Now, I could go on from here to develop the basic theory of single sideband and suppressed carrier transmission but that's not the point. What I'm trying to show is the way a simple diagram of three arrows can send your thoughts in all kinds of unexpected directions.

If you want to experiment with these ideas, try to think what would happen if the two side frequencies of Fig. 1a were increased in amplitude relative to the carrier. Would the circuit of Fig. 2 be able to make sense of the result? What would the transmitted waveform look like if one side frequency was removed? What would our simple radio receiver make of that? How about if one side frequency *and* the carrier were dumped? Is there any way at all to recover the modulating frequency from the result?

In applying phasors to specific circuits rather than general ideas, we have only considered networks of three or four components. It has to be admitted that phasors become rather cumbersome when more than half a dozen or so components are involved — if the diagram has too many arrows it becomes difficult to visualise the relationship between them and the way this might vary with frequency or with component values. Apart from the fact that many more powerful techniques have their roots in phasor diagrams, this doesn't limit the technique as much as you might think.

If you think for a moment about how you go about designing a circuit, it's essentially a matter of beginning with a broad outline then considering finer and finer detail as the design progresses. In the early stages you look at the circuit as a whole, later you may find yourself wanting to tweak up the performance of one very small area which may only consist of three or four components.

An example is the triac snubber network shown in Fig. 3a. The capacitor is intended as a kind of dustbin where the surplus energy of the inductive load can be dumped when the triac turns off. Unfortunately, the capacitor forms a resonant circuit with the load, like the series RLC circuit last month, and ringing of the circuit can cause more problems than the one it was intended to cure!

In an earlier article (ETI March 1987) I described a way of choosing these component values by rule of thumb but the situation can also be pictured in terms of phasors. Figure 3b is taken from a triac data book and shows the kind of diagram you might come across in your general browsing through the data books.

The very same RLC circuit crops up all over the place (although sometimes R might be the resistance of the inductor or of some other device, rather than a physical component). In a transformer there will always be some magnetic leakage — flux which does not link both coils — which makes the transformer appear to have an inductor in series with each winding. In many applications this can be a nuisance but in fixed frequency circuits it can often be 'tuned out' with a capacitor chosen to resonate with the leakage inductance at the circuit's operating frequency. The capacitor doesn't prevent the magnetic leakage, mind you, it just prevents the effects from upsetting the circuit's operation.

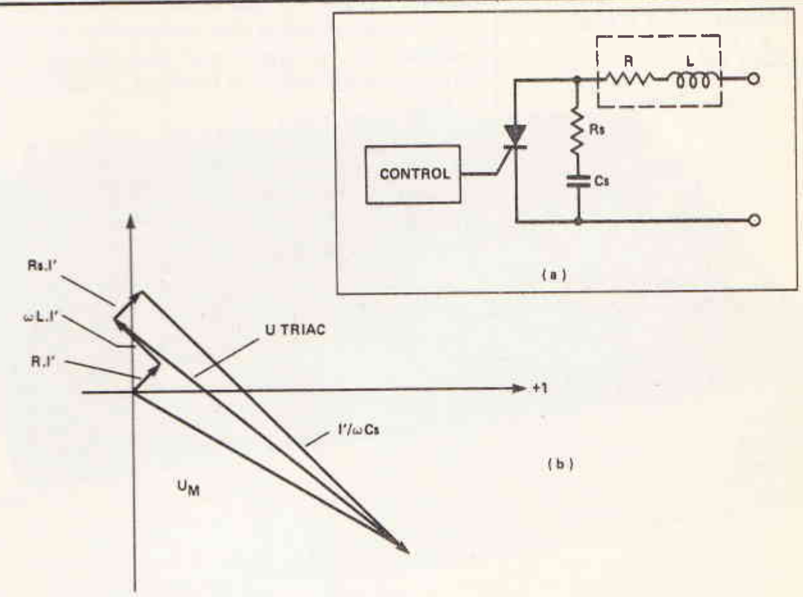


Fig. 3(a) Triac snubber network. (b) Phasor diagram for the network drawn from a triac data book. U_M is the mains voltage, the three 'zig-zag' phasors to the left are voltages in the load and suppressor resistor generated by currents flowing in the resonant circuit. I'/C_s is the voltage across the suppressor capacitor and U_{triac} is the voltage across the triac, which exceeds the peak mains voltage.

Choosing a suitable value for the capacitor is easy enough if you have a value for the leakage inductance but you might be more interested in knowing the effects of component tolerances or frequency drift on the circuit. A quick sketch of a phasor diagram should show up the likely results.

If you are keen to find out more about phasors, you could do a lot worse than to track down the eponymous book by M. G. Scroggie. Being about twenty years old now it's unlikely you'll find it on the shelves of a bookshop but your local library may have a copy. A large portion of the book is devoted to examples based on networks and circuits which demonstrate the practical side of phasor diagrams. It assumes a certain level of understanding of basic techniques but if you've followed the ETI articles you shouldn't have any difficulty with it. ETI

VIRTUOSO POWER AMPLIFIER

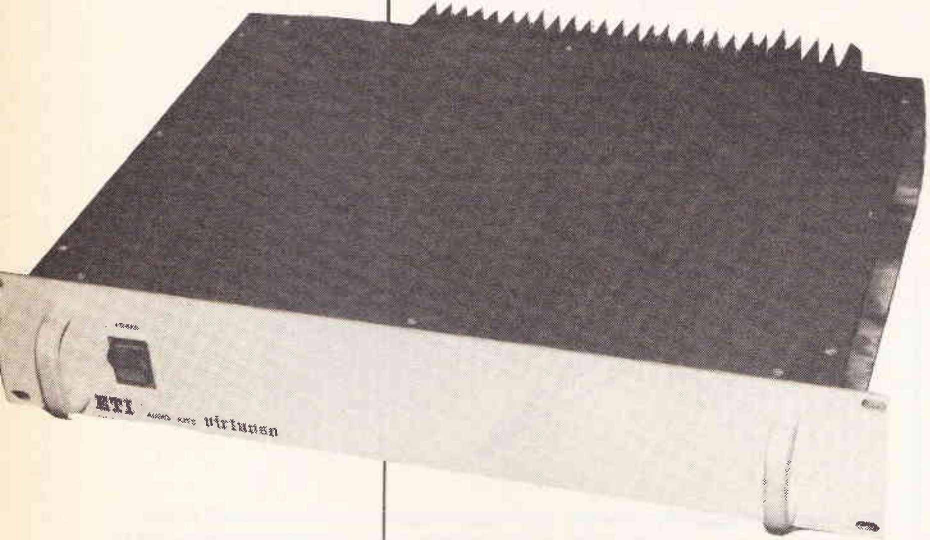
Graham Nalty launches his super-fi project with a look at the design features and power circuits of the Virtuoso Power Amplifier

PROJECT

High fidelity amplifiers should drive loudspeakers to produce the same sounds that create the effect and enjoyment at a live performance.

For a top performance amplifier it is vital to use top quality components. I was pleasantly surprised at the number of readers who opted to build the upgraded Virtuoso pre-amp rather than the standard version (ETI June-November 1986). In preparing this matching power amplifier I have taken the upgrading a stage further, using even higher quality components.

The requirement that an amplifier should be designed for accurate (and pleasurable) sound reproduction presents a problem or two. Such a



requirement cannot be measured during development, only auditioned when complete. Fortunately as a result of extensive research, development and testing of audio amplifiers, I can identify those design areas which are most crucial to sound quality.

Those features I have listed below as crucial or important should be pursued to the limit of your budget. Every improvement in these areas should give an improvement in sound quality. The other features of design may not give an improvement in sound quality but inadequate design may result in degraded sound quality or other problems.

Crucial Factors

A power amplifier needs a good strong power supply with low impedance through the whole audio frequency range (and beyond). A mains transformer with a VA rating several times the total power rating is the very first requirement for a good sound.

Passive components (resistors, capacitors) are extremely important and the price difference between the standard and upgraded versions of this amplifier is mostly due to higher grade passive components.

Every cable carrying the signal or power supply will degrade the overall sound as a result of conductor impurities and dielectric losses in the insulation.

Important Factors

Temperature generated distortion can occur when the gain of an audio amplifying transistor varies with changes in the temperature at its junction. The changes in gain cause a blurring of the sound — possibly the reason why some people prefer valve amps which only suffer from temperature generated distortion due to ripple on the heater supplies.

The solution is to use power transistors attached to the heatsink wherever large current or voltage swings from the input signal are found.

This type of distortion also occurs in resistors and can be solved by using resistors with lower temperature coefficients and better heat dissipation properties.

Even with a good power supply, the amplifier circuit itself needs good power supply ripple rejection. Without it, crescendos become blurred and ambience is degraded. Cascade circuiting and ultra-high dynamic impedance improve ripple rejection considerably and using separate rectifiers and smoothing capacitors for separate stages of the amplifier helps prevent ripple from one stage affecting another.

Each switch contact and connector degrades the quality of a passing audio signal. If oxidised the contact acts more like a diode and sound quality is seriously degraded. Hence it is very important to use high quality switches (even gold-plated contacts for low level signal connections).

Slew Rate

Figure 1 shows how slew rate limiting can distort a sine wave signal.

It is essential that the amplifier can accurately process the fastest signal that it is likely to encounter. Also it is important that the amplifier can handle a slew rate considerably larger than the fastest input since distortion rises sharply as signal speed approaches slew rate.

It has been established that there is a strong correlation between slew rate and sound quality — the lower the slew rate the worse the sound. However this may not be because of the slew rate itself, but because the measures taken to increase the slew rate also improve the sound (very fast output transistors sound better because their gain is more linear at high frequencies for example).

DC Offsets

The DC offset is the DC voltage at the loudspeaker

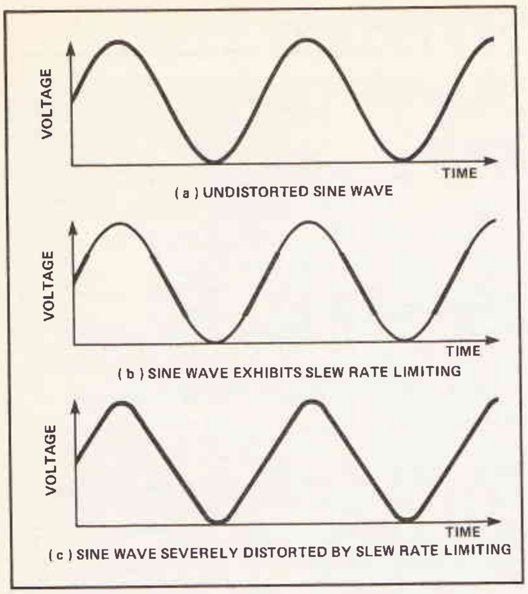


Fig. 1(a) Slew rate limiting.

terminals when no input signal is applied and which is constantly supplied to the terminals. I work within limits of +200mV — the level at which a noise becomes noticeable when a loudspeaker is connected. The Virtuoso Power Amplifier is specially designed for much lower offset.

The one way not to reduce DC offset is via a supply derived from the power supply lines as shown in Fig. 2.

Harmonic Distortion

Harmonic Distortion measurements have no direct relevance at all to sound quality. Measures such as cascode circuitry (Fig. 3) improve distortion figures (by improving linearity) but actually improve the sound quality because of improved power supply rejection (Fig. 4a).

Multiple feedback loops may reduce distortion (lower V_{be}/I_c variation) but in my experience are audibly inferior. This is possibly due to Transient Intermodulation distortion.

This distortion occurs when the signal input rises so fast that the feedback signal from the output of the amplifier cannot catch up. In an amplifier with large negative feedback the open loop gain that results is very large and overloads the internal stages of the amplifier. This does not sound pleasant!

An easy way to reduce TID is to lower the negative feedback (Fig. 4b) by lowering the open loop gain. Unfortunately this increases the harmonic distortion.

Current Delivery

Many designers are now claiming excessively large output current capability for their amplifiers, to some extent as an over-reaction to the situation where some high-powered amps were shown to have inadequate current delivery.

An amplifier can be overloaded either by voltage limiting (clipping) at a voltage just short of supply or by current limiting (by protection circuitry, power supply or breakdown current of the output devices).

An ideal amplifier has current and voltage capability designed so that the maximum voltage and current delivered under normal use are very close to (but do not exceed) the maximums. The ideal low-powered amplifier should in normal use overload on 50% of occasions due to voltage limiting and on 50% due to current limiting.

In the case of high-powered amplifiers the ability to supply a larger current or voltage can add considerably to the cost. At the same time it can be expected to have a large margin of reserve capability over the requirements for its use.

The Virtuoso Power Amp should be more than adequate for most users with a peak voltage capability of 40V and peak short term current limit of 40A (from protection circuitry). Also important is high frequency stability (oscillation at supersonic frequencies or ringing when driving square waves into reactive loads).

Those purists who can detect audible differences from phase inversion (reversed connections to each loudspeaker) would also include correct polarity (positive gain) as an important design feature.

These are the major features which are of concern in the design of audio amplifiers. Now we are able to move on to the details of the Power Amplifier.

As the power supply is the number one feature in a high fidelity power amplifier, I shall start with that (see Fig. 5).

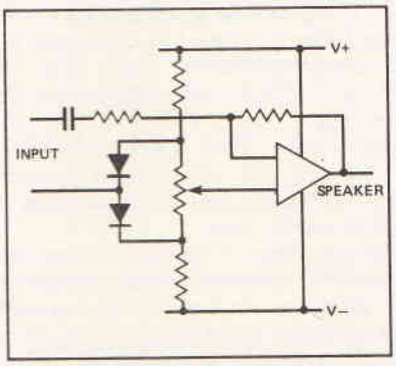


Fig. 2 DC offset adjustment not suitable for hi-fi applications

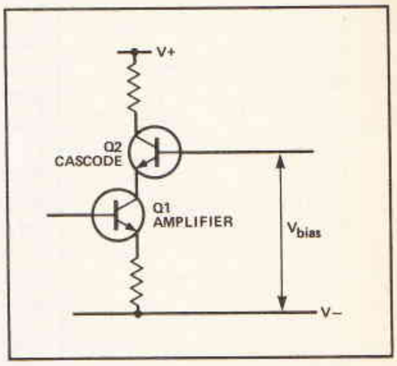


Fig. 3 Cascode circuitry improves linearity of gain for Q1 and power supply rejection from power supply

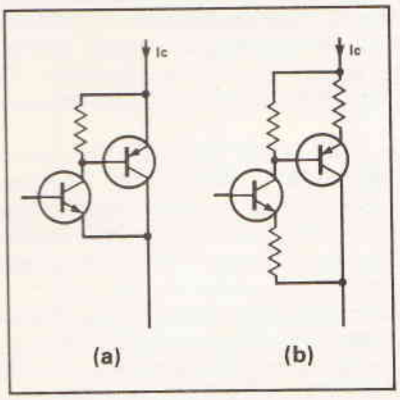


Fig. 4(a) Low variation of $\frac{V_{be}}{I_c}$

(b) Reduced negative feedback

Mains Supply

The great British mains supply is not exactly high quality but it is the only one we have, so let's make the most of it.

The effect of load interference from fridges, cookers and other assorted appliances can be considerably reduced by connecting a separate mains supply from the fusebox. A second separate supply can be used to good effect to power tuners, pre-amps, CD-players, turntables and cassette decks.

Further, a copper bar in the ground connected to the earth of these supplies will make an

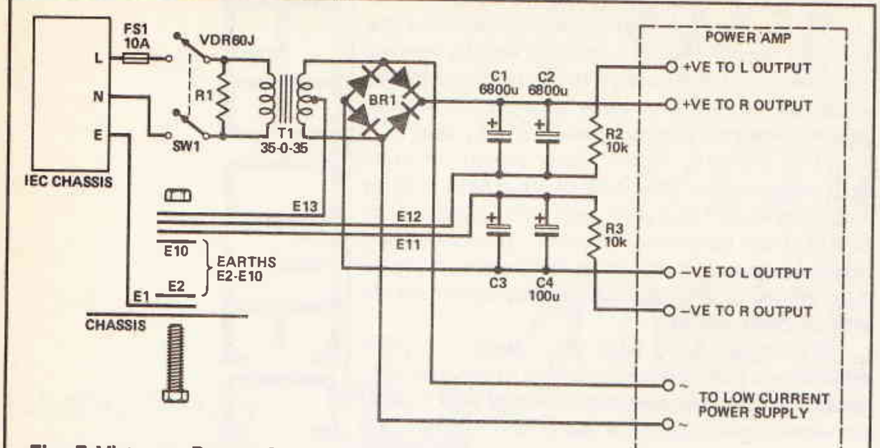


Fig. 5 Virtuoso Power Amp power supplies circuit theory

audible difference by removing currents induced in the earth by household appliances.

The old 15A plugs and sockets make a much better contact than the new 13A types, and it is possible to obtain gold-plated mains plugs and sockets (13A and 15A) to reduce the problems of mains tarnishing.

For mains cable there is a version of the Kimber 4 TC loudspeaker cable suitable for mains, its only drawback being that it cannot easily be fitted into a 13A mains plug.

The Virtuoso Power Amplifier has been fitted with a standard IEC socket which cannot really be justified in hi-fi terms. Anyone who wishes could bypass it by taking the mains lead directly from the fuse and switch (see power supply circuit in Fig 5).

Kimber Cable

Kimber cable is a multistrand cable of 7 different sized strands of oxygen-free copper, specially treated to increase surface conductivity. The insulation is of Teflon tested at 1500V to ensure its integrity.

I have found it the best cable for internal wiring of amplifiers to date. Firstly the sound quality is good — better sonically than the single strand cable I used in the Virtuoso Pre-amp. The second advantage of Kimber is that it is easy to use — flexible but it stays where it is put.

Kimber cable has two disadvantages. Firstly it sounds different if the direction is changed so it is usually supplied with arrows pointing in the preferred direction from cartridge to speakers (or from mains socket to rectifiers or from mains transformer to rectifiers to amplifier circuits). Secondly it is ten times the price of the single core cable used in the pre-amp!

Fuse Views

The mains fuse FS1 will of course slightly degrade the sound quality of the amplifier but is included for safety reasons (and because most constructors will want it). The 1¼in fuseholder used has a higher current rating than 20mm holders but is not ideal for hi-fi because of its lightly sprung contacts.

It is time to look seriously at fuses in audio amplifiers. We should have fuses firmly attached (screwed down) to the fuseholder. We should test many fuses for audio quality to find those with the lowest sonic degradation. (I would be interested in hearing from any readers who have encountered silver fuses for audio applications).

PARTS LIST

	Standard	Upgraded Version	3U Case
RESISTORS			
R1	VDR 60J 275V	VDR 110J 275V	VDR 110J 275V
R2, 3	10K ½W metal film	—	—
CAPACITORS			
C1, 2	6800µ 63V	6800µ 63V* BHC ALS 20A	15000µ 63V BHC ALS 20A 2200µ 63V LCR FAC114/ULL
C3, 4	100µ 63V	100µ 63V Mullard 108	100µ 63V Mullard 108
SEMICONDUCTORS			
BR1	25A 200V bridge	Motorola BYW62	IR 25CPF20 + 25JPF20 or 26MBF20502
MISCELLANEOUS			
FS1	Mains fuse holder 1¼in × ¼in chassis mounting with 10A fuse		
SW1	Mains switch rocker type		
T1	Mains transformer (low mechanical noise) 35-0-35 300VA	35-0-35 500VA	

IEC chassis plug and insulating cover. ¼in blade push-on connectors and insulating covers. insulating fuse-holder cover. 2BA soldertags. 2BA crimp connectors (red sleeve*). heavy duty cables*. M16 cable gland and cord grip bush (3U version in place of IEC plug).
*see Buylines.

It has been observed that by increasing the fuse rating, the sound quality is improved. Unfortunately this reduces the protection given and may even result in legal problems if the house burns down as a result!

Similarly the best mains switch in sonic terms would be no switch at all, but for safety reasons I cannot recommend its omission.

Even with a separate supply for your amplifier and a copper bar going through your floor the mains voltage is still far from a perfect 50Hz sine wave. There are three ways to reduce the problem.

Mains filters have series inductors in the current path and this resistance to the transformer current demands make the amplifier sound sluggish, degrading the portrayal of rhythm and tempo in music.

Capacitors can be used for interference suppression although class X capacitors should not be used in positions where failure might expose anyone to electric shock. Class Y capacitors do not have that restriction.

Voltage dependant resistors exhibit a high resistance at voltages below the mains peak (350V for 250V RMS mains). When this peak is exceeded by a certain margin the resistance rapidly decreases and the VDR absorbs all the energy of the excess voltage.

The rating of VDRs is normally specified in joules. The VDR in the Virtuoso (R1) is rated at 110J. If the voltage surge reaches 600V the VDR will pass a clamping current of 40A — obviously for a very short period of time.

Transform Your Mains

The mains transformer is the heart of a good amplifier. It is simply not good enough to say that your amplifier gives 100W per channel so needs a 200VA transformer. Having a bigger transformer will significantly improve the all-round quality of the amplifier.

In the standard version of this Virtuoso Power Amplifier the transformer is rated at 300VA. The upgraded amplifier uses one rated at 500VA — the largest that will fit in a 2U case. If you were prepared to use a 3U case you could fit a 625VA transformer.

The problem of mechanical noise from the transformer is addressed by using an audio-grade transformer wound specially for low mechanical noise.

Many constructors prefer to house the transformer outside the case containing the circuitry to avoid either transformer vibration or electromagnetic/electrostatic fields affecting other components. Certainly I would reduce vibrations by situating the amplifier on a non-resonant surface. The disadvantage with a remote transformer is the finite resistance of additional cable, plugs and sockets.

Rectify Yourself

I have used a standard (low cost) 25A bridge rectifier in the standard version and the Motorola BYW62 35A bridge in the upgraded version.

In both cases the bridge is bolted to the heatsink to minimise any effects of temperature generated distortion.

Recently I was most impressed by the improvement achieved by fitting fast recovery rectifier diodes in place of standard power diodes in an amplifier. I will be recommending them in the low current power supplies of upgraded Virtuoso Power Amplifiers.

The main reservoir capacitors (C1, 2) of an amplifier are extremely important. These have a great influence on the sound quality and you *must* use capacitors of the highest quality (long life, high ripple current, low ESR).

Such capacitors are very expensive but are justified by their sonic performance.

Large electrolytic capacitors have excessive inductance so you can improve their impedance characteristics by bypassing them with smaller values which have less inductance and react faster to high frequency transient loads.

The upgraded amplifier shown pictured has a main reservoir capacitor of 6800µ (C1,2) bypassed directly by a 100µ Mullard 108 long life electrolytic (C3, 4) with a further top quality 1µ0 polypropylene located on the circuit board very close to the output devices.

Incidentally the value of 6800µ is restricted by the size of the case and constructors seeking extended deep response are recommended to use larger values.

The output stage of the amplifier draws high currents and even with a low impedance power supply the effect of these currents is to generate an additional ripple voltage on the power supply lines.

Despite very careful design the input circuit of the amplifier is very sensitive to such a ripple voltage.

The most effective way to prevent ripple caused by the output stage from reaching the input stage is to feed both parts of the power amplifier from completely separate rectifiers and reservoirs.

Figures 6-8 show different ways of providing power to the lower level stages of a power amplifier.

Fig. 6 is very common in low quality amplifiers. Not only does this kind of circuit give poor sound quality but it is more prone to high frequency instability from unwanted high frequency oscillations fed back along the power supply lines.

The circuit of Fig. 7 gives better performance at high audio frequencies and suffers less from high frequency instability but that of Fig. 8 is considerably more superior still in both ways.

It is not essential that the power supply components (rectifier and reservoir) are as high quality (expensive) as those required for the output stage.

Next month I shall be moving on to describe the power supply regulator circuits.

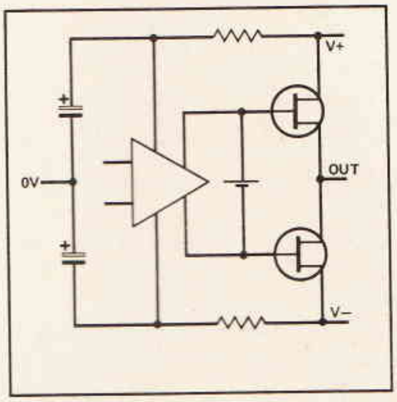


Fig. 6 Power amp power supplies connections

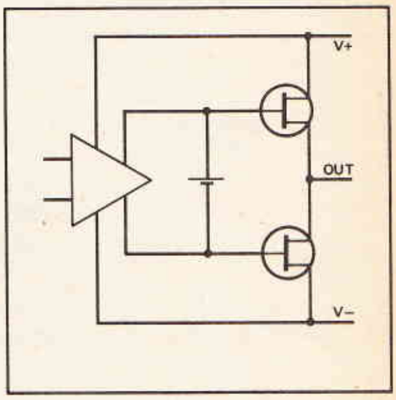


Fig. 7 Improved power supply

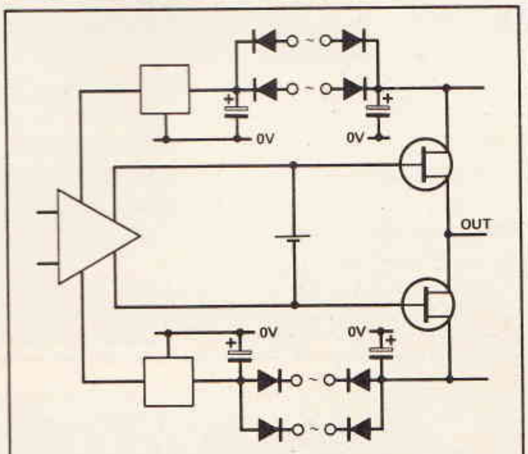


Fig. 8 Top quality power supply

BUYLINES

If a larger case than the suggested 2U case is used, the value of C1, 2 should be increased. Only highest quality capacitors should be used such as ALS 20A, Mullard 114, LCR FAC 114/CW or DIVM slit foil.

The 2BA red-sleeve crimp connectors are suitable for cables of 0.5mm² to 1.25mm² (2 cores of Kimber cable). Cables between 1.5 and 2.5mm² require blue-sleeved connectors, and up to 6.55mm² require yellow.

For the upgraded Power Amplifier 2 cores of Kimber cable in parallel (twisted together) are recommended for all high current connections.

Top hi-fi reviewer Paul Miller gives his verdict on the 2U versions of the Virtuoso.

Although most enthusiasts will derive great pleasure in the construction of their own amplifier, the absolute quality of these units remains a bone of contention. This short piece assesses the basic and upgraded Virtuoso power amplifiers — technically and subjectively — in the light of comparably priced domestic designs.

On test there proved to be significant differences between the two products. Taking the more expensive amp first, the distortion figures were very good at the 1W level, being primarily composed of second and third order harmonics. The higher order and more subjectively disturbing harmonics were suppressed by at least 100dB throughout the power bandwidth. Only the second-order intermodulation results were a little weak at this price level, however 0.11% is acceptable.

A 2.67dB power increase was registered between the 8 and 4 ohm loads but the supply sagged quickly into lower impedances — the 3.4dB loss will restrict the use of more 'awkward' loudspeakers.

Another thing to watch is the input level. With less than half a volt required to reach full output it will be very easy to drive the amp into clipping. This may reduce the useful range of a preamp's volume control but it does allow the Virtuoso to be driven directly from line sources, such as tuners, cassette decks and CD-players.

The cheaper Virtuoso amplifier had similar power characteristics but proved to be marginally unstable under the test conditions. Fortunately, full-blown oscillations did not occur but a parasitic RF resonance (probably around 10MHz) caused intermodulation within the audio band. This was manifested as 'fuzzy' crest on the output sinewaves (as viewed on an oscilloscope) long before clipping was reached.

Furthermore, the spectrum analyser revealed a large increase in 2nd-10th harmonics (typically around −68dB) associated with all fundamental tones above one quarter power. This is reflected in the THD figures. I am sure that this is a layout (capacitive?) problem which should be easily rectified, at which point the technical parameters should be on a par with those of the upgraded amplifier.

Subjectively, the Virtuoso sounded quite 'fast' and dynamic, reaching some form of sonic equilibrium very soon after switch-on (some amps take several hours).

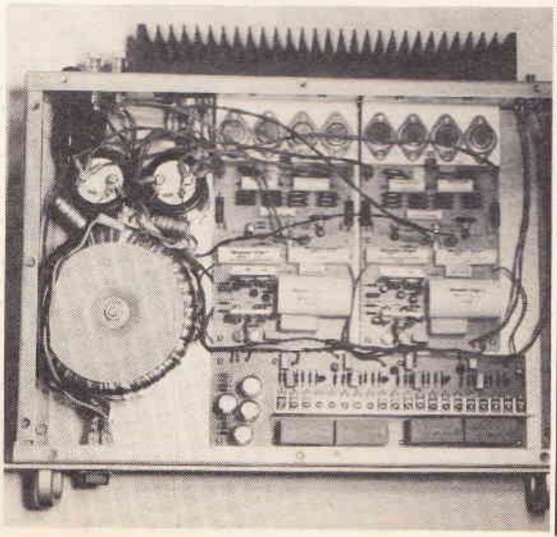
The bass was suitably tight and well controlled but the upper octaves appeared rather more forward and 'obvious'.

Strong vocal material was articulate and well-defined, the stereo soundstage was not as precisely focused as with some of the better domestic amps but the larger-than-life image certainly had a tanglible quality about it. Percussion was detailed, incisive and full of a sharp, metallic timbre. This is a hard and fast amp that reveals bags of detail.

The standard version was noticeably softer-sounding than the top Virtuoso with a restrained top-end and less of the latter's beguiling fluidity. Of course, much of this may be attributed to the complex distortion structure which is precipitated by the instability. Nevertheless, many enthusiasts may actually prefer the laid-back, less incisive, but ultimately less accurate reproduction of this amplifier.

The Virtuoso power amplifier will stand comparison with some of the better domestic products in most aspects of its performance — slotting comfortably into most good-quality hi-fi systems. It should also be great fun to build!

Test Results	Standard	Upgraded
Max continuous power output, 8 ohms	103W	89W
4 ohms	173W	164.5W
2 ohms	50W	75W
8 ohms + 2µF	Marginally unstable	Output voltage held
Total harmonic distortion (0dBW=1W)		
100Hz	0.011%	0.0021%
1kHz	0.0035%	0.0036%
10kHz	0.0067%	0.0046%
(at ⅔ power) 100Hz	0.093%	0.001%
(at ⅔ power) 1kHz	0.088%	0.001%
(at ⅔ power) 10kHz	0.027%	0.0019%
Anharmonic distortion	−73dB	−84dB
Noise (unwtd)	−99dB	−105dB
Intermodulation distortion (0dBW)		
in-band	−55dB	−58dB
out-of-band	−58dB	−58dB
(at ⅔ power) in-band	−56dB	−70dB
(at ⅔ power) out-of-band	−48dB	−71dB
Input sensitivity (max output)	497mV	402mV
Output impedance/Damping factor	0.054 ohms/148	0.033 ohms/245
DC offset	−7.7mV	+32.6mV
Phase	positive	positive
Kit price	c. £250	c. £450



AMBIENCE AND CRESCENDO

The ambience of a live musical performance is an easily degradable property. Ambience can be lost by delayed electrical disturbances such as dielectric absorption in capacitors, by temperature generated distortion in resistors and semiconductors, by low level 50Hz and 100Hz ripple in power supplies and by poor power supply ripple ejection in the amplifier circuit.

There are several 'audiophile' amplifiers that sound pleasant for a single instrument or voice but which sound blurred when several instruments play together or crescendo. The main cause of this is poor power supply ripple rejection, and also power supplies being shared between different stages of amplification.

Needless to say, the Virtuoso Power Amplifier tackles all these problems head on.

CLOCKWISE

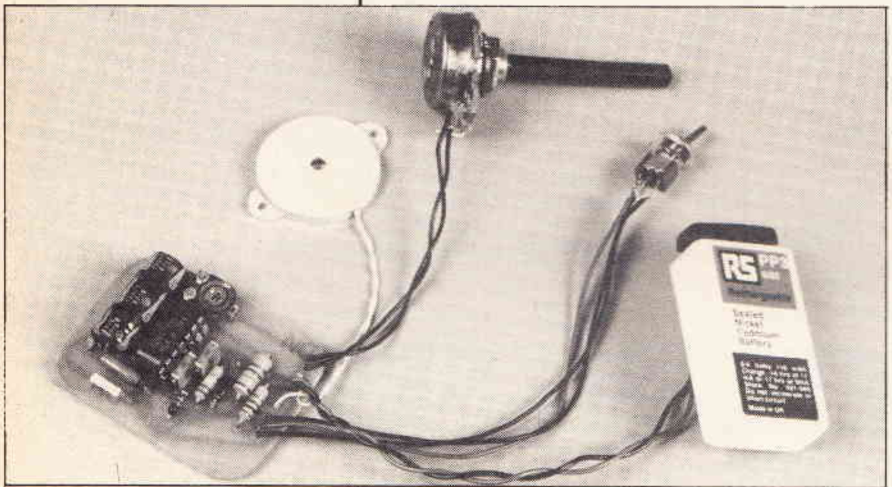
Fed up with hard soft-boiled eggs? Un-chuffed with singed toast? Keith Brindley kicks off our beginners' project series with a kitchen timer

Although this project could never be as accurate as a quartz-locked, microprocessor-controlled, sooper-dooper, whiz-bang model, you've got to admit it's simple and it's neat. It will give timing intervals of 1 to 30 minutes, with only a few seconds or so leeway, and we reckon that's good enough for *most* kitchen or household uses.

With a few minor component value modifications the circuit could also be used to time many other ranges too as a photographic timer, PCB ultra-violet exposure timer or the like.

If You Can't Take The Heat

Most kitchen timers are either mechanical devices which you wind up and which give a single ring of a bell at the end of the timing period or are LCD digital clock-type devices. The former are only as accurate as the mechanism allows (not very)



whereas the latter types are quartz-locked and so are extremely accurate. The ETI timer falls somewhere in between the two, having the advantages of electronic timing while still being easy to build.

The timing method used is a simple capacitor charging circuit. Maximum delay is approximately equal to the time constant formed by just two components so you simply have to change these component values to suit other applications.

Construction

Two ways are suggested to build this project — on PCB or stripboard. Both methods are straightforward and apart from a few points are more-or-less self-explanatory.

On PCB, construction doesn't need to follow any particular order, although it's probably best to leave the integrated circuit till last. Follow usual precautions handling the chip but it needn't be mounted in a socket. Instead solder it in — 4011s aren't exactly pricey so if you destroy one you can bung in another. Go easy on the heat. Solder one pin then leave the IC to cool before moving on to solder the next pin.

On stripboard, it's probably best to stick to a conventional order. That is, make all copper track cuts first then insert and solder all wire links followed by resistors, capacitors, flying leads to peripheral components. Lastly insert the IC, although as with the PCB version there's no essential need to use a socket.

Whichever construction method you choose, check that no solder links or bridges are present between components or IC pins.

Although we've offered no suggestions for

HOW IT WORKS

Gates IC1a, b form a gated astable multivibrator with a free running frequency of about 3.8kHz. Output of this stage is connected directly to a piezo buzzer.

The astable is gated by the input at IC1 pin 5 and is driven by the output of a monostable multivibrator, formed by gates IC1c, d. The monostable 'on' state is defined by the time taken after switch-on for capacitor C2 to charge up via preset RV2 and potentiometer RV1 such that when pin 8 voltage falls below the gate's threshold value the monostable turns off taking the gate output at pin 10 high and turning on the multivibrator.

$\text{Time} = 0.8 \times C2 \times (RV1+RV2)$

So, for the component values in this circuit, the maximum delay is:

$0.8 \times 1000 \times 10^{-6} \times (2.2 \times 10^{6} + 1 \times 10^{5})$

that is, 1840 seconds or about 30 minutes. Greater ranges can be obtained with larger value components, smaller ranges with smaller value components.

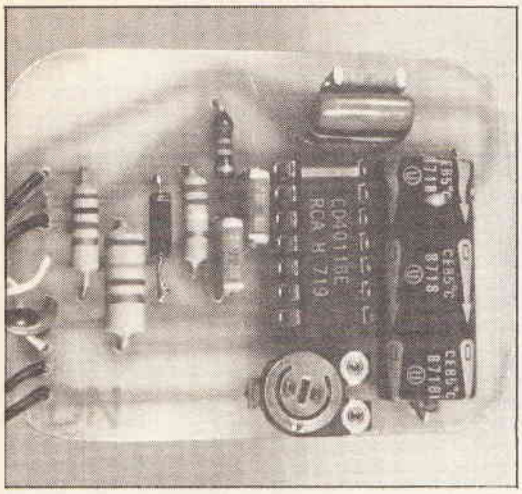
Zener diode ZD1 provides voltage regulation so the circuit operating voltage (3V) is maintained at a constant value regardless of battery voltage. A slightly higher zener value than this (up to 6V8) can be chosen if a louder alarm is required. The higher the zener value, however, the shorter the time until the battery operating voltage falls too far for the regulated voltage to be maintained — creating timing inaccuracy with flat batteries.

To ensure the charging capacitor C2 is fully discharged between consecutive timing operations, switch SW1 connects resistor R2 in parallel with the capacitor when the timer is turned off.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	1k0
R2	270R
R3	1M0
R4	220k
R5	180k
RV1	2M2 lin pot
RV2	100k sub-min horizontal preset
CAPACITORS	
C1	100n polyester
C2	1000µ 16V electrolytic
C3	4n7 polyester
C4, C5	1n0 polyester
SEMICONDUCTORS	
IC1	4011
ZD1	3V0 500mW zener diode
MISCELLANEOUS	
B1	9V PP3 battery and clip
SW1	SPDT toggle switch
BZ1	Piezo buzzer (3.8kHz)
PCB or Veroboard. Case. Connecting wire.	

1st CLASS



housing your project, any suitable sized box can be used. The only real precaution you need to follow is to mount the piezo buzzer on the outside of the case (if it's on the inside you won't be able to hear it!).

Setting Up

You'll need a fairly accurate watch here, preferably with stopwatch facilities. Initially, set potentiometer RV1 to minimum resistance — fully anti-clockwise. Also set preset resistor RV2 to about the middle of its range. Make sure that switch SW1 is in the off position — resistor R2 must be connected in parallel across capacitor C2. Connect the battery.

Now simultaneously turn on your project and note the time (or set your stopwatch going). Nothing should happen. Good eh? However, after 40-50 seconds, the alarm tone should be heard from the piezo buzzer. Note the time taken and turn switch SW1 off. Setting up is now just a simple procedure of adjusting preset RV2 and re-timing the time interval until exactly one minute is obtained.

Once you've done this, turn potentiometer RV1 (the main control) fully clockwise (maximum resistance) and then re-time the interval again. Something around 30 minutes should now elapse between turn-on and alarm.

Once your project is housed, the potentiometer control can then be marked off in a linear scale from the one minute minimum to the maximum.

If you have a frequency meter you can fine tune the alarm frequency to make sure the astable multivibrator's frequency is on the resonance of the piezo buzzer, to give maximum volume. However, this is by no means essential as the piezo buzzer will still sound pretty loud, anyway. ETI

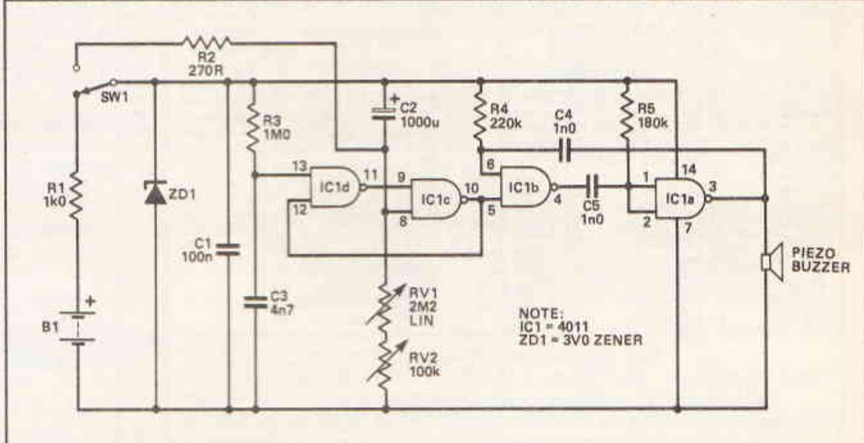


Fig. 1 Circuit of the ETI kitchen timer

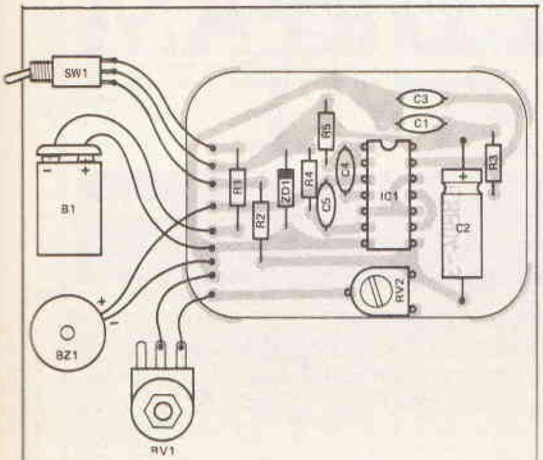


Fig. 2 Component overlay for the PCB

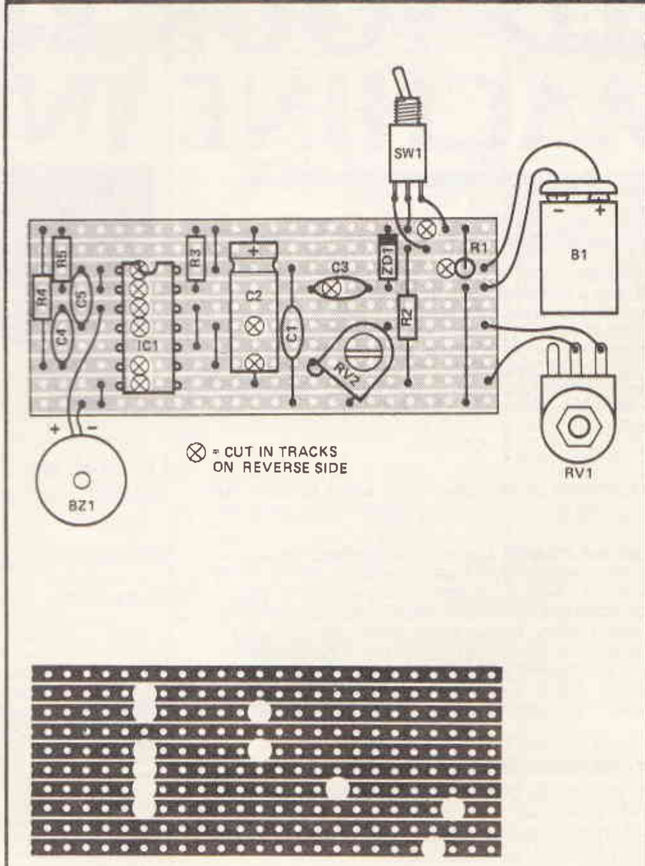


Fig. 3 Strip board component layout and track-cuts on copper side

BUYLINES

All components are readily obtainable from most sources. Values of most components are not particularly critical, so you can use closest alternatives. Capacitor C2 and the variable resistors define the timing range, however, so if they are altered the range will be changed too.

Piezo buzzers of the resonance used in the prototype were obtained from Maplin, although any other resonance will work — in which case the necessary resistance/capacitance values could be adjusted to give greatest output alarm volume.

PCB is available from ETI's PCB Service.

PROJECT

COMBO-LOCK

Chung Yiu Ko keeps his valuables safe and sound behind closed contacts with his combination lock circuit

Neighbourhood Watch schemes cover the land. Little orange stickers appear in the windows of every semi-detached in the Kingdom.

Security in the home has a higher profile today than ever before and a simple electronic locking device could be worth its weight in missing cufflinks.

This circuit detects correct sequence input and provides a relay output suitable to trigger an electronic lock. Its main beauty is that it uses no ICs and keeps thing simple and cheap.

The correct combination is hardwired rather than programmed and the lock could be used to protect door openers, burglar alarms, car ignitions — the applications are limited only by your imagination.

The circuit diagram is shown in Fig. 1.

The heart of the circuit is the sequential detector which interprets the correct sequence inputs from the key switches, turns the output on and activates a relay. An indicator (LED1) indicates that the correct number sequence has been entered.

HOW IT WORKS

The sequence sensing circuit is constructed around Q1 to Q6, the key switches and the relay.

Initially Q1 to Q6 are non-conducting. As soon as key 1 is keyed Q2 is forward biased, collector current flows through R4 and the base and emitter of Q1. C1 charges via R3 and R4 which provides sufficient bias to turn Q1 on. The voltage drop developed across R2 (due to Q1 collector current) briefly holds Q2 on and a constant current source is now available at the emitter of Q1, forming the power source for the remaining stages of the emitter follower.

The functions of Q3 and Q4, Q5 and Q6 are similar, except that the loading of the final stage is a relay coil and LED indicator.

Obviously the keys must be keyed in correct sequence (1, 6 then 8 as shown in Fig. 1) otherwise there will be no power source available from one stage to another and the relay will never energise.

The incorporation of the keypad or keyboard enables the user to select any three digits of any combination number he chooses while the remaining keys are connected to the reset/alarm mode input.

Whenever the unselected keys are pressed the circuit is reset by pulling Q1 base to negative (via D1 in alarm mode) and at the same time discharging C1. Q1 is biased off turning off Q2. At this stage the entire sequence must be repeated.

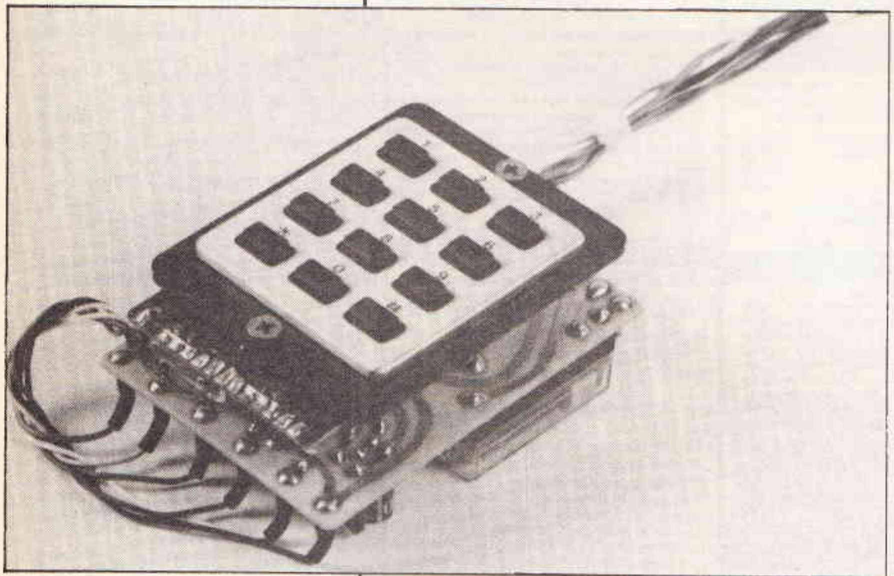
The second half of the circuit is alarm warning circuitry. Whenever a reset/alarm key is keyed (except the actual reset key 0) the alarm will sound for a short duration.

Q7 and Q8 form a basic astable multivibrator circuit. Initially the oscillator is inoperative, because Q8 is biased off via resistors R14 and R11 to the positive supply. As soon as a reset/alarm key is keyed, capacitor C4 charges via R16 with the polarity shown, Q8 becomes forward biased and the oscillation starts for a duration determined by the R11 and C4 network.

Gradually C4 discharges across R11 sufficient to cut Q8 off and the oscillator stops.

Q9 is a simple direct-coupling emitter-output power amplifier.

The circuit will operate well on 12V DC and draws a maximum standby current of 20mA. The maximum current is 400mA with the alarm and relay energised. This makes the device ideal for 12V car system or a mains derived supply.



If the right numbers are entered but in the wrong order then the sequence detector is reset and the entire sequence must be repeated.

Alarm circuitry is incorporated in the design and this is activated if the digits not appearing in the combination are pushed.

Construction

Though stripboard could be used with care, the PCB is recommended and the overlay is shown in Fig. 2.

The specified relay (see Buylines) will fit directly onto the PCB. It is possible to use any relay having a 12V 300R or higher resistance coil, but it may be necessary to redesign the printed circuit layout or mount the relay off board.

The key switches are of push-to-make momentary action type and any switches of this type can be used. However a low profile keypad or keyboard is more desirable for ease of construction (again see Buylines).

After inspection of the PCB for short circuits, broken tracks and any damage, the resistors should be soldered onto the board, followed by the capacitors, then the diode and transistors (care being taken with polarity of these components).

Once all the components are securely fitted onto the board, connect the corresponding wirings to the desired sequence and reset key switches.

In Fig. 1 the sequence number is shown as 1-6-8. Zero is for reset and the remaining unselected invalid keys are connected in parallel to the reset/alarm warning circuitry input.

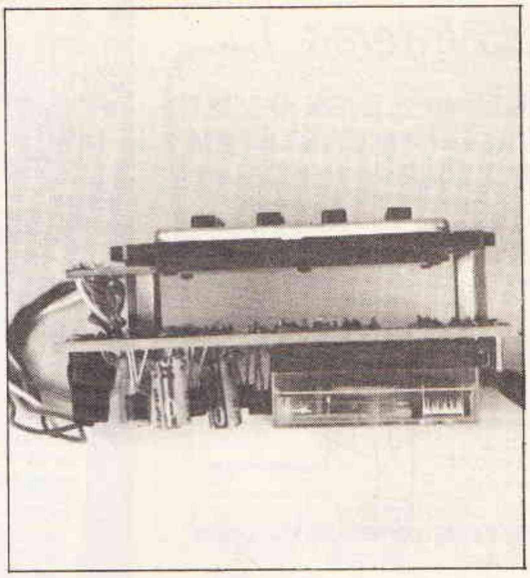
The PCB is purposely small so that it can be mated back-to-back with the keypad by two spacers, and tuck away in any suitable front panel.

For door opener applications the unit can be fitted in a metal blanking plate (as used in house wiring) and mounted in the doorframe, with the

PARTS LIST

RESISTORS (all ¼W 5%)	
R1, 5, 8	470R
R2, 6, 9	150R
R3, 7, 15	1K0
R4	82R
R10, 12	510R
R11, 13, 14	56K
R16	5K0
CAPACITORS	
C1, 2, 3	3µ3 12V electrolytic
C4	100µ 12V electrolytic
C5, 6	20n ceramic
SEMICONDUCTORS	
Q1, 3, 5, 7, 8	ZTX400
Q2, 4, 6	ZTX500
Q9	BD135
D1	1N4001
LED1	red LED
MISCELLANEOUS	
RLA1	12V relay 300R or higher
SW0-9	keypad or push-to-make switches

PCB. PCB pins (16). Wire. Nuts and bolts.



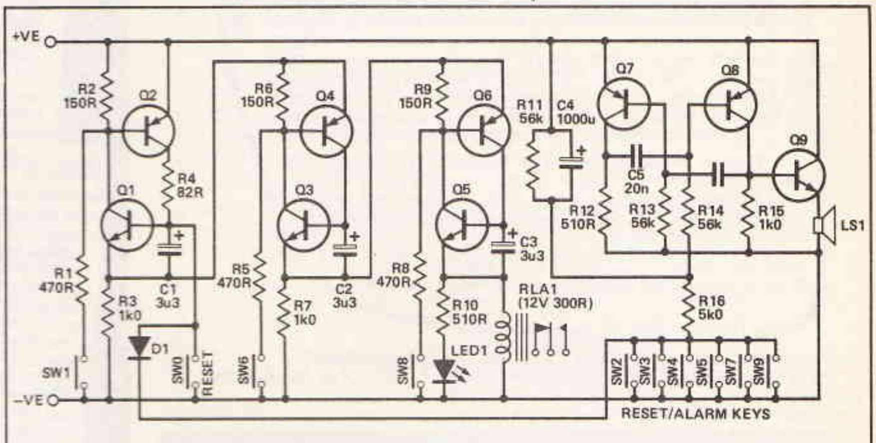
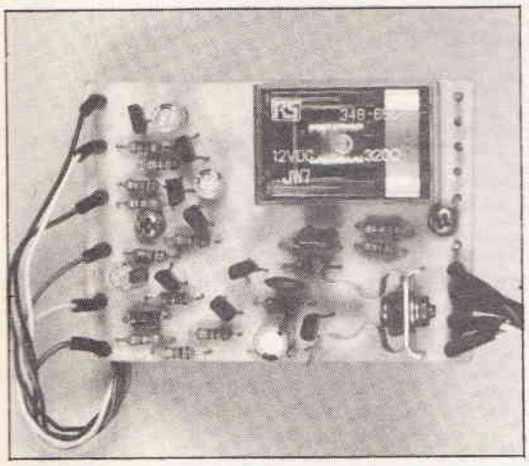


Fig. 1 The circuit diagram for the combination lock



speaker wired remotely indoors.

For automotive applications a small module case with metal front panel is most suitable. The base of the case can be secured onto the dashboard, with the metal front panel used to mount the complete unit.

The alarm in the circuit shown is not going to wake the street and alert the local alsatian brigade. In its present configuration it is more of a loud indication that the incorrect sequence has been entered.

It would not be difficult to fit a second relay into the alarm section of the circuit which could trigger a bell alarm, or a flashing neon arrow with 'Burglar' written on it, or even to release an enormous weight from the second floor onto the burglar (please note that ETI can take no responsibility for any visitors flattened by this method).

ETI

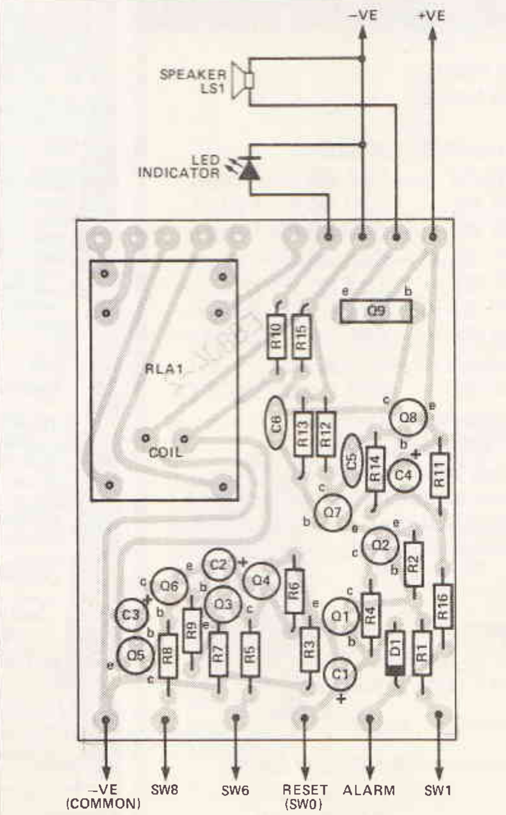


Fig. 2 The component overlay for the combination lock

BUYLINES

The relay used in the prototype was from RS components, stock code 348-655.

The keypad used was also from RS, stock code 333-704.

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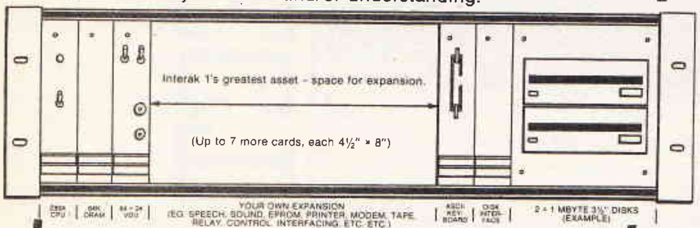

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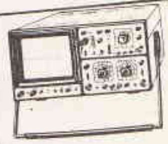

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TRANSATLANTIC TIME ZONE CORRECTOR

Andrew Armstrong flies economy but still arrives in good shape

PROJECT

An increasing number of people are now familiar with the problem of jetlag. It can be difficult to readjust the body clock to a significantly different time zone, particularly when travelling east. For people who habitually stagger out of bed just in time for work or appointments, the strain of having to get up five hours earlier can be the last straw.

Such is the case with a certain transatlantic friend of mine. On her visits to Britain every few years, it takes her a month to reprogram herself to get up before lunch time, and by then it is almost time to return home.

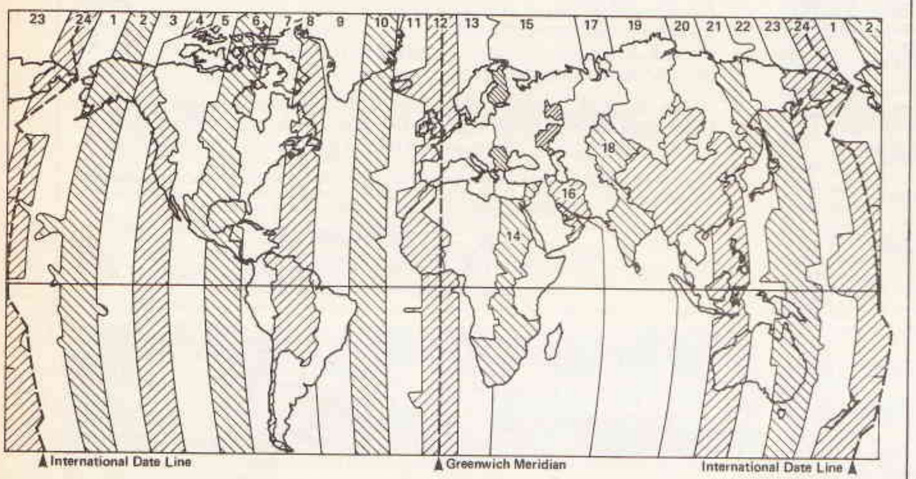

Fig. 1 The international time zones

On the theory that the body acts rather like a phase locked loop and comes into lock at a rate proportional to the time zone mismatch (the error signal) I resolved to reprogram her to move faster. The phase locked loop analogy suggested a possible solution. A bigger 'error signal' could be generated by switching on room lighting somewhat before dawn and the switching of the lamps could be controlled by (of course) a phase locked loop.

An oscillator frequency of one cycle per day (CPD) is obviously required and my first thought was to use a memory backup capacitor of perhaps one farad as the timing element. In fact, though, a more reasonable solution is to use a higher frequency oscillator with a more reasonable capacitor value and divide it down to 1CPD (0.0000115Hz).

The use of an exclusive OR gate phase detector in the phase locked loop takes care of the phase advance required in the control system because phase locking is achieved with the two waveforms 90° out of phase. All that is needed is a means to ensure the control output is phase leading rather than phase lagging. A lead/lag detector controlling another exclusive OR gate acting as an invert/noninvert gate will solve the problem.

It is in the phase detector that the high value capacitor comes into its own. Though the oscillator runs at a high frequency, the phase comparison must be carried out at the input frequency of 0.0000115Hz. This requires a time constant of at least several input cycles — several days. The values shown in the circuit will give a time constant of 5½ days, which will permit the circuit to lock in after only a few cycles.

Theory suggests that lockup times of between two days and two weeks are possible, depending on the switch-on time of the circuit, its initial state and the phase of this moon. This last effect is because a full moon may cause the photodetector to switch on earlier or off later and may induce a certain amount of phase jitter on the signal to which the oscillator must lock.

Some readers may be surprised at the choice of a relay to switch the load, rather than a triac. The reason is that it is felt the best form of lighting may be a flourescent lamp of the 'artificial daylight' or 'northlight' variety. (These tubes simulate the spectrum of normal daylight more closely than other forms of light. You can demonstrate this by trying to read a resistor colour code which includes purple and red or blue, under ordinary lamps and under these special types).

Fluorescent lamps are notoriously difficult to switch with triacs, so a relay is chosen for this application to ensure long term reliability.

Assembly

The circuit is best built on the printed circuit board, shown in Fig. 4. For those who wish to do their own stripboard layout, the following tips may be useful.

Make sure decoupling is good and that the earth consists of two parallel tracks to obtain low resistance. It is vitally important to prevent interference from being picked up by this circuit. After all nobody wants to find, after two weeks of waiting for the loop to lock properly, that the phase is disrupted due to the activities of the local CB enthusiast using slightly over the specified four watts.

The rest of the assembly should be simple, with the relay and power transformer being off-board to prevent mains-borne interference from disrupting its operation. One thing to remember is not to underestimate the space required for the 1F0 capacitor. On the prototype, this was fitted late in the assembly to avoid heat damage. It wouldn't fit and had to be glued upside down on top of IC1. Don't make the same mistake!

No specific case has been recommended for this project, but in order to allow light in to the phototransistor, one might use a transparent case. A perspex cube of the type intended to display photographs would be a good choice.

Fast Locking

Those constructors who are impatient to check the operation of the circuit and who possess the necessary test equipment may use the following procedure.

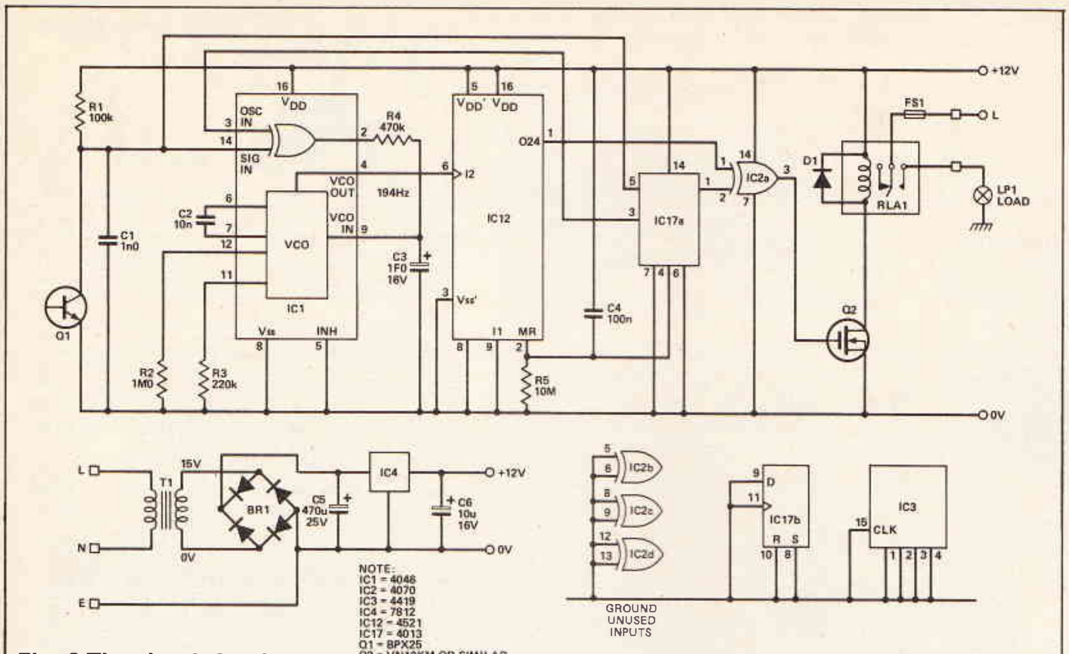

Fig. 2 The circuit for the time zone corrector

At midday switch on the circuit. The counter will receive a reset pulse via C4 and R4 and then will be allowed to count. This is the state which it should be in at midday, assuming that midday is in the middle of the daylight period. In this phase, the output of the counter will be at logic 1 when the lamps should be on and does not require to be inverted so the flipflop which stores phase information (lead or lag) is also reset.

To complete the fast locking procedure, connect a 1k0 potentiometer across the power supply lines and connect its slider to the top of C3, via a 470R resistor. Measure the frequency of the VCO using an oscilloscope or a frequency meter and charge C3 (by adjusting the potentiometer) to whatever voltage corresponds with approximately 194Hz. Disconnect the potentiometer.

The circuit has now been artificially put into a condition near lock. The phase may vary or oscillate around optimum for a few days but it should be useable almost immediately.

For those constructors without the requisite test gear, the method of testing is simple, if rather slow. First check that all the IC pins are receiving the correct logic levels and that the clock is clocking. If you connect a meter to the clock output and it reads about 6V then it is a reasonable assumption that it is working.

Then all you can do is wait. Sometime in the next 24 hours the relay should switch over, which shows that the counter is working. Then it is a matter of waiting for up to two weeks to see if the loop will lock. If it does not, check C3 was installed with the correct polarity and if not throw it away and buy another one. Check also that the phototransistor is actually detecting the daylight. If not, perhaps a period of testing near a south-facing window would be in order.

Test Results

Publication deadlines prevented a proper testing programme, so the author and the ETI staff carried out an advanced computer simulation to check all aspects of the theory. A simulation of the time zone corrector was compared with a simulation of a digital timeswitch (Woolworths, £9.99) and the results tended to indicate conclusively that the phase errors on the time zone corrector were no more than 5% greater than the digital timeswitch, an impressive performance for an analogue system.

For any who may doubt the validity of these tests, I would stress the simulations *were* realistic and included the effects of a failing timer battery and of the triac in the timeswitch being destroyed by a mains spike generated by a defective fluorescent tube starter.

ETI

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	100k
R2	1M0
R3	220k
R4	470k
R5	10M
CAPACITORS	
C1	1n0 ceramic
C2	100n enamelled
C3	1F0 16V electrolytic
C4	100n ceramic
C5	470µ 25V electrolytic
C6	10µ 16V electrolytic
SEMICONDUCTORS (all black unless specified)	
IC1	4046
IC2	4070
IC3	4419
IC4	7812
IC12	4521
IC17	4013
Q1	BPX25 (silver)
Q2	VN10KM
BR1	W005 (mauve)
D1	1N4148
MISCELLANEOUS	
FS1	5A slow blow
LP1	mains lamp
RLA1	12V SP relay
T1	15V 6VA mains transformer
PCB or stripboard. Case. Sense of humour. Nuts and bolts.	

Due to lack of space the remainder of this project has had to be held over until the April 1989 issue.

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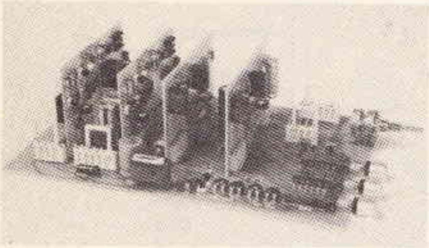

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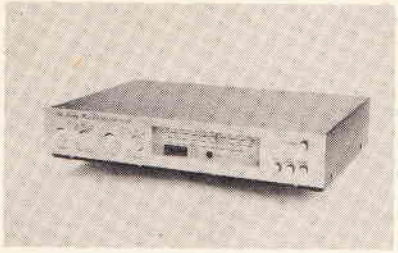

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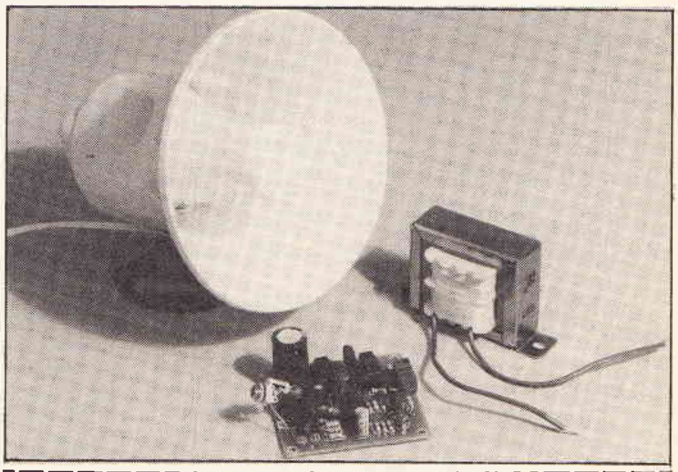

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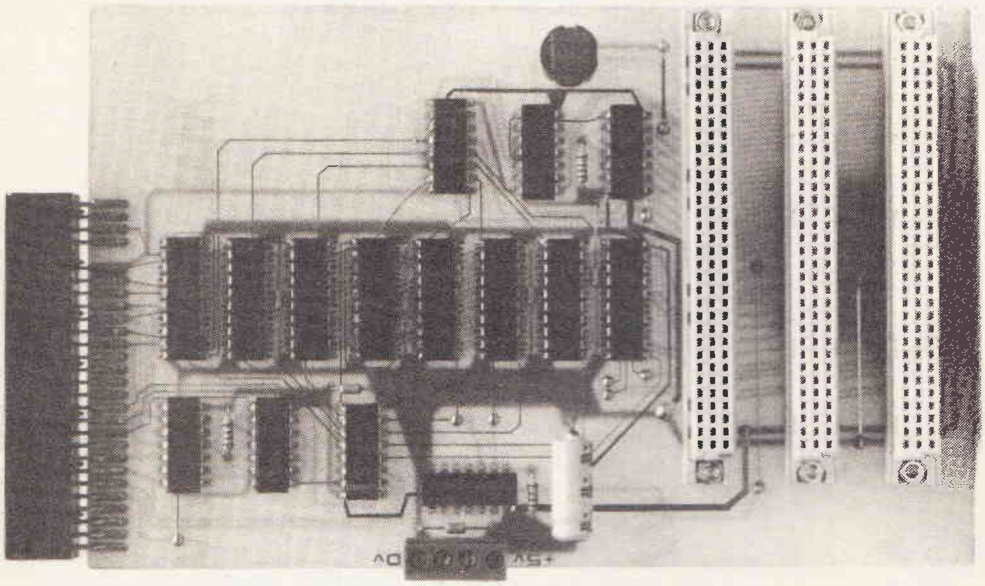
SPECTRUM CO-PROCESSOR

PROJECT

Graeme Durant continues to build his masterpiece and this month looks at the interface between the two machines



Over the past two months we have looked at the design and construction of a Z80 based CPU card and a Z80 compatible 256K DRAM card. Now we must turn our attention to the interface board which will turn these multipurpose circuits into a dedicated co-processor for the ZX Spectrum.

The interface board (see Fig. 1 and photo) has at one end a standard edge connector which plugs onto the expansion port of the Spectrum and at the other end a three slot 'mini-backplane' which conforms to the standard already adopted by the CPU and DRAM cards.

In the middle there are four locations of memory shared by the Spectrum and the co-processor, through which data can be passed to achieve bidirectional communication between the processors.

A reset button for the co-processor is also included, which is useful if software being developed gets stuck in a loop.

This board derives its power from an off-board 5V supply, separate from the Spectrum PSU. In this way, the already overworked Spectrum power unit is not strained. It is also possible to run the co-processor without the Spectrum attached, this being particularly useful if a stand-alone target application is being tested.

Construction

If you have managed to struggle this far through the project, the construction of this last card should prove no problem at all. Like the Z80 CPU and the DRAM card PCBs, this board is double-sided without through-hole plating (Fig. 2).

Links between the two layers must be made using tinned copper wire or the pins of the ICs. No discrete component leads are used to form through connections on this board.

If you prefer to put the ICs into sockets, 'turned pin' types must be used so connections can be made to the upper layer of the PCB (see the construction notes for the Z80 CPU card). Note that there are no links or components hidden under ICs to worry about on this board.

This PCB includes three connectors SK3, 4 and 5, which form a mini-backplane. These DIN41612 connectors should be soldered in position and bolted down for reliability, using short M2.5 nuts and bolts.

The edge connector to the Spectrum (SK6) is sited at the other end of the interface board, on the edge of the PCB. It should be mounted so that one row of pins are soldered to the top side of the board and the other row to the bottom side. A small modeller's vice can be used to squeeze the two rows of pins closer together before fitting to make soldering easier. Solder should then be run along each pin in turn to form a good connection with the PCB pads underneath.

The rest of the discrete components, the reset switch SW1 and the power supply connector SK7 should now be fitted. Finally, after thorough checking for solder splashes, clean away any remaining flux deposits from the board.

Testing

Without sophisticated test gear at your disposal, the best approach to testing is to plug the fully populated CPU and DRAM cards into the interface card, making sure that the various PROMs are also present.

Without using a Spectrum at this stage, connect the power supply (a 5V unit with a current capability of around 2A). If all is well, the co-processor will run its self test routine at power-up and as the DRAM pages are tested, the page LEDs

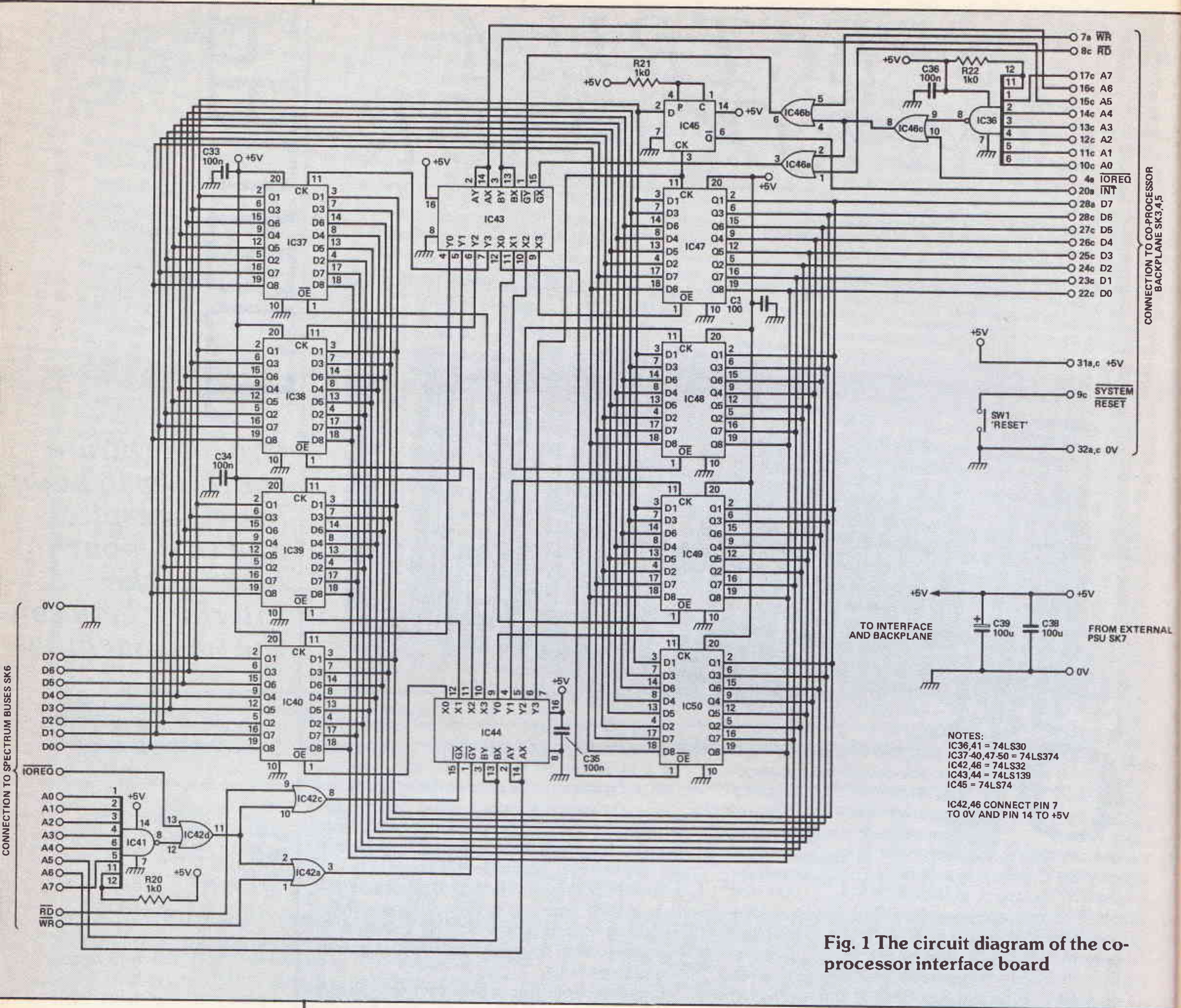


Fig. 1 The circuit diagram of the co-processor interface board

should each light in turn for a couple of seconds. If this does not happen, remove the power and check your construction.

The notes on testing which accompanied the construction notes on the CPU and DRAM cards apply equally to builders of the interface PCB.

If all is well, the power should be removed anyway (but with less haste!) and the interface board plugged onto the back of your favourite Spectrum. Apply power to both. Wait until the co-processor LEDs have stopped flashing and the Spectrum has come up with its start-up message. Now, on the Spectrum, type OUT 255,0 and press Enter then OUT 255,224 and press Enter again.

This is the command sequence from the Spectrum which tells the co-processor to run its self-test routine. If all is well, the DRAM page LEDs will sequence again. If not, a problem exists in the interface PCB and this must be checked thoroughly.

If you manage to get this far with everything working: congratulations! It looks like you have at least the majority of your co-processor hardware functioning. The acid test will be to see if a real application will run.

A fully documented application program for an interactive Z80 software development tool will appear in next month's article. Once this has been tried and proved to work, you can be certain your hardware is fully operational. In the meantime, we shall go on to have a closer look at the low-level software side of things.

The Software

The co-processor software is the final part of our system and it moulds the otherwise general purpose hardware into a dedicated co-processor.

This software consists of two distinct parts: the software which runs on the co-processor CPU itself — handling data transfer, command interpretation and execution — and the software which runs on the Spectrum — handling the other end of the data transfer plus the supply of co-processor commands.

All the co-processor's actions are initiated by a command from the Spectrum, passed via the four shared registers. As mentioned in the first article, the co-processor recognises just five different commands from the host — quite sufficient for all general purpose applications.

HOW IT WORKS

Although visually complicated by the bussing, the operation of the interface circuit (Fig. 1) is quite straightforward. The circuit may be considered in three main sections — the shared memory itself, the address decoding for the Spectrum and the address decoding for the co-processor.

Looking first at the shared memory, this appears to each of the processors as four locations of read/write storage. However, reading one of these locations will return the value last written into that location by the other processor. Thus, a bi-directional medium for data transfer is created between the processors.

To ease timing problems, access to the shared memory is asynchronous — data can be written or read by either processor at any time.

To achieve this asynchronous bi-directional operation, the memory used must be capable of being written to at one location, whilst simultaneously being read at another. This precludes the use of ordinary RAM and, since special dual-port RAM devices are very expensive, ordinary TTL D-type octal latches are used as the basis for the shared storage in this design.

Such latches have separate input and output data pins and separate clock data input and output enable controls. This allows reading and writing of their contents to occur independently and simultaneously. These registers are shown on the circuit diagram as IC37-40 and IC47-50.

IC37-40 have their data inputs driven from the co-processor data bus and their data outputs drive the Spectrum data bus. This allows the co-processor to write data to IC37-40, which can in turn be read by the Spectrum. Similarly, IC47-50 provide data transfer from the Spectrum to the co-processor, completing the bi-directional interface.

The Z80 microprocessor provides two mechanisms for passing data between itself and external circuits — basic memory addressing (normally used to access RAM and ROM) and I/O addressing (usually for accessing peripherals and the like).

Since the entire 64K memory space is already in use in the Spectrum, this project makes use of the I/O addressing facility of the Z80 for passing data between the machines. This idea was continued in the co-processor for the sake of simplicity.

All that remains is to drive the clock data input and output enable lines of the registers to provide access control to the processors.

This is the job of the two areas of address decoding logic. The address from the Spectrum is decoded by the logic based on IC41, IC42 and IC44. In the Spectrum itself, some of the I/O port locations are already in use. The unused ports are those which are one less than an integer multiple of 32.

In other words, the spare port addresses are those with their five least significant bits set to ones. Since there are eight such ports and we only need to use four of them, the most significant port address bit, bit A7, is also used in the decode process.

IC41, used here as a 6-input NAND gate, monitors the Spectrum address bus and determines when a shared port is being addressed. The output of IC41 is low only when the address low-byte is either 159, 191, 223, or 255 in decimal — these being the locations used for the shared registers in this interface.

The output of IC41 is ORed with the Spectrum $\overline{\text{IOREQ}}$ strobe by IC42d. So, the output of this gate is low if one of the four interface ports is being accessed.

The Spectrum address bits A6 and A5 select which one of the four shared ports is required. This is decoded by IC44, a dual 2-to-4 line binary decoder which has active low outputs. One half of IC44 drives the output enable pins of IC37-40 and is enabled when a Spectrum read access is detected by IC42c. When enabled, one of the four decoded outputs will go active low, according to the states of address bits A6 and A5.

The register thus selected will enable its data onto the Spectrum bus to be read. The other half of IC44 drives the clock pins of IC47-50 and is enabled when a write access is detected by IC42a.

When this happens, one of the four decoder outputs will go low, again determined by the states of address bits A6 and A5. The register selected will receive an active clock signal at the termination of the Spectrum $\overline{\text{WR}}$ strobe which will write the Spectrum data into that register. The net result is that the Spectrum can read data from any one of IC37-40 and write data into any one of IC47-50.

When IC47,the register at port location 255, is written to by the Spectrum, a single D-type latch IC45 also receives a clock pulse. Its data input is connected to the most significant bit of the Spectrum data bus. Thus its Q output reflects IC47s MS bit latch contents without the imposition of a tristate output.

The Q output of IC45 is used to drive the interrupt line feeding the co-processor backplane. This forms a convenient signalling mechanism from the Spectrum to tell the co-processor that a valid command is available (see the main text).

Unfortunately, the interrupt system in the Spectrum is already used and adding further interrupt sources would only serve to complicate things. So handshaking from the co-processor to the Spectrum is achieved via a polled shared register.

The address decoding for the co-processor is identical to that described above and is based around IC36, IC43 and IC46. This time, when the co-processor writes to a shared port, the data is put into one of IC37-40. When it reads from a shared port, the data comes from one of IC47-50.

This is the opposite way round to before and provides the desired capability for bi-directional data transfer.

To avoid confusion, the same port addresses are used as for the Spectrum end, even though the restriction on available ports does not apply. So, if the Spectrum writes data to its port at address 191, the co-processor will pick up this same data from its own port at address 191.

A Reset button is provided on the interface board, to force the co-processor into its reset state. This is simply achieved by switching the $\overline{\text{SYSTEM RESET}}$ line on the backplane to 0V.

Due to the potentially high power requirements of the co-processor and its periphery, the power to the backplane is derived from an external source. This is instead of using the Spectrum's already overworked PSU, which remains separate. A connection is of course made to the Spectrum's 0V rail via its edge connector, to maintain a ground reference throughout the system.

Finally, it is worth mentioning a few words about adding new peripherals to the co-processor. Obviously, to really make full use of the co-processor, it may need to have its own I/O channels, which are independent of the host. Any standard Z80 peripherals may be used with the co-processor, plugged into the spare third slot on the backplane.

These can interface with the CPU via the usual Z80 busses, which are all available on the connector. The only restriction is that new circuitry does not map into any memory or I/O locations already in use. Peripherals which may be added include parallel/serial I/O, analogue I/O or even a video interface to a monitor.

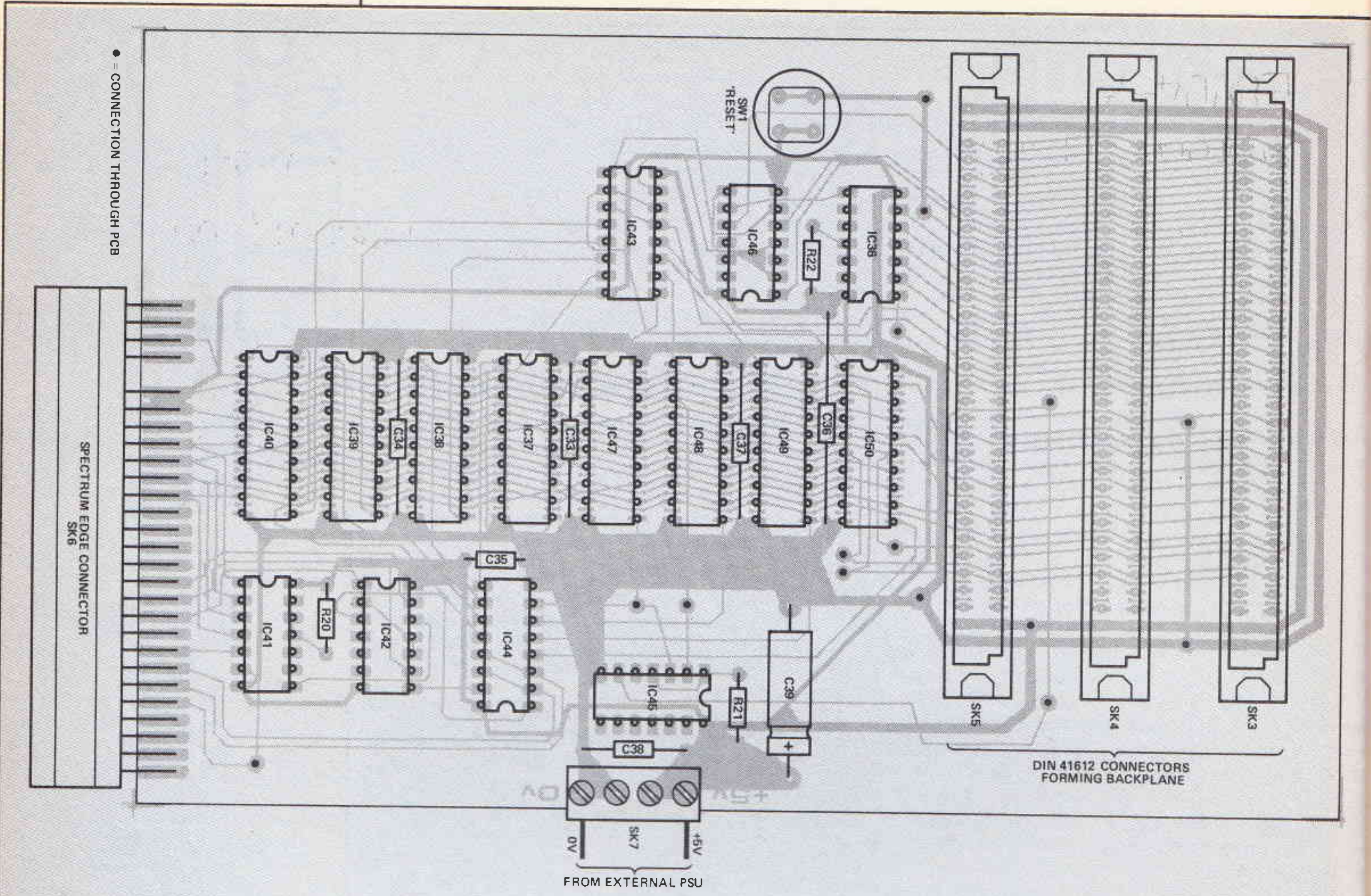


Fig. 2 The component overlay of the interface PCB

PARTS LIST

RESISTORS (all ¼W 5% unless otherwise stated)

R20-22	1k0

CAPACITORS

C33-38	100nF monolithic axial ceramic
C39	100µF 10V axial electrolytic

SEMICONDUCTORS

IC36, 41	74LS30
IC37-40, 47-50	74LS374
IC42, 46	74LS32
IC43, 44	74LS139
IC45	74LS74

MISCELLANEOUS

SK3-5	DIN41612 type C 64-pin PCB mounting socket
SK6	Edge connector for Spectrum
SK7	4-way PCB mounting terminal block
SW1	PCB mounting push-button

PCB. IC sockets. Tinned copper wire. M2.5 nuts and bolts.

BUYLINES

The co-processor interface board uses no particulary exotic components and most of the parts should be easily available.

The miniature axial ceramic capacitors are available from Verospeed (Tel: (0703) 644555) as order code 92-50952H. The DIN 41612 backplane connectors and the Spectrum edge connector are both available from Maplin, their order codes being FJ47B and FG23A respectively.

Finally, the Printed Circuit board is available from our PCB service.

However, there is also the facility in the co-processor code for the user to add additional specialised commands to these five — more on that next month.

The commands are transferred from the Spectrum to the co-processor using a special handshaking protocol implemented in software which ensures each party knows the exact state of the other, at all times. The flow diagram (Fig. 3) illustrates the handshake protocol used.

A command from the Spectrum consists of an 8-bit value with its most significant bit set. Commands are always written by the Spectrum to the shared port address 255.

This 'one' in the MS bit position causes the co-processor to receive an interrupt. Table 1 shows all the valid commands recognised by the co-processor, along with their defined code values in binary. Up until the time a command appears, the co-processor is sitting in a program loop doing nothing more than wasting time.

When the command is received, the co-processor interrupt routine leaps into action. First the co-processor disables its interrupt response — the Z80 interrupt line is level sensitive and would otherwise repeatedly detect interrupts until the command was withdrawn. The co-processor must

	D7	D6	D5	D4	D3	D2	D1	D0
Block Read	1	0	1	0	X	X	X	X
Block Write	1	0	0	0	X	X	X	X
Execute User Code	1	1	0	0	X	X	X	X
Break Execution	1	1	1	1	0	0	0	0
Self Test	1	1	1	0	0	0	0	0

'X' = Don't care

Table 1 Spectrum to co-processor commands

	D7	D6	D5	D3	D2	D1	D0
DATA label	0	1	1	1	1	1	1	0
NULL label	0	1	1	1	1	1	1	1

Table 2 Handshake labels from Spectrum to co-processor. Both of these labels have the effect of removing the interrupt to the co-processor if sent to the command port

	D7	D6	D5	D4	D3	D2	D1	D0
DATA label	1	1	1	1	1	1	1	0
BUSY label	1	1	1	1	1	1	1	1
IDLE label	0	1	1	1	1	1	1	1
BRKACK label	1	1	1	1	0	0	0	0
INVALID label	1	1	1	0	0	0	0	0

Table 3 Handshake labels from co-processor to Spectrum

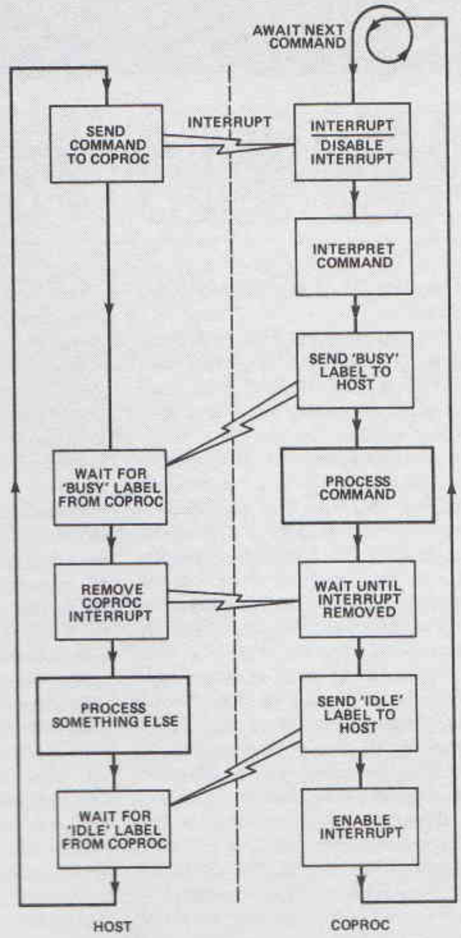


Fig. 3 Flow diagram for the Spectrum co-processor handshaking protocol

also ignore any new commands which arrive before it is ready to receive them.

Next, the new command is read in and decoded. Once the co-processor has decided what the command means, it lets the Spectrum know that all is well by sending a flag through port address 255. This is again an 8-bit value with its MS bit set to one.

Table 3 shows the flag values which may be returned. The usual flag to be returned is BUSY but DATA, BRKACK or INVALID may be used under certain circumstances. These will become clear next month.

The flag returned lets the Spectrum know what the co-processor is doing and that the last command was correctly decoded. After sending the flag, the co-processor is ready to get on with executing the command.

In the meantime, the Spectrum has been twiddling its thumbs, repeatedly reading shared port 255, waiting for the returned flag. Once received, it can remove the interrupt from the co-processor by writing a NULL label (with a zero in its MS bit position — see Table 2) into shared port 255. This serves as an acknowledgement to the co-processor that the flag was received and understood.

Now the Spectrum is free to do a bit of processing for itself, safe in the knowledge that the co-processor is also busy, executing its latest command.

When the co-processor has finished working on this latest command, it checks shared port 255 to ensure the Spectrum has removed the initial interrupt. If not, the co-processor waits for the Spectrum to do so.

Once the interrupt has gone, the co-processor removes its 'I am busy' flag from Spectrum port 255 by replacing it with the IDLE flag and enables its interrupt again to return to its time wasting loop awaiting the next command.

When the Spectrum has completed its little bit of processing, it looks at the contents of port 255 from the co-processor. If this is not the IDLE flag, the co-processor is still working on the last command. The Spectrum will wait (or could do a little bit more processing!) until the IDLE flag arrives. Once that has arrived, the Spectrum is free to send its next command to the co-processor, starting the whole process again.

Apart from the interrupt driven command transfer, this entire hand-shaking process is executed in software. Consequently it is slower than if it had been realised purely in hardware.

However, the aim of this project is to produce a versatile test-bed, suited to further experimentation. The limited scope for future changes which hardware invariably presents was enough to make its use less attractive. Opting for the software driven handshaking protocol allows the user to tailor the exact scheme used to suit the application.

It is also worth noting that although the use of interrupts in the protocol is limited to Spectrum-to-co-processor command transfer (due to the trickiness of using the Spectrum interrupts) this link is by far the most important of the two. In case of problems, the Spectrum is always in command of the co-processor even if user software in the co-processor goes haywire.

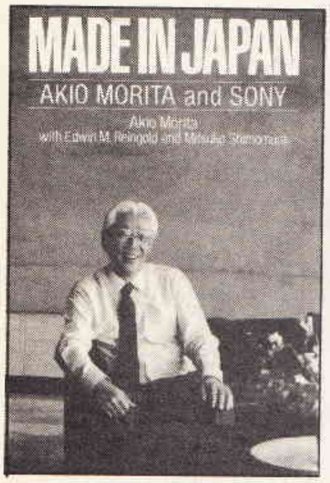
Next month, in the final article in this series, we take a closer look at the co-processor commands and the ways in which they work.

ETI

BOOK LOOK

Just to show you that ETI isn't all about slaving away over a hot soldering iron or tying your brain into knots over circuit calculations, this month I'm taking a look at two books which are definitely easy reading.

Made in Japan by Akio Morita with Edwin Reingold and Mitsuko Shimomura. Collins. £12.95.



This is the autobiography (semi-autobiography?) of Akio Morita. Go on, admit it. You've no idea who he is. Well Akio Morita is Sony.

Morita was 25 years old when in 1946 he and Masaru Ibuka founded the Sony Corporation in the Japanese ashes of World War II (it actually started as Tokyo Telecommunications Engineering — which is rather odd as the first product was an extremely dodgy electric rice cooker!).

He is now Chairman and Chief Executive Officer of Sony — one of the most successful companies in the world. After its unsuccessful attempts at electric rice, Sony has produced the world's first transistor radio and domestic video recorder, not to mention co-inventing compact discs and of course coming up with the ubiquitous Walkman — an idea entirely conceived by Morita.

The Walkman is typical of Morita's viewpoint on commerce. On suggesting the idea nobody actually laughed at him (well you wouldn't laugh at your boss, would you) but he was certainly given a hard time.

He still believes that no amount of market research would have indicated any public desire for a 'personal stereo'. Nevertheless he forced the idea through and now there are millions of Walkmans (and imitations) in use around the world.

Morita believes you have to *create* markets for innovative products. He's the Sinclair of Japan — only he hasn't gone bust four times proving it.

Made in Japan isn't just a story of a clever man's life, interesting though that life is. It is also a collection of his thoughts, ideals and visions and a fascinating glimpse into the Japanese commercial environment — so different to the reserved, hesitant face of British business life.

This book both confirms the common picture of Japanese workers beavering away giving their all to the faceless company, and at the same time exonerates this picture from western criticism.

However, *Made in Japan* is not an economics treatise. It is a biography of a successful life which has already achieved more than most of us can hope for and still has plans for much more.

I thoroughly recommend this one for an entertaining and an oh-so-slightly educational read. At £12.95 it is a high price for a bedtime book (it is hardback, though!) but if it doesn't come out in paperbook soon, persuade your local library to enlarge the biography section by one.

Harwin Chronology of Inventions, Innovations and Discoveries by Kevin Desmond. Constable Publishing £10.95.

If this book was larger, it would be a 'coffee table book.' It has all the other qualities off to a tee. It is easy to read straight or to dip into while watching Eastenders. You can share the contents with others and it provokes discussion. It would go down a treat on Christmas day, after the Queen's speech.

The book is a chronology of inventions, innovations and discoveries from prehistory to the present day (well, to 1985 anyway) with a short excursion into the realm of the future to boot.

There are few details on each entry — just what happened and when — but there are an awful lot of entries. Of course, the early entries are a little vague in their exact timing. The domestication of wheat and barley is placed around 8000-9000BC.

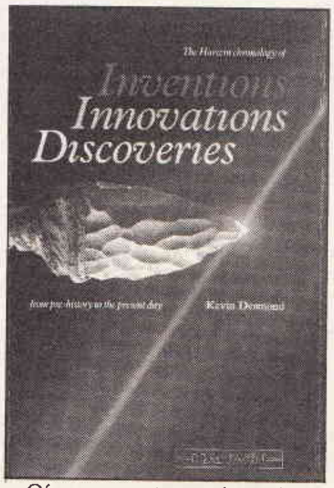
In more recent times, things get a little more precise and, for my part, considerably more interesting.

Did you know that asteroids were discovered in 1801, the microphone invented in 1828, evaporated milk in 1884, the Tuxedo in 1886, the toothpaste tube in 1892, the safety razor in 1900, the electric food mixer in 1918, the launderette in 1934 or the Morris Minor Mini in 1959?

I could go on. There are simply thousands of entries in this pot-pourri of trivia. Few of these gems of knowledge will prove useful today, this week or even this month but in the long run this book provides a fascinating way to pass a few spare minutes and is a handy reference source for those otherwise unanswerable problems.

There is some wastage of space with the comically vague prehistorical entries and the 'shape of things to come' for the next 50 years. Some of the items in the latter are sensible and predictable (and thereby omissible) — such as the channel tunnel and a nationwide chain of lead-free petrol stations — but many are (I believe) just silly — cloned superhumans, time machines, laser space battle stations and the like.

All the real inventions are arranged in chronological order by year and a comprehensive index is provided for their location when the date is not known. I don't know if *every* entry is suitably entered in the index but *I* had no trouble finding entries in this way.



Of course, not every invention is featured here at all. However, this is a pretty good list. If you take this book as I believe it should be taken — as 200-odd pages of entertainment — and you can remain entertained after being relieved of the £11 it will cost you, you will not be disappointed.

Martin Tame

PLAYBACK

Recently the Editor forwarded a letter to me from a man who has been reading electronics magazines for many years.

The letter drew my attention to a technique of improving the apparent bass response of a sound system, sending me photocopies of the original article and subsequent correspondence from Wireless World 1951.

Hi-fi it is not but it serves to illustrate some current sound processing techniques.

The article outlined a technique whereby low frequency notes (which loudspeakers of 1951 vintage handle less efficiently than present day ones) could apparently be reproduced more accurately. Low frequencies were filtered off and fed to a nonlinear stage which generated harmonics. The harmonics were at frequencies which the loudspeakers could handle efficiently and the presence of these harmonics was intended to fool the ear into hearing the fundamental that was not, in fact, there.

The original circuit used valves, with which many readers may not be familiar, so I have rendered the elements of the circuit into block diagram form (Fig. 1) for ease of understanding. Excerpts from the letter and my reply should throw further light on the subject.

The Letter

Dear Mr Armstrong,

The ideas in the enclosed article *Bass Without Big Baffles* have interested me since I first read it but I did not have time to build it. Now I have decided to take another look at it, but everything is semi-conductor now and I am no design engineer. Do you know of any further articles on the subject or would ETI consider doing such an article?

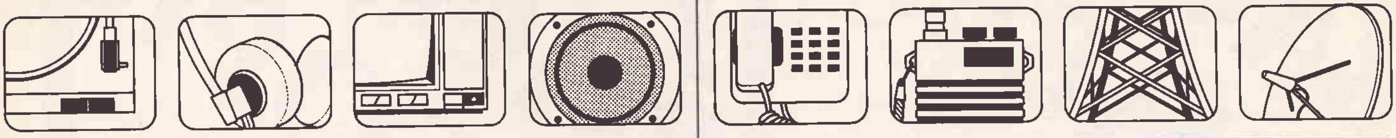
H Hodgson

The Reply

Dear Mr Hodgson,

I am afraid I haven't time to build one of these units either but I will see what I can do from a theoretical angle.

So far as I know, there is some validity to the idea that the impression of bass can be provided by its harmonics. Virtually the only time the ear receives, say, a 100Hz tone and a 150Hz tone at the same time is in the presence of a 50Hz fundamental so there is an unsur-



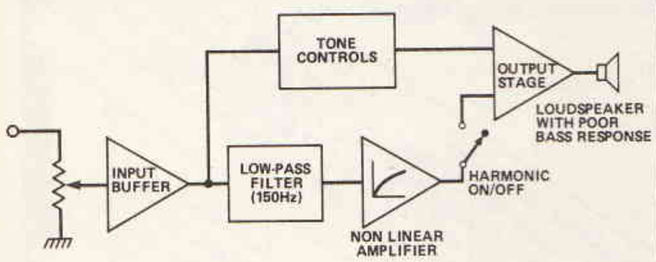


Fig. 1 Block diagram for bass harmonics

prising tendency to 'hear' the fundamental. The drawback is that tones with little natural harmonic content cannot be simulated so accurately.

Two personal observations relate to this. Some small loudspeakers I have come across appear to give a lot of bass output but are in fact generating harmonics of low frequency signals when these signals are of any significant amplitude. Here we have an acoustic/mechanical system doing the same as the bass amplifier circuit.

High amplitude bass signals drive the bass cone outside its linear region and generate harmonics. The harmonics are filtered mechanically by the loudspeaker so that only low order harmonics are audible. This prevents the distortion from sounding too harsh and 'sandpapery' as it would with an overloaded transistor stage.

When I changed from a modest sized pair of loudspeakers to a large pair (the WW transmission line design) the bass was at first less noticeable, until my ears had 'returned' to hear the fundamental rather than the harmonics.

The present loudspeakers seem to be much more linear at reasonable outputs down to about 40Hz than any others I have used. Now I am used to this I do not enjoy the sound from smaller loudspeakers.

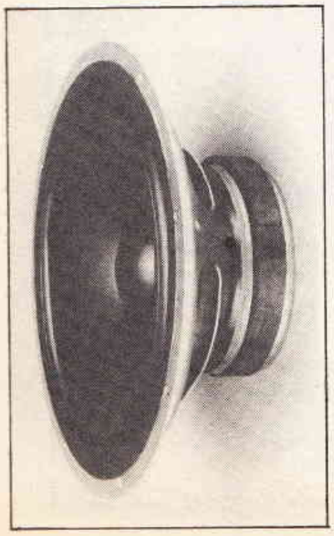
In another guise, the use of harmonics to make the fundamental sound louder is with us as the Aphex Aural Exciter. Sometime over a year ago ETI published an exciter circuit which does much the same thing. Lower middle frequencies (where the fundamental tones of most instruments are to be found) are selected and distorted by a circuit with a non-linear transfer function which generates low order harmonics (very little above the fifth harmonic).

These harmonics are added to the music as well as or instead of the naturally occurring frequencies in the range. At any given volume level, the resulting signal sounds louder. It works for voice, and is used to enhance the sound of some rock and pop music. It is also used in conjunction with compression to make the adverts on TV almost impossible to ignore, even when the volume is set so that the programme is only just audible.

On reflection, I think that one further point should be made. The valves in the 1951 circuit distort the signal asymmetrically, generating a significant number and volume of even harmonics as well as odd ones. This is in contrast to most distortion generated in modern equipment, where the waveform is distorted symmetrically and almost no even harmonics are generated. I would expect the presence of even harmonics to make the illusion of bass more convincing so it may be that the system proposed could work.

It might, for example, enhance the apparent bass output of 'ghetto blasters'. Perish the thought.

Andrew Armstrong



OPEN CHANNEL

The wonders of modern telecommunications systems, coupled with electronics and computing, never cease to amaze me.

Shoppers in Oxford and High Wycombe may be amazed too to find their local branches of Sainsbury's are now linked on-line to the Link debit card network.

Now at the end of a long hard slog around the aisles with that bloody trolley (whose left front wheel *never* turns) to pick up the peas, pizzas, potatoes, parrot-food and piccalilli, it's possibilities to pay for the goods not with real money but with a piece of plastic.

No more do you have to fumble through your pockets looking for that twenty-pee piece. This remember is the age of *electronic funds transfer* (or EFT for those in the know) where reality becomes a dream — oops, sorry — dream becomes reality. A single wipe of your card through the electronic till is sufficient to debit your bank account by the requisite amount.

The two stores are taking part in a year long trial by Sainsbury's to evaluate cashless shopping with the aim of bringing the system to all the company's retail outlets soon after.

It's For You, Your Majesty

Another test site for something new in telecommunicating is Windsor — no, not the Castle. Windsor Television runs a cable television network franchise covering some 100000 homes in the district. Recently it has been given the nod to start a telephone service operated in tandem with the TV network.

Business users on the Slough industrial estate are the guinea pigs for a five month trial of the service which if successful will be run throughout the whole of the network.

If it's successful all users of the cable network could be linked by telephone within just a few months. Trunk charges on the network are expected to be pitched below British Telecom charges (naturally) and somewhere around Mercury's.

Being an integral network of course will give significant benefits for local calls, with charges expected to be considerably below BT's local charges.

Don't Tell Anyone, But . . .

It must gall some of the bigwigs seated at the top of BT to realise that even the greatest generator of chitter-chatter along the telephone lines — the British Government — is not convinced of the efficacy of the only recently released ex-monopoly.

Rumour abounds that the Department of Education and Science is the first governmental department to have made the decision to switch from BT to Mercury.

It is anticipated that this cost-cutting exercise will save the Department over £25,000 a year.

Rumours also abound that Mr Baker's mob, although the first to leap the railings and abandon ship, will not be the last.

On The Air

The old 405-line television band known as Band III is now being used as a private mobile radio (PMR) network, as the Philips-led consortium called Band Three Radio took to the air in October of last year. Aiming for a coverage of around half of the population by mid-year, Band Three Radio expects total coverage within the next year. Band Three Radio's rival, GEC's National One, had not switched on at the time of writing.

Germany Does It First

First production D2-MAC decoder chips are now available, fully working, for inclusion into MAC-based satellite receivers for German direct broadcast by satellite television systems.

Readers of this column will know from November that D2-MAC is the MAC (multiplexed analogue component) version opted for by Germany and France as a way of encoding and transmitting their allocated DBS channels. The proposed British DBS system will be in the D-MAC version (similar but not similar enough).

Availability of D2-MAC chips (but not D-MAC chips) means that German (and French for that matter) television manufacturers cannot flood the British market with their products before our manufacturers have a chance to get their houses into order.

What it also means though, is that German manufacturers can now get down to the incredibly serious (snigger, snigger) business of making and selling televisions capable of receiving transmitted channels from the German DBS satellite (snigger, snigger) launched at the end (snigger, snigger) of last year (snigger, snigger). Of course, this relies on the fact that they can get their stuffed turkey . . . oops, satellite to work (snigger, snigger). Currently, they can't!

Keith Brindley

BACK NUMBERS

- Missed part one of your favourite project?
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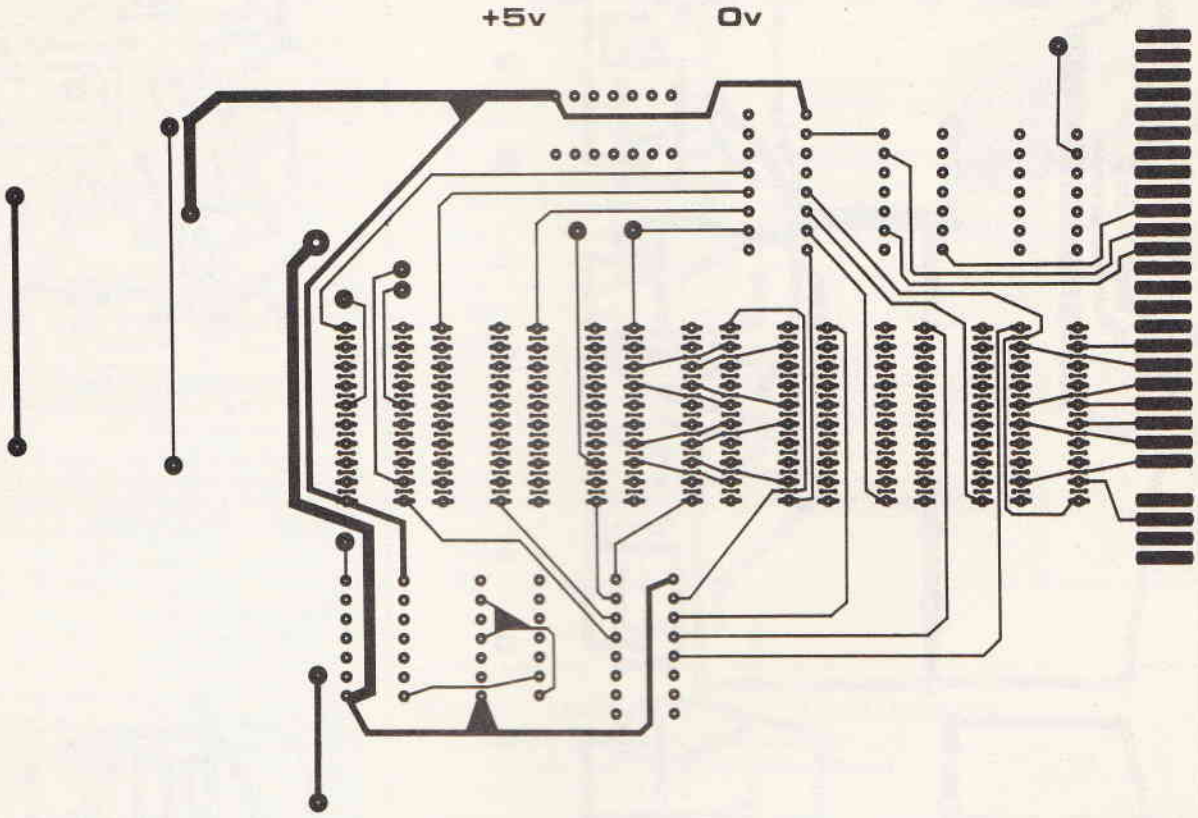
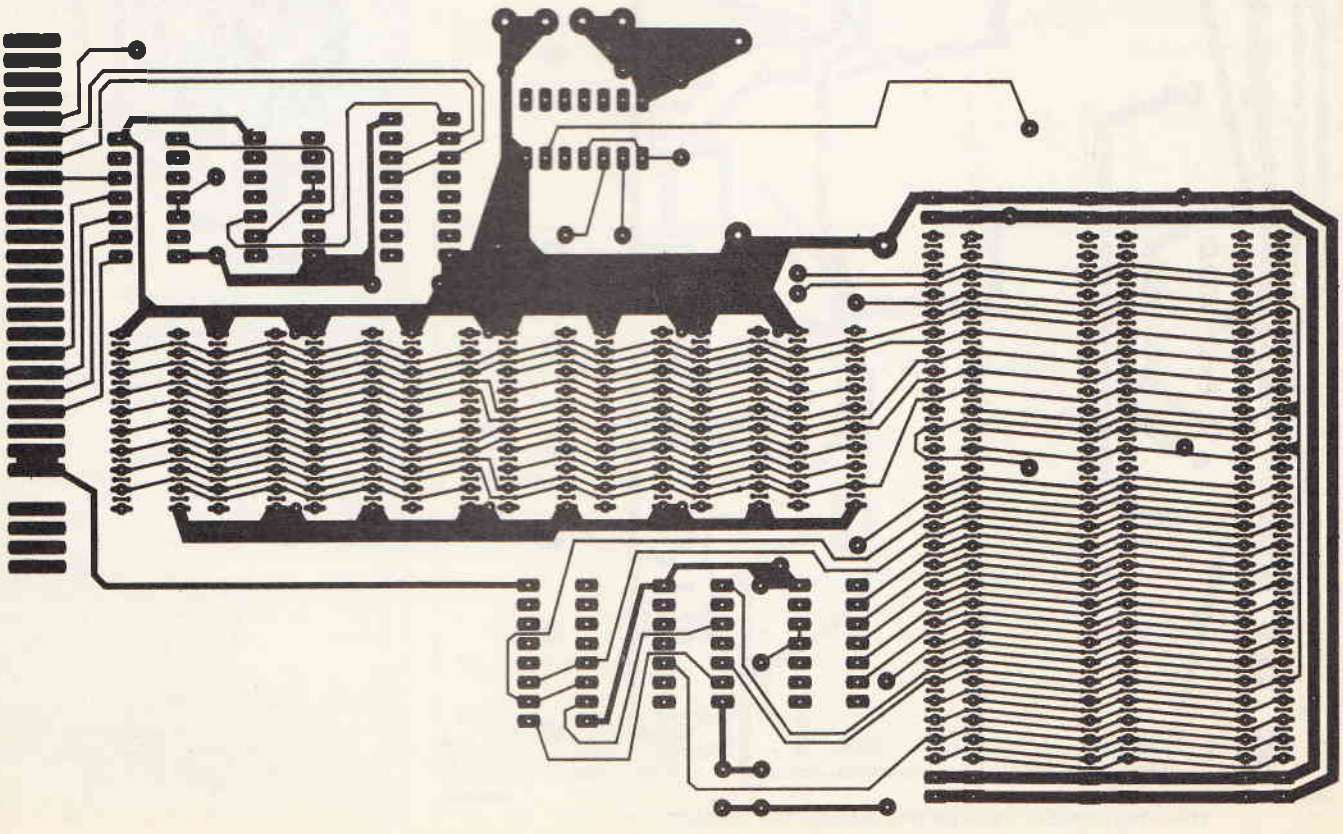
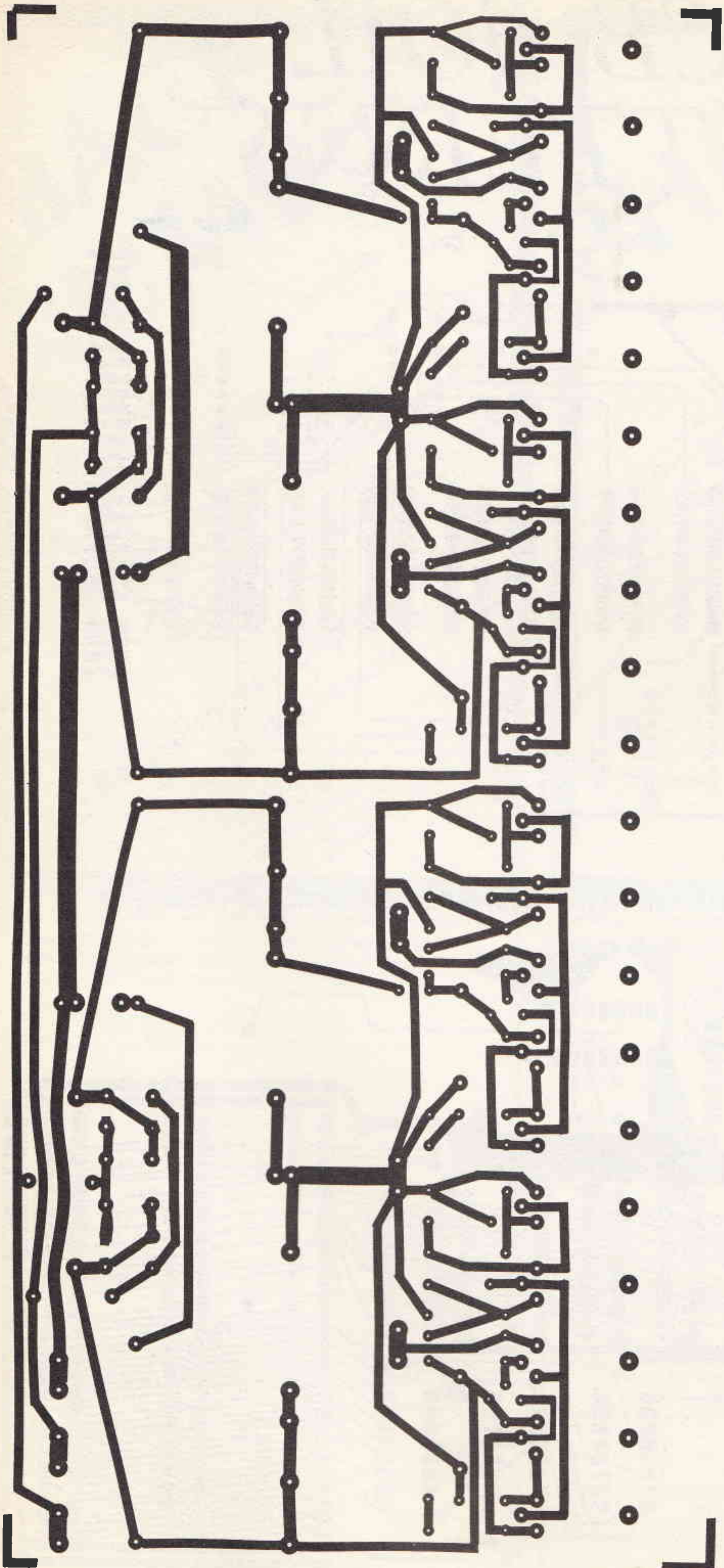
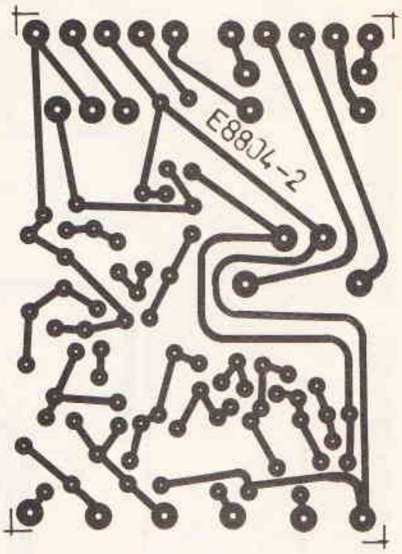


The Co-processor interface topside foil (above) and (below) the Co-processor interface solderside foil

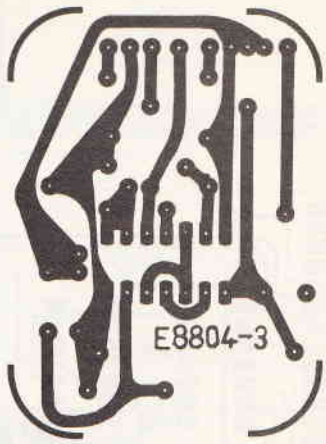




The Virtuoso 3u case power supply foil pattern



The Kitchen Timer PCB foil



The Combo Lock foil pattern

OOPS!

Knight Raider (August 1987)
In Fig.1(a) pins 4 and 5 of IC1 are swapped. IC2-3 show the correct pin-out.

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

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

EEG Monitor (September 1987)
In Fig.3a the pins of IC1 connected to the power rails are shown swapped around. In Fig.4a R7 is unlabelled and is between C3 and C6. In Fig.5 C20 should be £10 and R18 is unlabelled. It lies between R17 and R19.

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

Printer Buffer (November 1987)
The software for the EPROM had three errors listed. The byte at 039A should read 20, at 039B 14 and at 0492 30. All numbers are in Hex.

Dream Machine (December 1987)
The transistors used in this project are ST1702. BC108s can be substituted.

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 zener diode ZD1.

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.

Clean Up Campaign (January 1988)
In the component overlay (Fig. 3) ZD1 is incorrectly orientated. The positive terminal should be the southern end.

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

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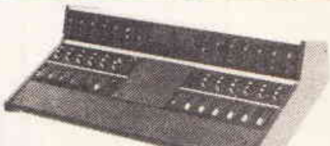

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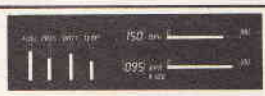

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