ETI

ELECTRONICS TODAY INTERNATIONAL

THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

JUNE 1988 £1.40

WIN Satellite TV system worth £1300 (see inside back cover)

THE FORGOTTEN COMPUTER
Analogue computers - due for a comeback?

UNIVERSAL DIGITAL METER Programmable logic display

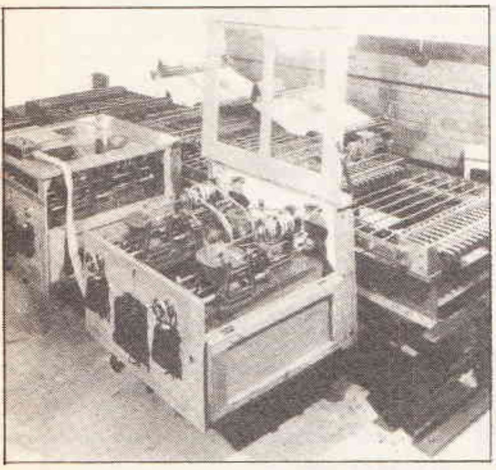
BEGINNERS 1st CLASS Metal detector project

OP-AMPS CIRCUIT THEORY The building block explained

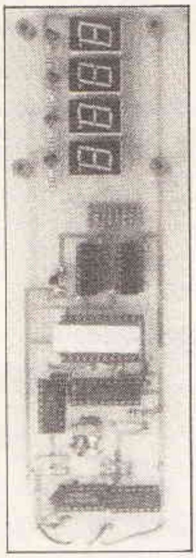
ETI ELECTRONICS TODAY INTERNATIONAL

Geoff Bains: Editor
Jez Ford: Assistant Editor
Paul Chappell: Projects Editor
Jerry Fowler: Technical Illustrator
Heather Hopkinson: Design
Ed Davis: Photography
Christopher Harris: Ad Manager
Julie Capstick: Classified Sales
Andrew Selwood: Copy Control
Mark Webb: Group Editor

Volume 17 No. 6



Page 10



Page 27

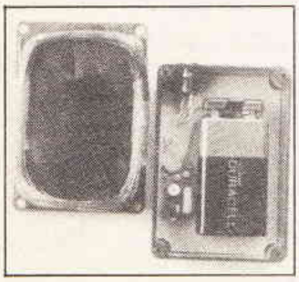
ISSN 0142-7229 | ABC | Member of the Audit Bureau of Circulation

● Subscription rates UK £16.80. Europe: £21.00. Middle East: £21.20. Far East: £22.80. Rest: £21.50 or US$32.00.

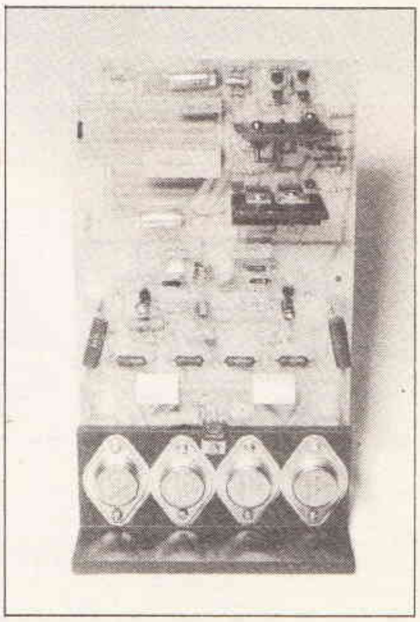
ARGUS PRESS GROUP
1 Golden Square
London W1R 3AB
Tel: 01-437 0626
Telex: 881196

Published by Argus Specialist Publications Ltd., 1 Golden Square, London W1R 3AB. Tel: 01-437 0626. UK newstrade distribution by SM Distribution Ltd., 6 Leigham Court Road, London SW16 2PG. Tel: 01-677 8111. Overseas and non-newstrade sales by Magazine Sales Department, 1 Golden Square, London W1R 3AB. Tel: 01-437 0626. Subscriptions by Infonet Ltd., 5 River Park Estate, Berkhamsted HP4 1HL. Tel: (04427) 76661. US subscriptions by Wise Owl Publications, 4314 West 238th Street, Torrance, CA90505 USA. Typesetting and origination by Multiform Ltd., Cardiff. Printed and bound by Adlard & Son Ltd., Letchworth. Covers printed by Loxley Brothers Ltd., Sheffield.

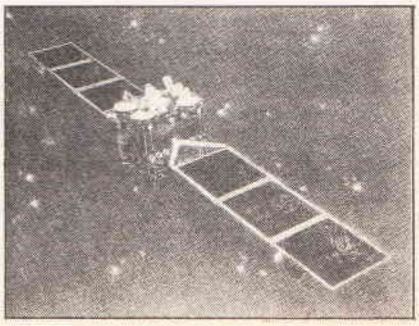
JUNE 1988



Page 38



Page 49



Page 58

NEWS

A MERGER MADE IN HEAVEN?

Lossmaking STV station Super Channel is discussing merger plans with Sky, according to *The Financial Times.* The two stations would combine to provide a single service across Europe.

Apart from the obvious economies of scale and cooperation, this would increase advertising revenue by removing the competitive barriers between the two channels. These barriers have stopped advertising rates from rising with the size of the market.

Another bonus for Sky would be the freeing of a satellite channel for Eurosport, a joint venture with the BBC (among others).

However the merger could flounder if either NBC or the Television Broadcasting Company succeed in acquiring a majority stake in Super Channel. The TBC consortium of Carlton Comms, Thames TV, LWT, Dixons and the Saatchis would prefer to keep control of Super Channel as a separate service.

CD-ROM JUKEBOX

Listening booths may find their way back to record shops and megastores if the CD-ROM jukebox catalogue from Robert Maxwell's Nimbus Records takes off.

Nimbus has put its classical catalogue onto CD-ROM in a package for IBM machines that looks more like CD-I than CD-ROM.

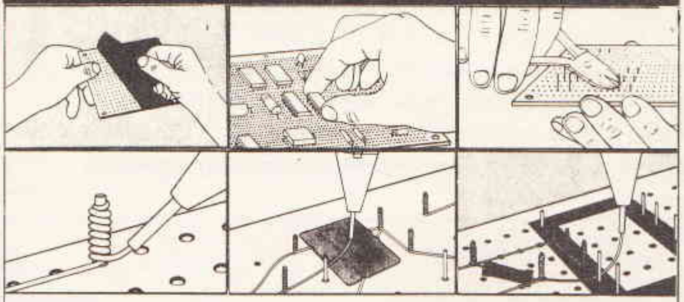
The catalogue can be accessed under title, composer, artist or music type and for each item provides information on both composer and artist.

Then (and this is the clever bit) the album cover is displayed on screen and a CD-quality excerpt is played.

If other record labels produce similar catalogues (and Nimbus is working on it) record shops could mount the whole lot in a jukebox arrangement with search and select facilities for the punters. Hey presto, record buying is fun again.

For further details contact Nimbus Records, Wyestone Leys, Monmouth NF5 3SR. Phone: (0600) 890682.

VERO WRAPS IT UP



BICC Vero (maker of Veroboard) is introducing a novel and effective new method of circuit prototyping for the hobbyist.

Entitled Easiwire, connections are made without soldering by placing components on a polypropylene matrix board (like Veroboard but without the strips). Links are made by wirewrapping from a penlike instrument fed by a wirespool atop the pen. Component leads are linked by wire as they would be by tracks on a PCB.

The system can be used for quite complex circuits (Vero has a television and a telephone constructed with the stuff) since connections can be made on both sides of the board and crossing wires can be easily insulated.

The basic starter kits cost £15, and all the bits are available separately.

Contact BICC Vero at Flanders Road, Hedge End, Southampton SO3 3LG. Tel: (04892) 88774.

MIX AND MATCH

K-Tek, suppliers of the M&A Series 4 Mixer (see review in March 1987 ETI) has produced a new range of audio mixer masterboards called Series X.

The boards vary from the X8-2 with 8 line inputs and one mic channel to the X32-2 with 32 line and one mic. Extra mic inputs may be added with the Xi-1 board and the XR-2 and XR-4 mix either two or four stereo inputs for say disco or broadcast applications.

K-Tek sell the plans of each board at between £9 and £16 — and you will need these to use the boards properly. Having said that, the boards are very reasonably priced: the X8-2 is £9.92, the X32-2 is £24.02 and the XR-4 is £17.91.

For full details and prices contact K-Tek, PO Box 172A, Surbiton KT6 6HN. Tel: 01-399 3990.

ELEVENTH HEAVEN

The latest DX keyboard from Yamaha is the DX11, an eight note polyphonic instrument with a five octave velocity sensitive keyboard.

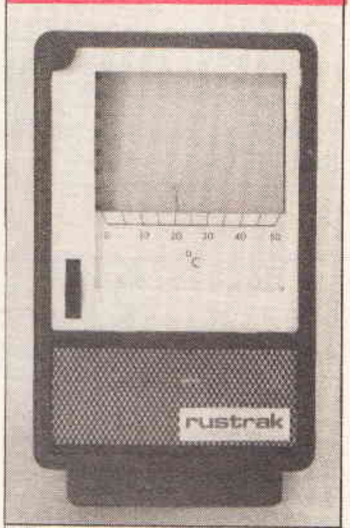
The voices have four operators as in the DX21 and DX9 (remember that?) but the DX11 is multitimbral so you can layer all eight voices — 32 shaped operators — under a single note if you so desire.

The DX11 has a ROM slot and effects memories, a new quick edit facility (to change the attack rates of all operators at the same time) — and it costs less than the DX9 did three years ago — £679 RRP.

Meanwhile a hilarious limited edition DX7IIFD has been produced to mark Yamaha's centennial last year. Finished in 'celebration silver' with golden sliders, it has a 76-key extended keyboard and costs (gulp) £2999.

Extraordinarily rich readers who want one should contact Yamaha-Kemble, Mount Avenue, Bletchley MK1 1JE. Tel: (0908) 71771.

RECORD CHARTS



Strip chart recorders for temperature and humidity are being supplied by Electronic Temperature Instruments of Worthing.

The Rustrak recorders are compact and reasonably versatile, ideal for keeping track of conditions in computer rooms for example.

The basic temperature-only module retails at £199 from ETI (no relation), PO Box 81, Worthing, West Sussex BN13 3PW. Tel: (0903) 202151.

HOME HUNTING

Tome Searcher is a database researcher for IBM PCs that accesses the European Space Agency's databases in Frascati, Italy.

The software is designed for free expression (AKA natural language AKA user friendliness) to understand and speak English so that no knowledge of data base searching is required.

The subject area is outlined by the user and narrowed down by the extensive semantics (expert in Electronics, Computing and IT) until an acceptable search strategy is established where Tome's estimate of the number of references expected from the ESA matches the limit set by the user. Each reference will cost about 30p in 'online time' so narrowing down the field is essential if you don't want your IBM pulling 3 million hits out of the system...

Considering that a search on the British Library's rival system averages about £45, Tome Searcher (actually orginally funded by the British Library as Plexus in 1983) has an affordable price tag of £495+VAT.

Contact Tome Associates, PO Box 1, Stotfold, Herts SG5 4LT. Tel: (0483) 810905.

STUFFED WITH POWER

Sage Audio's Supermos 2 is the new flagship of the remarkable Superseries class A power amp modules.

The Supermos 2 weighs over 2kg and can deliver 500W into 4R.

Les Sage claims his 'no compromise' design work has produced an astonishing set of specifications: slewrate above 685V/µs, THD at 0.0001% at full output, unmeasurable intermodulation distortion and zero crossover distortion.

The key to these performance levels is the active class A circuit operation which maintains pure class A operation right up to the maximum output stage current capacity — typically a massive 50-80A.

The Sage design eliminates output emitter resistors and stabilising zobel networks, it uses no fixed bias on the output stage so temperature tracking errors cannot occur and the number of signal capacitors has been drastically cut (along with their sound colourations).

The sound of PSU components is eliminated by clean clipping and feed-forward PSU correction.

For an eight-page brochure giving full technical details (£1) contact Sage Audio, Construction House, Whitley St, Bingley, W Yorks BD16 4JH. Tel: (0274) 568647.

DIARY

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

Rural Telecommunications — May 23-25th
IEE, London. International conference. Contact IEE on 01-240 1871.

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.

Commodore Computer Show — June 3-5th
Novotel, London. Contact Database Exhibitions on (0625) 878888.

Special Effects Seminar — June 3-5th
Pinewood Studios. Contact British Kinematrograph Sound and Television Society on 01-242 8400.

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

European Satellite Broadcasting — June 8-9th
Tara Hotel, London. Contact Online International on 01-868 4466.

Electronic Publishing 88 — June 14-16th
Wembley Conference & Exhibition Centre, London. Contact Online International on 01-868 4466.

Software Tools 88 — June 14-16th
Wembley Conference & Exhibition Centre, London. Contact Online International on 01-868 4466.

Denby Dale Mobile Rally — June 19th
Shelley Hill High School, Huddersfield, West Yorkshire. Contact Denby Dale Amateur Radio Society on (0484) 602905.

Networks 88 — June 21-23rd
Wembley Exhibition & Conference Centre, London. Contact Online International on 01-868 4466.

Private Switching Systems And Networks — June 21-23rd
IEE, London. Conference on telephone exchange technology. Contact IEE on 01-240 1871.

British Science And Tecnnology Exhibition — June 22-26th
Brands Hatch. Contact Sci-Tech 88 on 01-834 6680.

Intersatellite Links: Systems and Technology — June 29-30th
Royal Garden Hotel, London. Contact ERA Seminars and Exhibitions on (0372) 374151.

Computer Recruitment Fair — July 1-2nd
Rainbow Rooms, London. Contact Intro Ltd on (0491) 681010.

IEE Vacation School On Local Telecommunications Network — July 10-15th
Aston University, Birmingham. Contact IEE on 01-240 1871.

PCB CLONES

Amstrad users have two new PCB design packages to choose from.

The first, PC-B, is from Labcenter Electronics and runs on PC clones with an EGA card and the Amstrad 1512 and 1640.

Its speed, component library and icon driven operation are remarkable for the price and Labcenter provides a plotting service for users without a suitable hardcopy device.

PC-B costs just £80 and a demo disk can be supplied for £2.

Contact Labcenter, 14 Marriners Drive, Heaton, Bradford BD9 4JT. Tel: (0274) 542868.

The second package is Easy PC which runs on PC compatibles with at least 512k memory.

Easy PC can handle large boards (up to 17in square) with 4000 pads, 1500 symbols and 12000 track segments.

It can create multilayer designs of up to eight copper layers and provides drilling templates and solder resist details.

Easy PC costs £275+VAT from Number One Systems, Harding Way, Somersham Road, St Ives, Huntingdon, PE17 4WR. Tel: (0480) 61778.

CCD

Sony has committed itself to producing 3in CD singles aimed at a price and playing time similar to existing vinyl 12in singles.

The mini-CD format will be launched alongside Sony's 4in square Pocket Discman this summer.

Normal size (5in) CDs poke out of the Discman D88 and whizz round at high speed — presumably hampering the portability of the unit substantially.

Sony says the record industry is very excited about the CD single. Who should be cited as proof of this enthusiasm? Surprise surprise, it's CBS Records. Who was it that bought out CBS Records last month? Good heavens, it was Sony . . .

Contact Sony at Sony House, South Street,. Staines TW18 4PF. Tel: (0784) 61688.

FREEBIES

This month's ETI guide-to-getting-more-mail starts with the Greenweld Spring Supplement — 24 pages long with a good selection to add to their main catalogue for 1988.

Greenweld has just started an inhouse credit card scheme (details of which you'll no doubt receive with the supplement). For your copy phone (0703) 772501.

STC has produced a huge 320-page instrumentation catalogue covering everything from computers to oscilloscopes, chart recorders and design aids. Phone (0279) 641641.

Even huger than this is the PMI analogue data book, with 1200 pages of data on DACs, ADCs, op-amps and other ICs. Free from Jermyn on (0732) 450144.

Lastly, Marston Palmer's 1988 heat sink catalogue is available with engineering profiles of over a hundred spiky heat sinks. Phone (0789) 773347.

STICK WITH US

The ETI Readers' Services Department has gone into the glue business.

In conjunction with Adhesive Brokers we're offering a promotional pack of adhesives comprising two 20g cyanoacrylates (one thin and fast, one thick and slow), two 40g epoxies (a two part adhesive and a fast set) and finally a 20g general purpose threadlock compound.

The set costs £9.95+50p postage (normal price £13.71) from ADH, Readers' Services, 9 Hall Road, Hemel Hempstead HP2 7BH. Credit cards on (0442) 41221.

Next Month in ETI

ELECTRONICS TODAY INTERNATIONAL

Next month's ETI sees your very own analogue computer to build, a logic probe project for beginners to electronics and an ingenious electronic lock using bar codes as the key. As if that wasn't enough there's also part two of the satellite TV competition and the usual blend of wit and wisdom that go to make ETI the best there is.

THE JULY ETI – OUT 3rd JUNE

Following last month's history of the paper that goes to form the pages of this illustrious magazine, we have been inundated with requests to reveal all about the luscious inks and pigments, the Swiss-tempered staples and the felt-tip pens the ETI editorial staff use to shade in the colours on each copy of pages such as this.

Now we can reveal all.

The ink is unique to ETI. We have a storehouse housing the drums of ink that date back to 1798 when Duke Carshalton was pioneering the great tramways of the Gobi desert, now sadly lost in the sands of time (or more specifically buried in the sands of the Gobi.) The tramways were a disastrous investment for Lord Carshalton. Although some 2400 miles of track were laid on platforms 60 feet above the dunes, they were frequently obliterated by storms and destroyed by marauding nomads who enjoy that sort of thing ... Carshalton's greatest disaster was that no-one had yet invented the tram, nor would they for another hundred years.

The only byproduct of the Gobi Tramway project was the enormous number of Esquado beetles thrown up by the excavations. These beetles were so surprised at being dug up in the middle of the desert by a pioneering English Duke that they died instantly and had to be stockpiled in their billions.

As the beetles decayed in the bright Gobi sun, their juices seeped onto the sands staining them a dark indigo. Enterprising as the British were in those days, the Duke bottled and kegged the juice and sent it off to England where it lay in a bonded warehouse until 1927.

At that time an eminent Scottish entymologist visiting London recognised the aroma of decayed Esquado beetle as he was passing the warehouse in Limehouse. Intrigued, he had the kegs opened and the contents blessed by the Bishop of Woolwich (who was in the area opening a ferry service).

Pope Pius XI was suitably enraged at this flagrant betrayal of the mother church and quickly decreed that Esquado was to be henceforth banished from all Christendom. 32 kegs saved from the mob were hidden by members of the extremist animal rights group the 'Esquado Front' in underground vaults beneath Golden Square to be discovered by accident in 1972 when freak storms flooded the area bringing them to the surface. By happy coincidence ETI was just starting up the morning after and desperately in need of a supply of ink.

The July issue uses up the last of the Esquado juice stocks and so it may be the last. Make sure of your copy!

READ\WRITE

LOOK SHARP!

Wowee! What is this mag I see before me? Methinks the designers at ETI have been stalking round to the offices of The Grauniad and microfilming their redesign notes.

White space and shaded boxes ... much more readable and pleasing to the eye. Unlike The Grauniad!

Well done.

Steve Drayton
Chelmsford, Essex.

I have today received the April copy of ETI and I could not believe my eyes. Sixty pages including front and back with articles reduced by a quarter page blank margin. Titles twice the normal size and blank spaces in a two page contents.

I think that you are, as many others are nowadays, giving less to the customers for the same price — or perhaps you are running out of material.

J Dussart
Morpeth, Northumberland

Mixed reaction to our April redesign, with much of the criticism aimed at the 'white space' margins in articles. What many of you have missed is that the print size has come down a notch and with many diagrams and photos filling the margins we now fit more on a page than we did before! As for the charge of plagiarising The Guardian ... the mere suggestion is ridiculous – witness our design for the next ETI logo below ...

HI-FI FOOL

I have just bought April's ETI and perused it for the traditional April Fool article — but none could be found. That is until I read the *Virtuoso Power Amplifier* article. I do not believe Graham Nalty can be serious.

To take one of the many examples, can we please have an end to the myth that cables are in some way implicitly 'directional.'

It is tripe like this that casts doubt on the professional integrity of 'hi-fi purists' and shows that we are still not recognising the extremely subjective nature of hearing. So come on, stop pretending we can hear things we can't and just sit back and enjoy the music.

Ian Harvey
Trinity College, Cambridge

We do try to listen to both points of view ... our article The Truth About Hi-Fi *(May 1987) knocks much of the more extreme hi-fi mythology. There are a great many readers, otherwise apparently sane, who reckon there's a definite difference in quality from wire direction and so forth. Subjectivity is indeed the operative word.*

Er ... by the way, the April Fool article was the Transatlantic Timezone Corrector ...

STARS ON SUNDAY

Further to your recent *Doctor Who* correspondence, I feel that the public should be aware of the increasingly disturbing relevations appearing in the *Lost in Space* shows on Channel 4 during Sunday lunch (set in 1997).

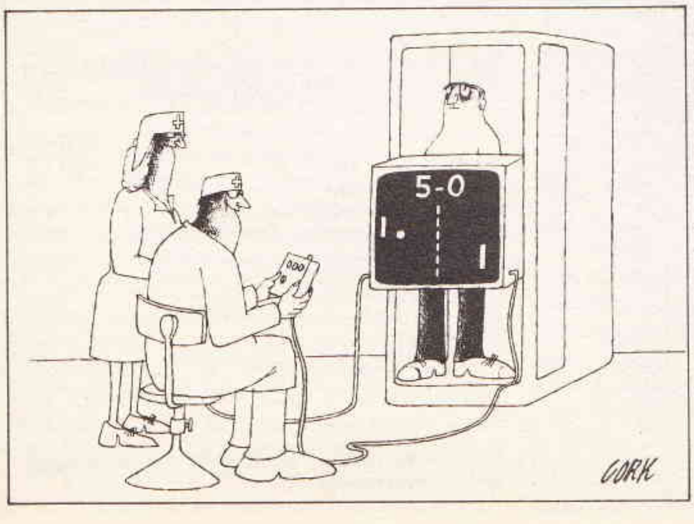
According to these programmes within ten years we will all be wearing Bacofoil jumpsuits and using 1950s computer hardware.

Space exploration will leap ahead while robotics still has metal men waving their arms up and down like Zebedee in *The Magic Roundabout*.

All very disturbing, especially since the jumpsuits will make it very hazardous for me to use my new microwave oven. What should we do?

Yours in chainmail undies,
Gavin The Opera Singer,
Tewkesbury, Gloucs.

Don't worry. In another two years Moonbase Alpha will break orbit from the sun in the pilot of Space 1999 and the resulting climatic disturbance and solar radiation break-through will render your microwave redundant as all meat will be cooked at source. Meanwhile you may like to see a (The) Doctor.



TERMINAL PROBLEM

I wonder if you or your readers can help me solve a problem I'm having with telephones.

BT have recently installed a BT modular master socket in my home. This works well with a phone I purchased from a retail outlet. However, I have two extension sockets and have obtained two ex-rental BT phones to use.

I fitted suitable plugs and cords and the two ex-rental phones dial out correctly but will not ring with an incoming call. The phone from a retail outlet rings on any socket.

I can only conclude that the connections in the ex-rental phones must be different when used with line jacks.

Can anyone help?

Mr A Wint
Ilkeston
Derbyshire

Well firstly we are duty bound to point out that those phones you have adapted for use on BT master sockets and associated wiring/ sockets are only approved for the original old type BT connections and not on your new connection. Use of them as such is distinctly naughty of you.

However, if nothing we can say will deter you, we will answer your query.

Inside the telephones you will find two rows of terminals numbered T1 to T9, and T10 to T19. If you connect a jump lead from T17 to T18, the bell will ring with incoming calls.

STRIP IN ETI

Many thanks for publishing your timer project with a stripboard design as well as the normal PCB (April ETI).

I hope there will be more like this as PCBs cost so much if you haven't got your own tank (and I haven't but I do have drawers full of stripboard).

Mr K Picton
St Helens, Merseyside

The 1st Class series of projects will all feature stripboard designs (so hang on to your drawers) although we'll continue to include the PCBs for readers who like their neatness and ease of construction.

HENRY IS MISSING!

With reference to the letter in April's ETI from R A J Howard concerning the transistor-protection diode, may I clarify the issue.

Your magazine is correct to say that with the diode in place, the voltage at the collector of the transistor cannot exceed that of the supply plus about 0.7V.

But the formula without the diode in place should include the inductance of the relay:

$$V = \frac{L\,di}{dt}$$

Don't forget the Henrys!
C J Hinchcliffe
Cowplain, Portsmouth

We know what it's like filling in surveys. They never ask exactly what you want to say and it's so hard to be expressive with box-ticking as your sole form of communication.

So write to us as well. Send a letter. Give it to the postman. Drop it right in his sack.

Let us know, tell us everything at once. We care, we really do.

Send your donations, er ... I mean letters ... to:

ETI
1 Golden Square
London
W1R 3AB

THE FORGOTTEN COMPUTER

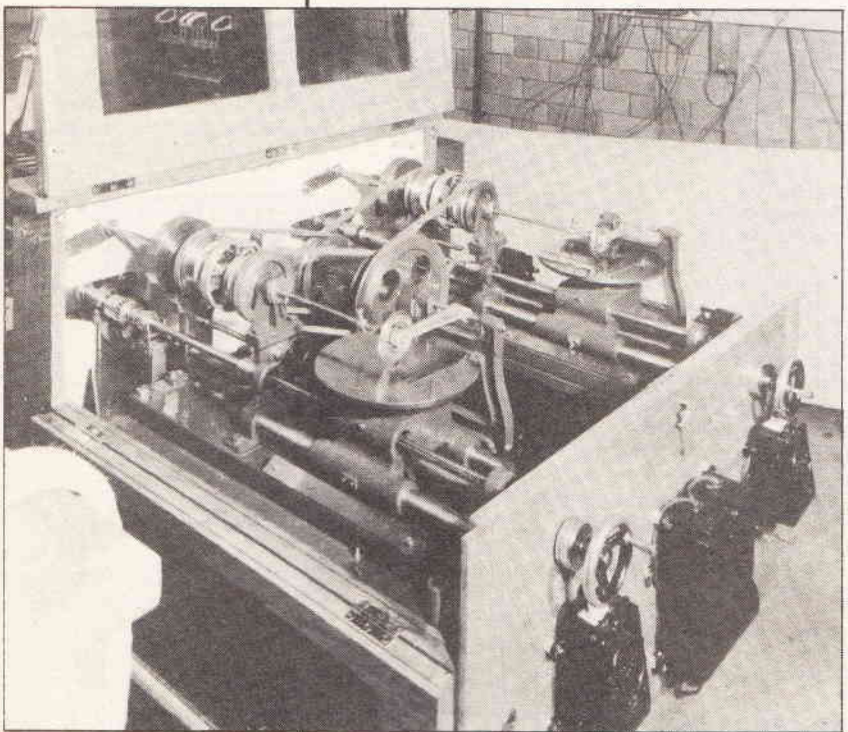
Paul Cuthbertson reveals the analogue computer is not dead but alive, well and usefully living in Aberdeen

The analogue computer has been with us in one form or another for some considerable time. Despite this, it could be called the 'forgotten computer.' Today the public imagination is swamped by notions of word processing, high resolution graphics and digital communications — all (rightly) the domain of the digital computer.

However, there are many analogue computers around. They lack the glamour and fascination of their digital counterparts and can be found incorporated into industrial controllers, dedicated to keeping steel at such a thickness and ketchup at such a consistency. Otherwise, they are mostly found languishing in dusty cupboards.

Analogue computers deserve a better fate than this. They are a valuable tool for the scientist, engineer and mathematician providing a direct means of modelling systems as diverse as control mechanisms, vehicle suspension units and animal populations.

The history of the analogue computer is as varied and interesting as that of the digital computer. There were a few mechanical versions about in the 19th century (the slide rule is really a mechanical analogue computer and you could argue certain ancient navigational instruments are too) but the first really successful mechanical designs arose about 1930 or so in such places as MIT and Cambridge. Electronic versions appeared in the 1940s. RCA built the first accurate design in 1950, since when the advent of integrated circuits has made the design of analogue computers easier, in just the same way as digital computers.



Many of the pre-war analogue computers had militaristic purposes such as bomb or gun aiming and were very successful. Connected directly to the airspeed, height and heading instruments in the aircraft, even the primitive versions of automatic bombsights were vastly superior to eye alone.

Further improvements used a gyroscope to allow for the aircraft banking and allowed the operator to input a drift rate to compensate for the effects of the wind. Anti-aircraft guns used a 'computer predictor' which computed a trajectory for a shell assuming that the target was holding a steady course, or that any change was at a constant rate.

Mechanical Matters

Mechanical analogue computers use the amount of rotation of a shaft or the length of a piston as the variable. Multiplication by a constant is achieved simply be meshing two gears of a certain ratio. Summation can be done by levers.

Integration (see photo) was performed in an intriguingly elegant manner by a 'spinning disc integrator.' A roller bears on the surface of a disc which spins at constant speed. This roller is free to move along its axle towards the periphery or the centre of the spinning disc. The shaft of the roller will accumulate a rotation depending on how near the roller is to the periphery of the disc. If the roller is at the centre of the disc, then no rotation occurs. If the roller is moved right over the centre and onto the other side, then the direction of accumulation reverses.

Figures, 1-4 show some examples of mechanical computer functions.

One of my friends who works in a fisheries research establishment tells me that there used to be a mechanical model of fish populations standing in one corner of his lab. Nowadays electronics has taken over and they use a big VAX computer system for such things.

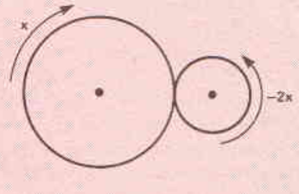


Fig. 1 A mechanical coefficient multiplier using two gears at 2:1 ratio (rotary motion)

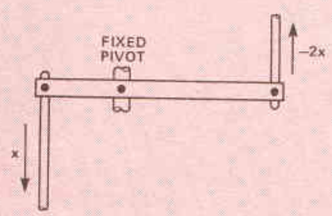


Fig. 2 A mechanical coefficient multiplier using levers (linear motion)

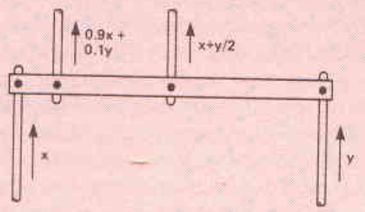
ACs

A digital computer deals with data in the form of discrete numbers and processes these in turn according to a sequence of instructions. The bit-length of the word dictates the resolution. The electronic analogue computer represents quantities as voltages. These voltages are analogous to the quantities we wish to represent and vary in a manner analogous to the manner in which the quantities vary — hence of course the term analogue computer.

To make an example of the differences in operation, suppose we fire a shell from an artillery piece and this shell will attain an altitude of 10km before its vertical motion stops and it starts back to earth. In the digital computer we might calculate the altitude of the shell at discrete intervals. If we calculate to the nearest metre, the number 2000 would represent 2km, 1000, 1km, and so forth. A binary word of 16-bits would easily accommodate the maximum altitude of 10km.

However, in the analogue computer the altitude of the shell would be represented by a continuously varying voltage — 1V might represent 1km. This is a far more direct method than the digital but each has its own advantages and disadvantages:

- Noise and drift (due to temperature and ageing) and tolerances in the circuitry all contribute errors in the analogue computer. There are no such errors in the digital computer, excepting gross fault conditions which cause a bit to change state.
- The digital computer suffers from rounding errors. In fact a small number added to a much larger one can vanish entirely under certain conditions! The resolution of the analogue computer is infinite (in any practical sense) and there are no rounding errors. We can minimise rounding errors in a digital system by increasing word length but then we suffer the cost of extra hardware or increased processing time.
- The digital computer is an essentially serial device performing primitive operations on fragments of numbers in sequence. This makes for slow arithmetic. An analogue computer is inherently parallel. A single summer could take an unlimited number of inputs, multiply each by a coefficient and add them all in a few microseconds. There may be tens or even hundreds of these 'computing elements' working simultaneously.
- Results are available continuously from an analogue computer. In the digital computer the results will progress by discrete jumps at intervals. A number which may be precise at the instant of its calculation will usually be progressively less accurate until replaced by its successor.
- There is a certain minimum hardware requirement for a digital computer. We have to have a processor, RAM, ROM and IO (even if these are all on the same chip). A useful analogue computer which might be used to solve a second order differential equation can be built from a few op-amps. The total cost of the components for such would be less than a pound. In fact an analogue computer model of a filter — a state variable filter — needs three or four op-amps, a few resistors and two capacitors. The display for an analogue computer can be a meter, an oscilloscope or a DVM.
- The method of interconnection of the analogue computer elements is a very direct way of numerically solving systems of equations, even those which might defy analysis. Compared with these methods the digital computer is an abstraction, requiring massive underpinning of languages, operating systems and such.
- A sensor such as a potentiometer can be wired straight into the analogue computer inputs. The outputs can drive an audio amplifier, or servo amplifiers.
- The operator can interact directly with the analogue computer in an experimental fashion — to 'try things out.' This is less easy on a digital computer.



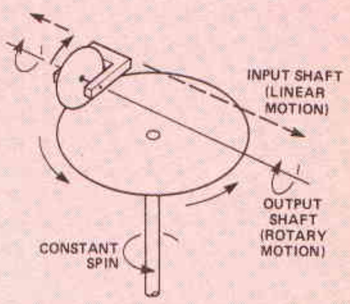


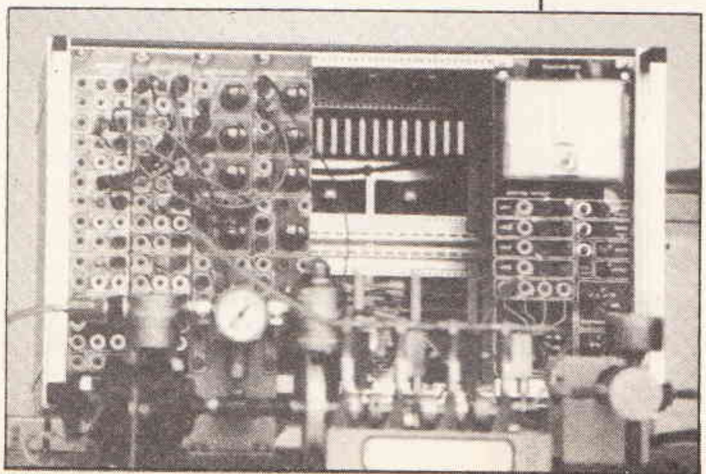
Fig. 3 Mechanical summation

Fig. 4 The principal of the spinning disc integrator

- An analogue computer cannot be used as a word processor or the like as it has no way of representing characters. The digital computer is ideal for that task. An analogue computer is a purely numeric machine.
- The parallel nature of the analogue computer makes testing easy. Each computing element can be tested independently and if needs be ignored until a service is done.
- The digital machine can store information indefinitely. This is not possible on an analogue computer.

I would identify inability of the analogue computer to store information or to handle text as the two major reasons for the ascendancy of the digital computer. Hybrid machines do exist — where numeric computation is performed by the analogue computer and the digital section is responsible for generating functions, for storage of output or for performing any long term integration or summation where speed is not important. Connection between the two parts is via DAC and ADC convertors.

Attempting to patch the analogue computer connections from the digital computer is a complex business. Interestingly enough, the arrival of a new generation of crosspoint switch chips on the scene a short while ago may herald a more compact and effective hybrid computer.



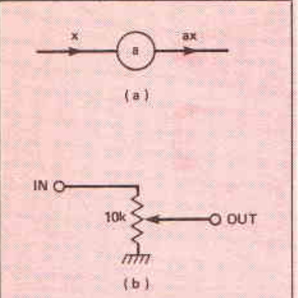


Fig. 5 The electronic coefficient multiplier symbol and circuit

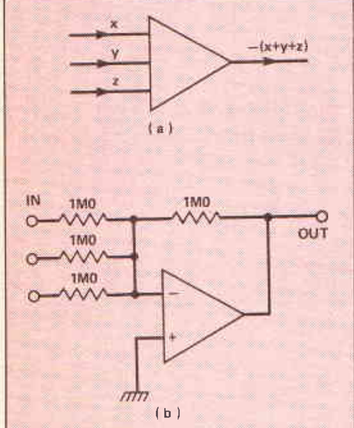


Fig. 6 The summer symbol and circuit

If you were to see an analogue computer and one of the more usual desktop digital computers side by side, the superficial differences would be glaringly obvious. In fact you might not recognise the analogue computer as being a computer at all, as all the more usual keyboard, video monitor, printers and disk drives are entirely absent. Instead we might have a large panel on which is an array of sockets, a set of knobs, one or two switches and an analogue meter movement (or possibly a simple scope or DVM).

The array of sockets is known as the patch panel and the analogue computer is programmed by linking (patching) various of the computing element sockets together, rather in the manner of the old time telephone exchange. The analogue computer software is easy to see. It is the wiring on the patch panel! There is no confusion about where the software 'is' on an analogue computer.

Let's examine the individual computing elements before discussing how they might be interlinked. The three most commonly used are the coefficient multiplier, the summer and the integrator. Useful work can be done on systems of linear equations with no more than these three types of elements. We built our own analogue computer at Aberdeen University recently. It incorporates all these three. Our approach has been slightly unconventional and where there are differences between the Aberdeen unit and the usual case, I'll mention them.

The coefficient multiplier multiplies an incoming voltage by a constant. The coefficient must be between zero and one. Physically the multiplier is usually a potentiometer, with one end connected to 0V (Fig. 5).

When the output of this arrangement is patched to the input of the next element, the set coefficient will tend to droop, due to the next element's non-infinite input impedance. Our own analogue computer has the slightly unconventional addition of an op-amp buffer after the potentiometer, which does away with this problem. Some of our potentiometers are also double ended — neither end is taken to 0V. This is occasionally useful and again unconventional.

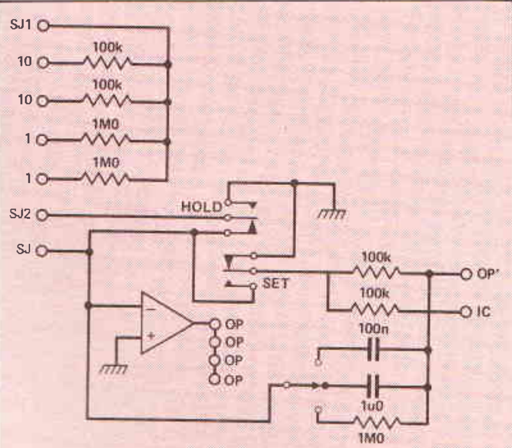


Fig. 7 The circuit for a basic conventional computing element

The summer (Fig. 6) takes a number of voltages as inputs and adds them together, inverting in the process. The actual circuit consists of a single op-amp and a number of resistors. In our version the input resistors are trimmable through a limited range to eliminate initial tolerances. Any practical circuit must also include a nulling potentiometer. The inputs on our version are each tied to 0V via a 10k resistor. This means the input may easily be left open without disturbing the impedance balance of the circuit too much, thus minimising offsets.

The input resistors are connected direct to the op-amp circuit, the general trend being to keep these separate. In a conventional computer this gives access to the virtual earth point and allows the operator to introduce feedback networks other than the ones supplied. Figure 7 shows a typical analogue computer summer element which illustrates this.

The conventional circuit also doubles as an integrator if you should switch in either of the capacitors, and another element's input resistors could be hijacked if necessary. In our circuit the elements are fixed and trimmed for accuracy, which does not allow this flexibility.

The integrator element integrates the sum of the input voltages with respect to time. If we suppose that the input x is a constant, the output voltage will change by xV in 1 second. Note that there is an inherent sign reversal as in the summer.

The Aberdeen unit is unconventional in that the initial conditions input is not sign reversed. The relays are to do with setting the element to its initial conditions or holding the computation at any point. We chose IC analogue switches instead, principally because they do not bounce. Figure 8 shows the symbol for an integrator.

Figure 9 shows the elements of the Aberdeen unit as they might appear on a problem flow chart. The triangle is an inverter. Normally one would press a summer into service as an inverter because of the way our circuit is built, there is a spare inverter with each summer, which is brought out to the front panel. The numbers refer to gains — 10 is a ×10 input. Use of stackable hermaphrodite connectors removes the need for the usual multiple outputs on elements.

There are numerous other circuits which can be used on analogue computers. Among the most important we could mention are four quadrant multipliers and the various diode circuits for modelling nonlinearity, discontinuities and hysteresis. In fact, any circuit which behaves in a fashion analogous to a physical system can be pressed into service. None of these non-linear elements are incorporated on the Aberdeen unit . . . yet.

So how do we patch these together to produce something useful? We can appreciate what is happening better if we devise a model of a system and set out to solve it. I have chosen the classic mass spring damper model of a car suspension, beloved of generations of long suffering fifth formers ever since Newton. It is not too complex to imagine what is happening in the mind's eye but at the same time it is not a trivial example. Figure 10 shows the arrangement.

The deviation of the spring from its natural (unstretched) length I have called x. This is a distance of course. The rate of change of distance with time is called velocity. The rate of change of velocity with respect to time is acceleration. I have called the velocity $\dot{x}$ ('x-dot') and the acceleration $\ddot{x}$

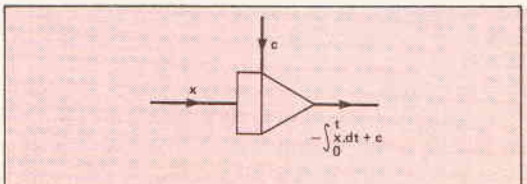


Fig. 8 The integrator symbol

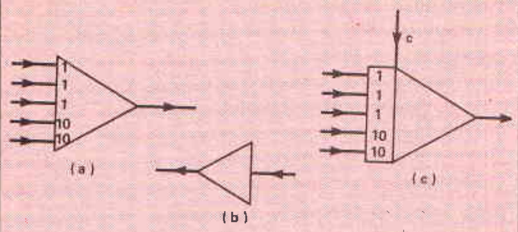


Fig. 9 Symbols for the Aberdeen unit computing elements (a) Summer (b) Inverter (c) Integrator

('x-double-dot') which is mathematicians' parlance for the derivative and the double derivative of x.

Now, you needn't worry about all this calculus. The only important point to remember for this purpose is that integration is the opposite of differentiation.

As the spring is stretched or compressed, it will exert a force equal to the stiffness times the distance we have stretched it. If we call the stiffness k, the force is kx. So far so good.

There is also a force exerted by the damper. The damper only exerts force when we try to move it. If we call the damping factor d, then the force exerted by the damper will be d times the velocity which is $d\dot{x}$.

These are the only forces on the mass, so we can add them together to get the total force:

$F=-d\dot{x}-kx$.

There are two important points to note here. We have ignored such complications as air resistance and mass of spring (and a good thing too, I hear someone saying). We also have to decide which direction is positive and I have decided that up is positive. When distance is negative, the spring is compressed and the force it exerts is upward hence the negative sign in front of the spring's force. Similarly when the motion of the mass is downward (negative) then the damper exerts an upward force.

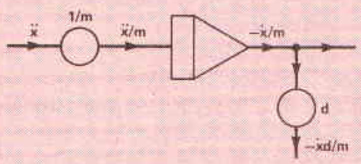


Fig. 13 Damping

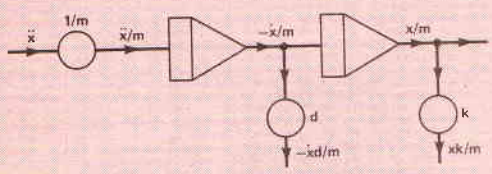


Fig. 14 Adding the spring

These forces make the mass accelerate. Newton (bless him) said that force is mass times acceleration, so

$m\ddot{x}=-d\dot{x}-kx$

All right then, that's our model of how the system behaves. How to get it into the computer? Let's indulge in some algebra and get m (the mass) out of the way to leave x on its own

$\ddot{x}=-d\dot{x}/m-kx/m$

I mentioned earlier that integrating is the opposite of differentiating so if we fix up an integrator as in Fig. 11, it's a good start. We get $-\dot{x}$ out (remember the sign inversion).

If I integrate a constant times $\ddot{x}$ I will get the same constant times $-\dot{x}$. So, if I put in a coefficient multiplier set to 1/m as in Fig. 12, we can see the result. Then we can add in a coefficient multiplier for d (Fig. 13) and then another integrator and coefficient multiplier for k (Fig. 14). Finally we can add these two in a summer (Fig. 15). It's fairly easy to see how the patching is built up. Figure 15 shows the 'open loop' flow diagram for the problem.

But there's still one last thing. We do we get $\ddot{x}$ from in the first place? Lo and behold, we have what seems to be the right thing coming out of the summer. We can make the left hand and right hand sides of the equation equal if we connect the input and the summer output together as shown by the loop in Fig. 16. This is the closed loop flow diagram and is the patch that we need to solve the problem.

Provided we've got the plusses and minusses right, the solution is a decaying sine wave. Mathe-

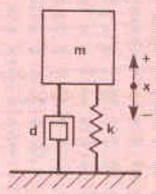
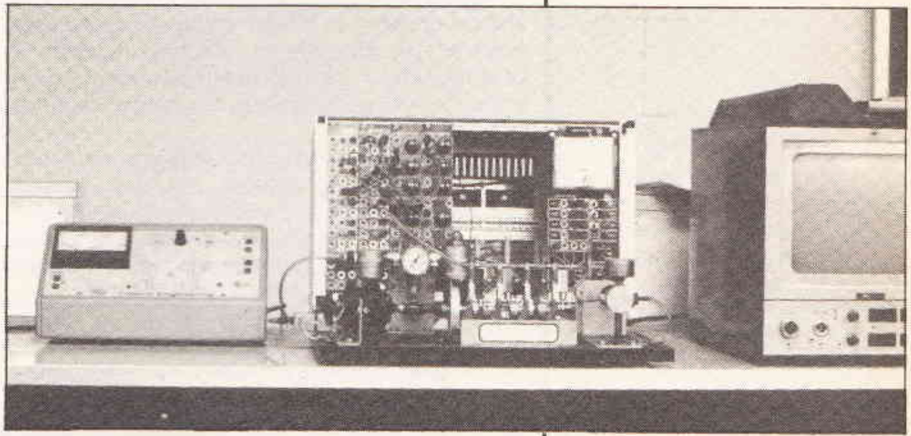


Fig. 10 The mass-spring-damper problem



matically it's possible to have a 'daft damper' which assists motion instead of retarding it. That gives an increasing sine wave. It's also possible to have a 'silly spring' which pushes in the wrong direction as we stretch it. The solution in this case would probably be an exponential (depending on the ratio of k and d).

This problem is quite easy to solve analytically. The analogue computer really comes into its own where we encounter sets of differential equations which are difficult to analyse. These are no more difficult in principle to solve on an analogue computer. For example air resistance, double acting dampers, spring masses and the like can all be built in. All we have to do is derive a set of equations which describe the system. We can build several separate models and interconnect to feed the results of one into the next.

The model we have just used does not account for gravity or a 'bumpy road.' We can add in any acceleration we like at the summer, including that of gravity. We can connect an oscillator to

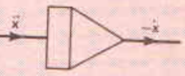


Fig. 11 First steps

Fig. 12 Accounting for mass

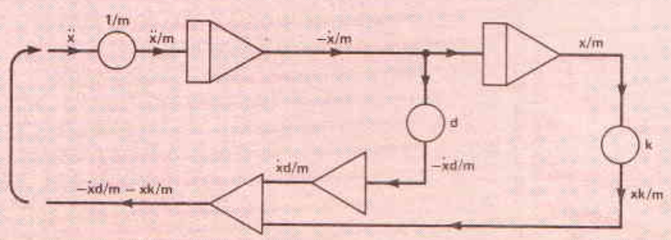


Fig. 15 The complete patch

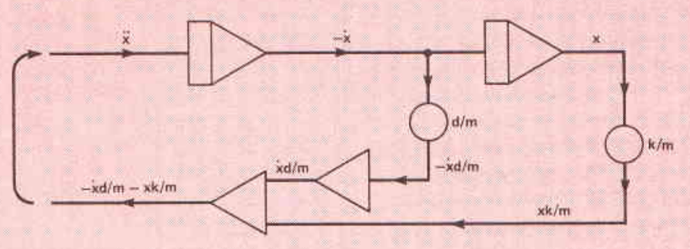


Fig. 16 An alternative patch with fewer coefficient multipliers

the same place, to inject 'bumps.' (This oscillation is known as a forcing function). This illustrates the direct nature of working with an analogue computer.

So far we have not attempted to quantify the settings of the pots. To get a useful quantitative result we must scale the problem. Ideally the model will use full dynamic range of the machine (+10V in our case) without going appreciably outside those limits (which may cause clipping and invalid computation).

It's a similar problem to that encountered by anyone confined to integer arithmetic or the user of a slide rule. The slide rule user has to keep track of all the zeroes or he will end up a factor of ten-to-the-something out. Similarly, the integer user may run out of bits.

I don't propose to go into scaling in any detail, except to say that there are well defined procedures for doing it which consist basically of writing out an equation for each computing element, estimating the maximum value a variable can be expected to take and dividing through, calculating the pot settings as we go. Some operators get by using try-it-and-see methods.

Anyone who is particularly interested in the rigorous scaling of problems is recommended to read 'Systematic Analogue Computer Programming' by Charlesworth and Fletcher which gives a detailed treatment of this and other facets of analogue computing.

My own interests in analogue computers started when I was asked to look at one which appeared faulty. Unfortunately it was an extremely poor design and was sent packing. Subsequently we decided to develop our own system. The photographs shows views inside and outside the machine.

On the right is a panel (the control unit) which contains a large analogue meter movement, three rotary switches, three push buttons and a variety of lamps and 4mm sockets. On the left are four narrower panels.

The control unit is the nerve centre of the computer. As well as controlling the hold and reset functions, it allows for monitoring of the progress of a computation and it also provides access for a BBC micro to gain control and monitor and store the results. Thus the Aberdeen analogue computer is 'hybridisable.' Two D-type connectors on the rear can be fitted with cables which plug into the user port and the analogue port of the BBC.

The meter is used to set up the potentiometers and to monitor the progress of computations. There are four yellow sockets which are used to input signals to the meter. A meter select switch routes the signals, as well as selecting reference or supply voltages to be monitored. A hold and a reset button toggle the hold and reset states on and off — an LED shows which state is selected. An unusual feature is the bandwidth control which switches capacitors in all the integrators, to allow faster operation.

Of the four smaller panels, one contains five integrators, one has five summers and five inverters and the two remaining panels each contain six coefficient multipliers, along with sockets to provide +10V and 0V to the programmer.

These four panels can be plugged into the frame in any of the seven possible positions as the bus structure is not position sensitive. The three spare slots allow the introduction of similar or other panels as they become available. The control unit must however be in position at the far right.

All the sockets are colour coded. Blue sockets are outputs. Yellow sockets are ×1 inputs. White are ×10 inputs. The initial conditions sockets on the integrators are brown. The red, black and green are for +10, −10 and 0V respectively.

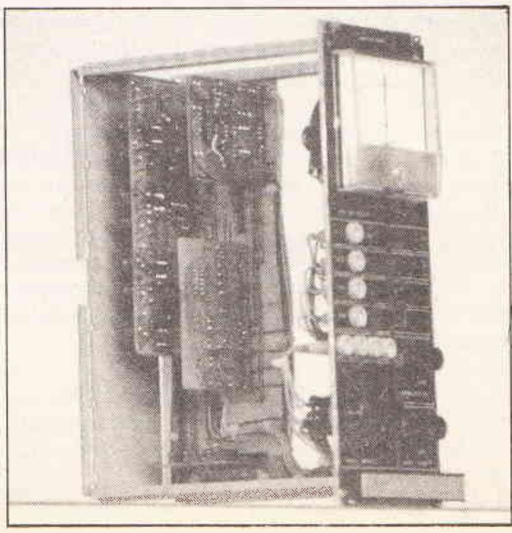
This makes it easy to find your way about. There are no legends, hieroglyphics or diagrams on the panels but there are group markings encircling sets of sockets which are associated with the same computing element. The five indicators on the summing and integrating panels are overload indicators. They latch on in the event an output exceeds about 11.5V. Resetting is by a common pushbutton marked OVV on the control unit.

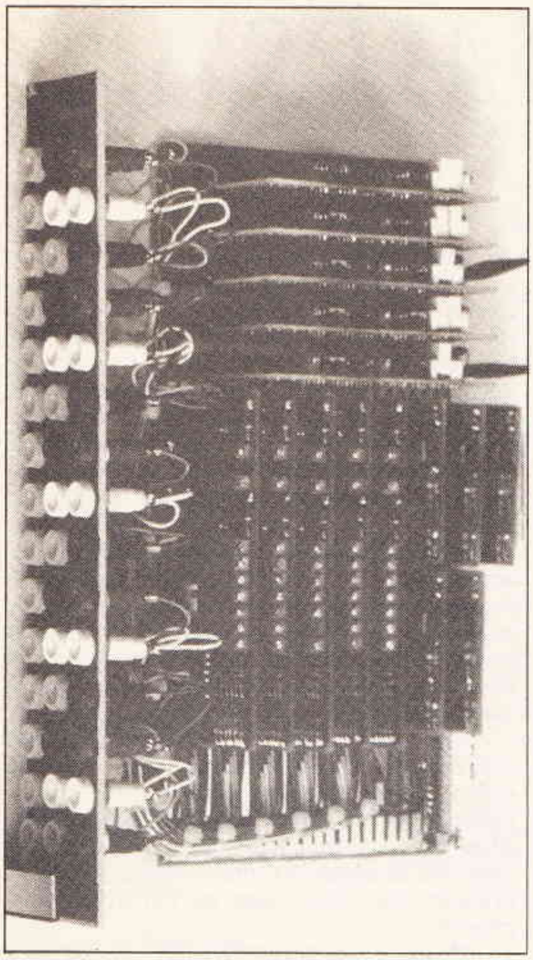
The control unit houses a motherboard and several daughter boards. There is a logic board which controls the hold and reset functions and a meter amplifier board which is controlled by the meter range switch.

There are two apiece of the others — generalised optical interface boards used by the BBC interface and generalised analogue conditioning used to switch signals or to attenuate and shift the normal +10V range of the analogue computer to suit the BBC ADC inputs.

The power supply board is on the rear panel of the frame, along with the transformer, filter, rectifier and reservoir capacitors which are all off board. This power supply performs well. No voltage deviation registers on 4½ digit DMM when full load (500mA) is applied. I couldn't believe it at first. No current limit is necessary as the supplies are not available externally.

The supplies are +15V for the analogue circuitry and +7V for the digital circuitry, which is all CMOS. The 0V line is not a supply, and does not carry supply currents. It is purely a reference. This also helps lessen noise. An interesting feature of the supply is its sequencing. The 15V rails cannot come right up until the 7V rails are established. This prevents damage to the CMOS analogue switches.





ACs

The master references are on this board too. These are trimmed to within 1 millivolt. We can claim 10.00V in fact, or 0.01% accuracy. The supplies are trimmed to within a few millivolts too. The primary reference is a band gap diode and the setup is remarkably stable in the long term. Each reference socket is individually buffered to prevent loading of the master reference.

Incidentally the integrators and summers on the Aberdeen unit are trimmed to within 0.01% as well. It's quite possible to set up the zero point, with the aid of a decent DVM, to within a few tens of microvolts. However, having said that, the time constant on the integrators is the very devil to set up accurately.

This, like most analogue computers, has proven to be a valuable tool. Even in these days of fast digital arithmetic, the analogue computer should not be despised or cast aside. It offers direct, easily interpreted evaluation of problems.

One of my little projects for the near future will be to make up a dedicated analogue computer which multiplies six variables by a coefficient matrix, giving six outputs. One of my colleagues will use it to investigate the motion of buildings during earthquakes.

It has to perform 36 additions and 36 multiplications. It could be made to work at up to 100kHz (although it won't need to in this instance). An equivalent digital system would need to do these 72 operations every five microseconds to keep pace — a good few transputers worth maybe, or a very fast DSP chip, plus converters, etc, etc.

The hardware I'm using? Two quids' worth of op-amps and a few dozen resistors . . . ETI

Next month Paul Cuthbertson describes a simple analogue computer project based on the Aberdeen University unit.

OP-AMPS

Paul Chappell starts an in-depth look at the designer's favourite chip

In circuits built from discrete components, a large proportion of the design effort is absorbed in trying to minimise the imperfections and unpredictability of the components used. In building a low frequency gain stage with a bipolar transistor, for example, beginners quickly learn that a current bias circuit (Fig. 1a) is no good because the wide variation in current gain between different samples of transistors of the same type means the base bias resistor must be selected by trial and error for each individual device.

The potentiometer bias circuit (Fig. 1b) reduces the circuit's sensitivity to transistor gain — with suitable choice of resistor values this circuit can accommodate any transistor of a given type without modification. The price paid for this convenience is partly that the signal 'headroom' is reduced because of the voltage across the emitter resistor but mainly that the circuit as a whole has very much less gain than the transistor itself.

The technique of trading off gain (or giving it up altogether) in return for better performance in other respects is a very useful one. Figures 1c and 1d show two non-amplifier applications of the idea. The first is a simple (and not very satisfactory) Miller integrator, where the transistor is used to linearise the charging of a capacitor. The second uses a transistor to simulate a very large capacitor (roughly $h_{fe} \times C$) at least as far as charging is concerned.

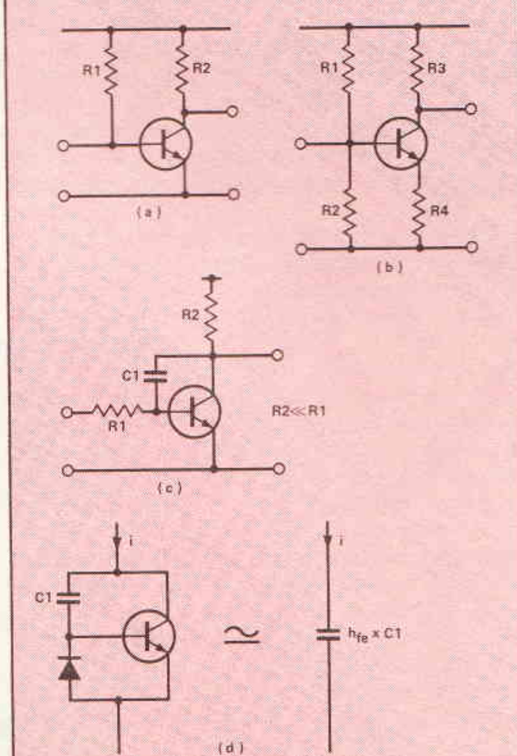


Fig. 1(a) Transistor current bias circuit.
(b) Improved potentiometer bias circuit.
(c) Simple integrator circuit.
(d) Simulating a large capacitor

The drawback of transistors is that individually they don't have a lot of gain to give up. Useful circuit building blocks are made not from one but several devices. They also suffer from being direct embodiments of a basic physical process and make about as much concession to practicality as a piece of school laboratory equipment. The 0.7V base-emitter voltage exists not because designers want it that way but because that's how transistors are. It's how the physics works.

A good case can be made for the view that op-amps have more in common with discrete components than with other ICs. Used raw — without any associated passive components — they are totally unmanageable, but just connect a few external components and a very wide range of useful circuit building blocks can be made.

The most striking advantage of op-amps over transistors is that the available gain is several orders of magnitude higher, allowing very precise control over the circuit's characteristics with a single device. What's more, the external connections are arranged for the convenience of the designer, not constrained by the demands of physics.

However, like discrete components, op-amps have their own imperfections and idiosyncrasies. Technology has moved the decimal points a few places but greater performance seems to lead inevitably to greater expectations. There is always somebody who can think of an application which would be possible if only the latest device were just that little bit better!

Coaxing the best performance from op-amps is still the same mixture of art and science as for discrete components. In this series of articles I intend to cover the basic techniques and also to touch on some of the finer points of designing with these versatile devices.

Op-amp ICs

With most families of ICs the pin configuration for each member has to be learned individually but with op-amps it's easy. They come packaged in ones, twos or fours and the pin connections are almost always the same for any brand (Fig. 2a). High performance devices are usually packaged individually in the 8-pin DIL or TO99 package and the spare pins may be used for offset cancellation or external compensation but the basic configuration of inputs, outputs and supply connections is usually adhered to.

Op-amps are very tolerant of supply voltages. Most will operate with single supplies from below 10V to above 35V. Some (particularly those intended for battery operation) will run from as little as 4V. Voltages above 40V are rare but you can have that if you want it (and can afford it!).

Op-amp circuits are usually run from split rail supplies (Figs. 2b, 2c). This is because the limits of the input and output voltages for correct operation fall short of the supply voltages, so the central 0V rail is a useful bias and reference point. (Note that although data sheets often give absolute maximum

CIRCUIT THEORY

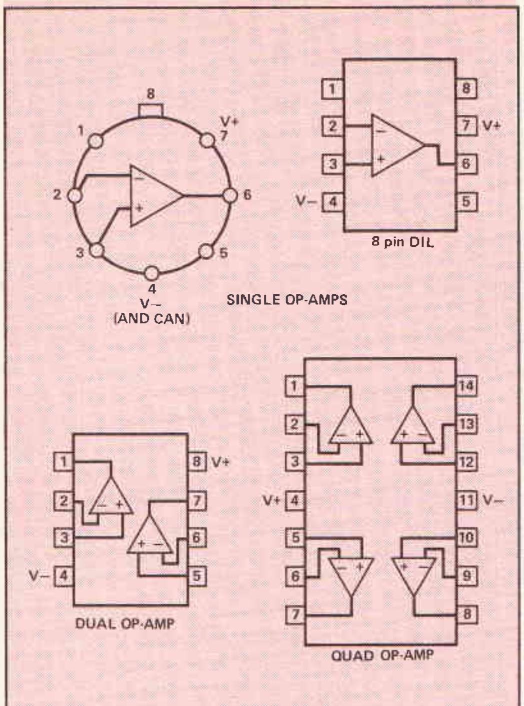


Fig. 2(a) Op-amp pin connections

input voltages as being equal to the supply voltages, this rating shows the most the IC will suffer without damage, not the range in which it will operate properly).

Op-amp Basics

Let's indulge in a flight of fancy for a moment. We've just received a sample of the very latest op-amp. It has extremely low drift and offset, superb common mode rejection, very low noise, bias currents of 1nA — in short it's the kind of IC any manufacturer would love to produce. Unless I say otherwise, it's this £200 Rolls Royce of op-amps that we'll be using in this article. Let's see how it behaves.

The IC has a voltage gain of 10^6. This means the output will be 10^6 × *difference* in the input voltages, taking into account which is the higher in voltage. If the + input is 1μV higher than the – input, the output will be at +1V. If the – input is 1μV above the + input, the output will be at -1V. If the two inputs are at the same voltage, the output will sit firmly at 0V.

Connect together the two inputs and vary their common voltage ('common' in electronics means 'both have the same' as in 'having something in common' — and not 'ordinary' as in 'common or garden' or even vulgar as in 'common as muck'!) by means of a pot (Fig. 3a). The output will sit firmly at 0V regardless of the setting of the pot (it won't follow the input voltage) because there is no difference between the two input voltages. This shows that the IC has excellent (perfect, in fact!) *common mode rejection* — it ignores voltages common to both inputs.

Figure 3b shows the IC's response to a *differential mode* signal. You have to imagine here that if the pot is set at the centre of its rotation, both voltage sources are zero.If it is rotated clockwise, v_1 gives a light positive voltage and v_2 gives an equal negative one. If the pot is rotated anti-clockwise, v_1 will be negative and v_2 the same amount positive. If you are happier looking at a more concrete circuit, Fig. 3c shows one that will do the trick.

The centre-zero microvolt meter M1 registers the differential mode voltage. The output of the op-amp will be one million times the voltage shown on the meter.

Figure 3d combines a common mode voltage (set by RV1 and shown on M1) and a differential mode voltage (set by RV2 and registered on M2). When the two inputs are not at the same voltage, their common mode voltage is defined as the voltage exactly halfway in between, so $v_{CM} = \frac{1}{2}(v_{(+)} + v_{(-)})$. The differential mode voltage is centred neatly on the common mode voltage.

Varying RV1 will have no effect on the output voltage, regardless of the setting of RV2. Varying RV2 will give an output exactly one million times the reading on M2, regardless of the setting of RV1. Just to make sure you've got the hang of it, if M1 shows -6.22V, M2 shows +3.2μV, what is the common mode input voltage? The differential mode input voltage? The voltages at the + and – inputs? Most important of all, what is the output voltage? Answers at the bottom of the page.

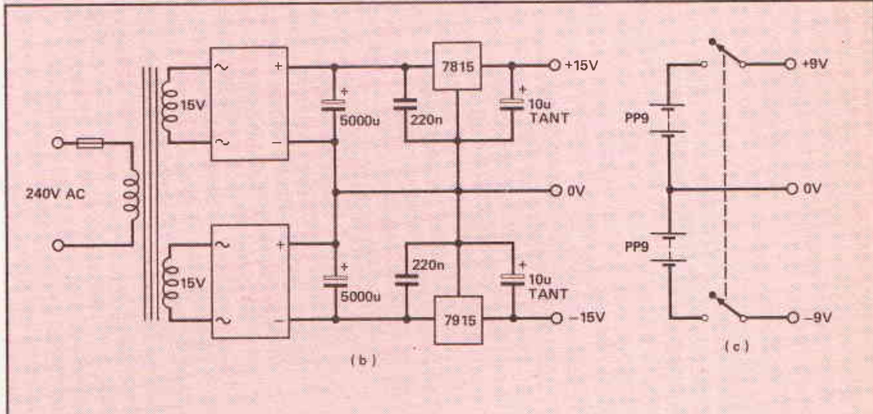


Fig. 2(b), (c) Split rail power supplies for op-amp circuits

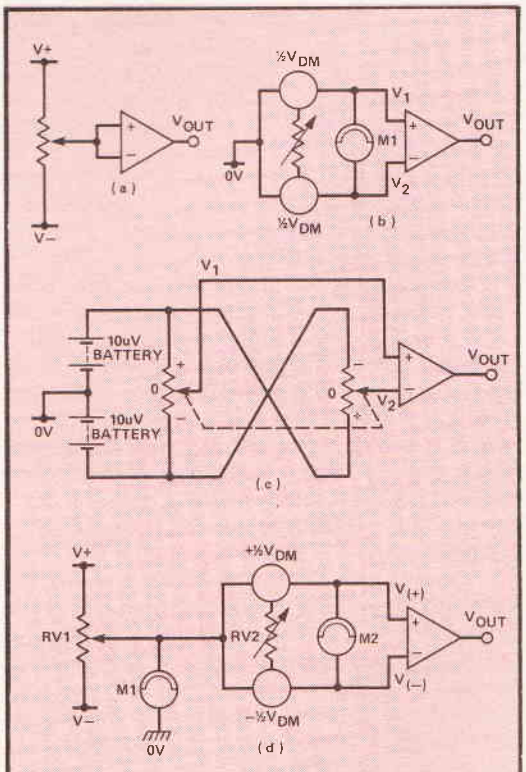


Fig. 3(a) Applying a common mode voltage. (b) A differential mode voltage. (c) Applying a differential mode voltage. (d) Common and differential inputs combined

The answers to the problems I posed earlier on, by the way, are: the common mode input voltage is -6.22V, the differential mode voltage is +2.3μV (I hope you got those!), the voltages at the + and – inputs are 6.219984 and -6.220016V respectively, and the output will be +3.2V.

CIRCUIT THEORY

Amplifiers

About the first thing anybody learns about op-amps is that they can be used to make amplifiers with a gain precisely controlled by the values of a pair of resistors. Figure 4a shows one of the ways this can be done.

Having read somewhere that the gain is given by –R2/R1, my fantasy is that the circuit of Fig. 4a has a gain of –10. I'll try to prove it to you.

The first thing to notice is that if v_{in} is 0V, the output will also be at 0V. If it tried to go just a teensy bit positive, the potential divider action of R1 and R2 would put a positive voltage on the – input, which would tend to push the output back towards 0V. If it tried to go negative, the resulting negative voltage on the – input would force it back up again.

In a way it's like one of those children's toys with weighted bases that always settle in the vertical position after being knocked. Any attempt to push the op-amp's output voltage by brute force results in a restoring force which will push the output back to 0V as soon as you 'let go.'

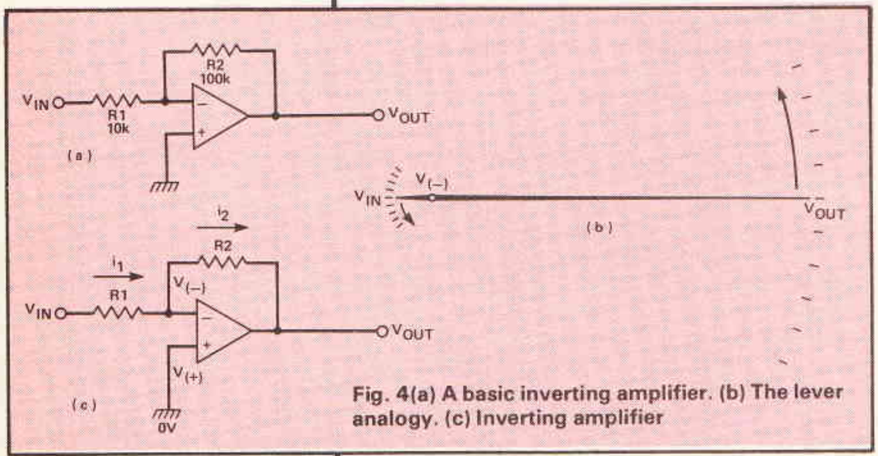


Fig. 4(a) A basic inverting amplifier. (b) The lever analogy. (c) Inverting amplifier

Suppose that v_{in} is increased to 1V. If I'm right about the gain being –10, the output will now want to settle at –10V. If so the voltage at the – input will be 0V, exactly the same as at the + input so the output must also be at 0V. What's gone wrong? It can't be at –10V and 0V at the same time!

The fault lies in my faith in rule-of-thumb calculations. The formula –R2/R1 for the gain is a very good approximation for most practical purposes, but it's not spot on.

Suppose that v_{out} settled at just a little above –10V. This would allow just enough positive voltage on the – input to be amplified up a million times and maintain the output at this voltage. Once again, the weighted base action comes into play. Any attempt to shift the output from this voltage results in a restoring force (using the term loosely!) which tends to force it back again. If you find the idea of 'just a little above –10V' too vague, don't worry. The calculations will be along in just a moment.

One way of looking at the circuit is to see it as a kind of voltage lever. The arms of the lever will be proportional to the resistor values and the pivot will be at the –input terminal of the amplifier. Pushing down on the input (lowering the voltage) makes the output rise ten times as far. The pivot is just a little bit loose — it moves just one millionth of the distance of the output arm, in the opposite direction.

If you don't care for mechanical analogies, perhaps reasoning from basic electronic principles is more up your street. Assuming the amplifier input only takes 1nA of current and since we are dealing with tens and hundreds of µA flowing in R1 and R2, it's reasonable to say that for practical purposes all the current in R1 must also flow in R2. Now, if there is the same current flowing through two resistors then by Ohm's law the voltage across each will be proportional to its resistance.

In other words, if 1.2V is dropped across R1, and the very same current is flowing in R2, you can say without further ado (and without bothering to calculate the current) that the voltage dropped across R2 will be ten times as great: 12V.

Now, whatever voltage appears at the output of the amplifier, the voltage at the – input will only be one millionth as much. There's very little point in taking it into account at all. We might as well say that it stays at 0V. So the input voltage will be the voltage across R1, the voltage across R2 will be the output voltage and we've already worked out that this will be ten times as great (or –10, taking into account that it moves in the opposite direction). In other words, the circuit has a gain of –10.

If all this business about ignoring little errors makes you feel uncomfortable, the only way to settle the matter is to do the calculations. Looking at Fig. 4c, by Ohm's law we can write:

$$i_1 = \frac{v_{in} - v_{(-)}}{R1} \quad \text{and } i_2 = \frac{v_{(-)} - v_{out}}{R2}$$

Now, if the op-amp's input takes negligible current (I'll have to fudge this bit for the time being or things will get impossibly complicated. I'll come back to it later) then $i_1 = i_2$, so

$$\frac{v_{in} - v_{(-)}}{R1} = \frac{v_{(-)} - v_{out}}{R2}$$

We also know that the gain of the op-amp is 10^6, so $v_{(-)} = -10^{-6}\,v_{out}$, giving:

$$\frac{v_{in}}{R1} + \frac{10^{-6}v_{out}}{R1} = -\frac{10^{-6}v_{out}}{R2} - \frac{v_{out}}{R2}$$

It's usual at this stage to point out that the terms involving $10^{-6}\,v_{out}$ are very much smaller than either of the other two terms (can you spot a condition where one or other wouldn't be?) and so can be neglected, giving:

$$\frac{v_{in}}{R1} \simeq -\frac{v_{out}}{R2} \quad \text{or} \quad \frac{v_{out}}{v_{in}} \simeq -\frac{R2}{R1}$$

which leads to the usual rule-of-thumb formula for the gain of –R2/R1. If we pursue the calculation to the bitter end without eliminating the two inconvenient terms, we end up with the exact formula for the gain, which is:

$$\frac{v_{out}}{R_{in}} = -\frac{R2}{R1 + 10^{-6}\,(R1+R2)}$$

Using this formula, the circuit of Fig. 4a, which I said would have a gain of –10, actually has a gain of –9.99989. So the rule of thumb in this case is not too far from the truth. In fact in comparison with the 5% resistor tolerances likely to be used in a practical circuit, it's pretty damn good!

My fudge factor — assuming the inputs take no current — doesn't affect the validity of the formula, although a proof of this and an investigation of just what effect it will have must wait for another time. There's more to these op-amps than meets the eye!

TRANSIENT CAPTURE

Mike Barwise shows how to be quick on the trigger with the ADC301 and ADC302 as rapid data loggers

CHIP IN

Last month we looked at a couple of fast *flash* analogue to digital converters made by DATEL. These devices (ADC-301 & 302) are implemented in ECL and I am going to show you how to interface them to TTL/NMOS.

The logic signals in and out of these devices are the differential input clock and the single-ended digital data outputs.

The device for interfacing the outputs is the MC10125 quad ECL to TTL translator (Fig. 1a). This contains four differential input ECL to single-ended TTL converters. Supply rails are ground, -5.2V (ECL) and +5V (TTL). A reference voltage output (VBB) is available for use when driving the input single-ended, which is what we are going to do.

Each converter has its non-inverting input tied to VBB and the input signal applied to the inverting input. The result is an inverting interface, so the polarity control pins (see last month) of the ADC should be strapped to inverting mode if you want true data output to your memory. Two 10125s provide the complete 8-bit output interface.

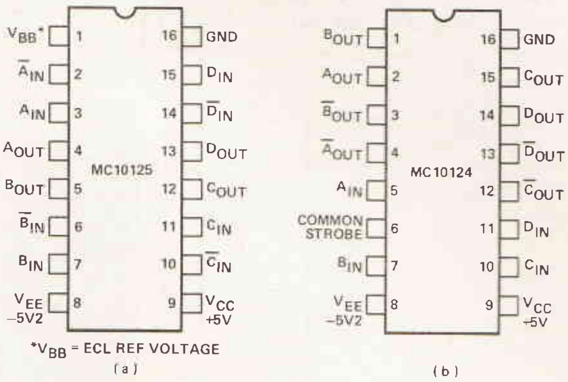


Fig. 1 (a) ECL to TTL translator. (b) TTL to ECL translator

Interfacing the clock input is apparently just as simple, but you have to watch out for timing problems. The interface part is the MC10124 quad TTL to ECL translator (Fig. 1b). This contains four converters, each having a single TTL input and sharing a common TTL strobe or enable — we only want one of the four internal parts so the unused inputs should be pulled up by about 10k each to VCC. The differential outputs of the selected part are connected to the clock inputs of the ADC with the oscillator connected to the TTL input.

So far — so good, but now we look back to last month and the clock timings. Let's take the 50MHz part (as the most critical). We see that we cannot use a 50/50 clock and still run the ADC at maximum rate. The total clock cycle at 50MHz is 20ns and T1 must be no shorter than 15ns. This leaves only 5ns, which (surprise, surprise!) is the minimum duration of T2.

However this assumes a perfect and lossless 3:1 clock generator which is in fact impossible to accomplish — there will always be some time absorbed in making logic state transitions, particularly in TTL.

It is possible to generate a 3:1 clock mark: space ratio (MSR) at a slightly slower frequency (say 45MHz max) which will serve, alternatively you could use a nominally 50/50 clock at say 30MHz max, which would yield a 16.5ns half period, with T1 and T2 equal.

Of the two alternatives I prefer the latter for experimentation, as the generation of the 3:1 MSR demands the use of a times four counter and selected state decoding. This means a 180MHz oscillator, so we're back to ECL again.

Okay, so we have a 30MHz max clock for the faster part. The slight apparent loss in performance is a small price to pay for easy implementation. The next consideration is how we are going to control the ADC and collect the data.

Making It Work

There are two alternative approaches to very fast data logging (burst logging). The first is the conventional one used at all speeds — the system is held ready to start (armed) and a trigger signal starts a logging sequence which continues at a predefined rate until the data store is full and then stops. The store will then hold a record of events from a time *just after* the trigger until some time later.

This mode of operation is the simplest to configure, but it has one major drawback at high sampling rates. If the trigger is experiment-derived, the events coinciding with the trigger event may well be of importance. We therefore need an alternative mode of operation.

If we could produce a system which would record events prior to and including the trigger event, we could then observe the points of interest. At first sight this seems a crazy suggestion — how can we start the logging sequence before the trigger event which starts it?! Wait, though. There is a way. Let us look first at the simple option and then I will show you how to do the impossible.

The Post-Trigger Logger

This is the first case where the logger captures data after the trigger until the store is full. The simplest implementation would be to couple the ADC output (via the ECL-TTL translators) to the input of one of the fast FIFO memories I have described before (ETI Sept 1987), connect the acquisition clock to the FIFO WRITE control in such a sense that the FIFO negative going WRITE pulse occurs concurrently with the ADC T2 half cycle and use a flip-flop to enable the acquisition clock.

The flip-flop would be set (clock runs) by the trigger input and reset (clock stops) by the FIFO FULL flag. The flip-flop will need a little sophistication to allow a predictable clock state at enable

CHIP IN

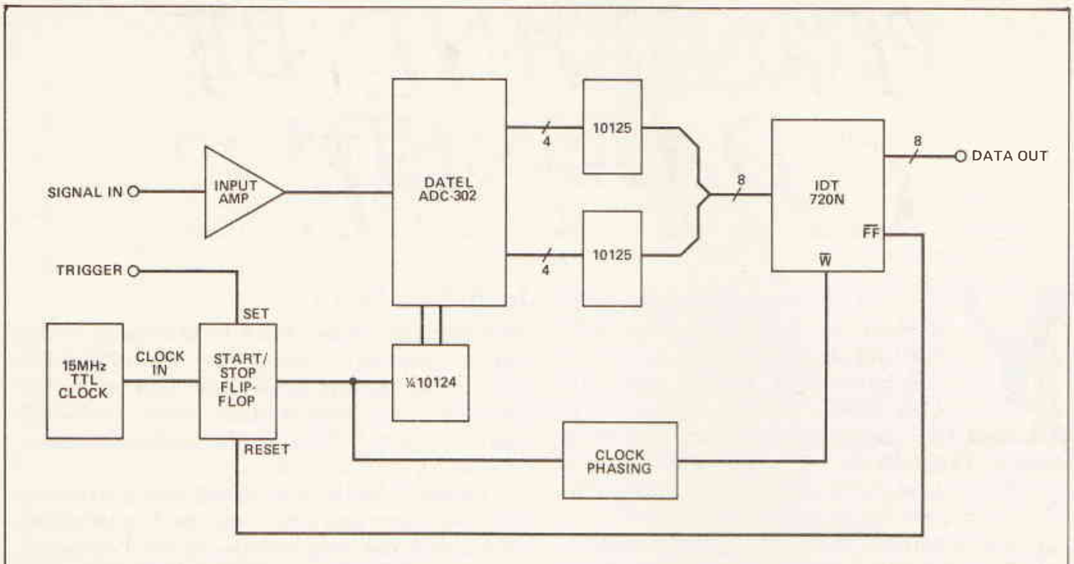


Fig. 2 Schematic of post-trigger logger

time, but this is not difficult to achieve.

Using an IDT 720N FIFO has the advantage that any writing after the device is full is ignored, so we can allow ourselves to be a little sloppy about stopping the system. A generalised schematic of this mode of operation is shown in Fig. 2. The only drawback of this design is that the fastest IDT FIFO has a 65ns write cycle, allowing a maximum 15 MHz throughput — about half that available with our chosen 30MHz max clock. The answer here is to use a two-FIFO commutator (ETI Sept 1987), where practically speaking the full 30MHz will be available.

The Pre-Trigger Logger

This is seemingly impossible. However, just stop and think for a minute.

If we were to invert the action of the flip-flop in the previous example, the logger would run all the time until stopped by the trigger (discounting the FIFO FULL condition). If we scrap the FIFO and replace it with a conventional memory chip with a counter coupled to its address lines and if we allow the counter to roll over at the end of its count sequence, the inverted flip-flop action will indeed stop an otherwise free-running continuous acquisition. As it proceeds, new data acquisitions overwrite old data in memory, so that when stopped, the memory always holds the last N data points, where N is the size of the memory.

This is the halfway point to our pre-trigger logger. As such it is not very useful, but let us propose another wheeze.

Instead of stopping the acquisition clock/ address counter, the trigger pulse *starts* a down counter that has been pre-loaded with the number of samples we want to save after the trigger occurs. This is also clocked by the acquisition clock.

What happens now is that the acquisition continues, decrementing the down counter until it underflows. The underflow signal from the down counter is used to stop the acquisition sequence. There you are! Wasn't so impossible was it?! A schematic of this (preferred) mode of operation is given in Fig. 3.

Added sophistications could include a variable clock divisor (at 35MHz the 74F525 could come in useful) and programmable post-trigger data volume.

The trigger pulse may also be written as a logic bit into a spare bit of the memory (using nine bit instead of eight bit memory). This would allow direct control of say a scope bright-up at the trigger point.

During the last month DATEL have announced the ADC-304, a 20MHz TTL compatible device which I would recommend for experimentation unless you really need higher speeds. Also, should you be interested in the very fastest conversion rates, there is the ECL ADC-303 (not pin compatible) which has a 100MHz max conversion rate. Details are available from DATEL on (0256) 469085.

That's about it on fast ADC handling for the moment. It will probably turn up again as time goes by (play it again Sam) but in the meantime I am going to give you the gen on *opto-electronic devices*. That should be illuminating! ETI

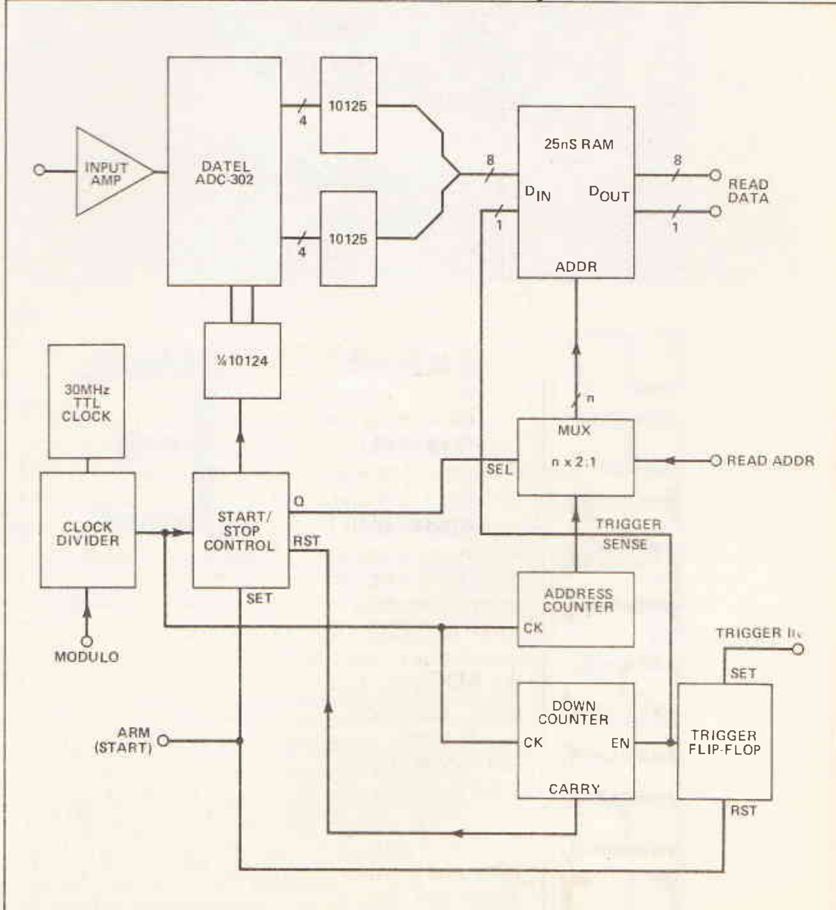


Fig. 3 Schematic of pre-trigger logger

PRINT AND BE DAMNED!

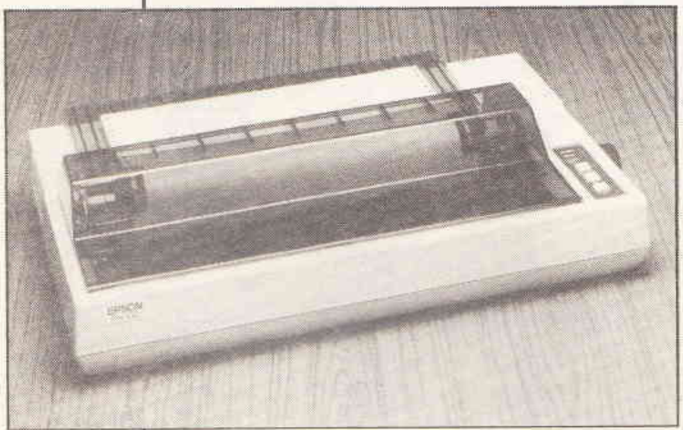
From golf balls to bubble jets, Mike Bedford outputs his look at the advancing world of printers

Yea verily did Johan Gutenberg in the year of our Lord 1450 bring forth from his works the first volume of moveable block type, it being the Holy Bible. And thus proceeding in 1474 did William Caxton devise the Historyes of Troye entitled The Recuyell. And at the last and most fearful time of the year 1972 did come forth the work known to the wide kingdom as ETI.

Thus have the landmarks of printing unfolded. In 1988 we live in the age of the 'paperless office' and printer technology that must reproduce the ever more complex images that can be created on the video screen. From dot-matrix through ink-jet and thermal transfer to ion deposition, the technology goes beyond electronics to include mechanics, optics, physics and chemistry.

Type Cast

Early printers for computers mimicked typewriter designs with characters embossed on cylinders, golfballs or the petals of a daisy wheel. These *character* printers were joined by *line* printers equipped with a full array of embossed characters for each of the print positions across the page, enabling a complete line to be printed at once.



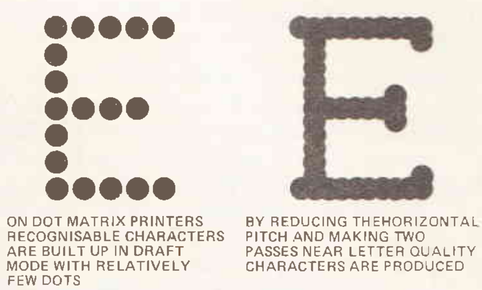


Fig. 1 Dot matrix characters

Early graphics were addressed using electro mechanical versions of pen and paper, and indeed pen/graph plotters maintain their popularity today against the influx of new technologies, thanks to their versatility and wide range of prices.

Join The Dots

Most readers will be aware of the basics of dot matrix printing. There are no embossed characters, instead a vertical row of wires (typically nine but 24 in more recent machines) strike the paper through the traditional inked ribbon.

Figure 1 shows how characters are formed and how their resolution can be improved by making a second pass with the carriage displaced by half a dot spacing.

Since individual characters do not exist as such within a dot matrix printer, microprocessor control is used. This gives much greater flexibility and the number of characters and font types are limited only by the amount of internal memory. Furthermore, control of the individual pins can be passed to the host computer enabling bit-mapped graphics to be produced.

A major limitation (and irritation) with dot matrix machines is that the ribbons are reusable and formed in continuous loops. As the ribbon becomes unevenly worn, printing becomes uneven which is especially evident on graphic displays.

Colour is becoming increasingly common these days with a four colour ribbon (yellow, magenta, cyan and black) moved up and down relative to the print head. For printing text the seven colours (plus white) produced by overprinting these ribbons are arguably sufficient. To reproduce graphics where hundreds (nay, thousands) of shadings may be used, a further sophistication is required.

All Of A Dither

On a VDU different shadings are achieved by mixing the three primary colours in different intensities but on most hardcopy devices a dot is either there or not — there are no half measures.

Instead printers use a method called dithering. Dithering relies on the hardcopy device having a greater dot resolution than actually required so that a block of actual printer dots can be used to represent one pixel.

In this way a number of different intensities can be created as shown in Fig. 2 which uses a four dot dither cell to produce five possible intensities. With a three colour ribbon this can create 125 (5^3) colours. A nine dot dither cell can produce 1000 colours and so on — you have a trade-off between resolution and the number of colours.

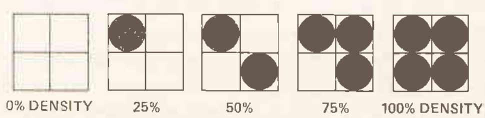


Fig. 2 The five tones obtained by dithering a 4- pixel cell

PRINTERS

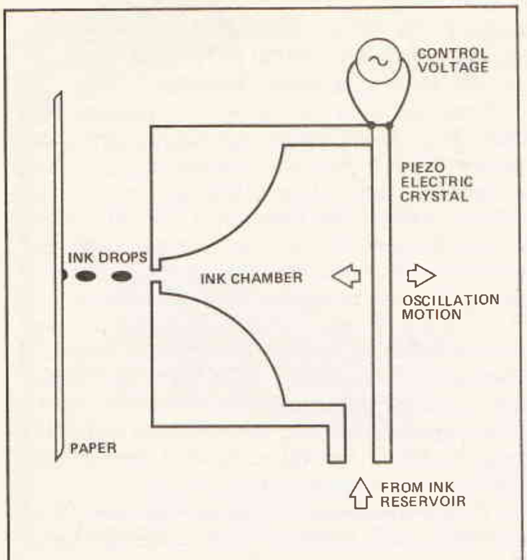


Fig. 3 Drop-on-demand ink jet print head

Non-impact Printers

All these impact printers — where something actually strikes the paper to deposit ink — have a large number of moving parts and tend to be noisy and prone to mechanical failure.

Most of the newer generation of printers use non-impact technologies, with ink jet and thermal transfer generally considered the most promising for low cost, high quality colour hardcopy in the short term.

Early ink jet printers operated by generating a continuous stream of electrostatically charged ink directed towards the paper. A cylindrical electrode either allows the stream to reach the paper or deflects it back into the ink reservoir.

More recent ink jet printers operate on the 'drop on demand' principle which is illustrated in Figure 3. Ink is inserted into a small chamber, one side of which consists of a piezoelectric crystal. By applying a voltage to this crystal, a vibration is set up, forcing out a droplet of ink in the direction of the paper. For a colour machine, four such ink chambers are incorporated into the print head.

The head either moves across the carriage like that of a dot matrix printer or, on higher speed devices, the paper is attached to a high speed rotating drum and the head moves along the length of the drum hence building up the image as a spiral.

In general ink jet printers tend to be fairly inexpensive to run, as most of the ink consumed actually ends up on the paper and they can typically produce A4 copies in about 2 to 5 minutes.

They can be somewhat unreliable, however, and ink jet clogging can be a messy business. Consequently much current ink jet development is concerned with chemistry to produce inks which are less prone to cause clogging and also to find ink/paper combinations which give fully saturated (bright) colours without compromising resolution.

More recent ink jet derivatives include solid ink types and the bubble jet. In the solid ink type, the possibility of jet clogging due to evaporation of the solvent from the ink is eliminated. A pellet of solid ink is heated to melt a small amount into the drop-on-demand chamber from where it is squirted onto the paper in the usual manner. These printers provide a very high quality result with an 'embossed' feel.

In the bubble jet printer (this is actually the trade name of a Canon product) the ink is forced through the orifice by vapour pressure caused by instantaneously vaporising the ink in the chamber by use of a small heating element. This is claimed to give increased reliability over the piezo-electric ink jet method.

Hot Stuff

Early thermal printers were direct thermal devices with the printer head heated and cooled as it passed across specially sensitised paper. The disadvantages were that no colour was available and that the paper was expensive.

In the thermal transfer printer, the temperature of the head causes wax-based ink from a donor ribbon to melt onto the paper as shown in Fig. 4. Colour images can be produced in four passes yielding very bright colours and resolution up to 240 dots per inch. The printers can also output onto materials other than paper — such as acetates for overhead projection.

Some thermal transfer printers can be used as direct thermal printers if the ribbon is removed which much reduces the cost of monochrome printing.

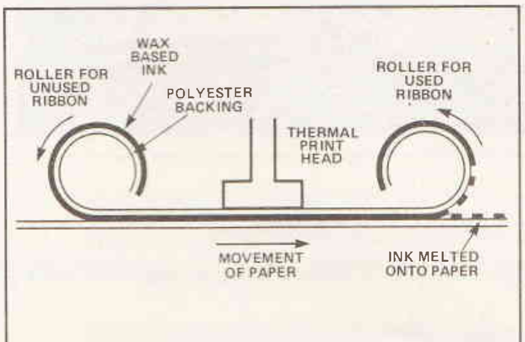
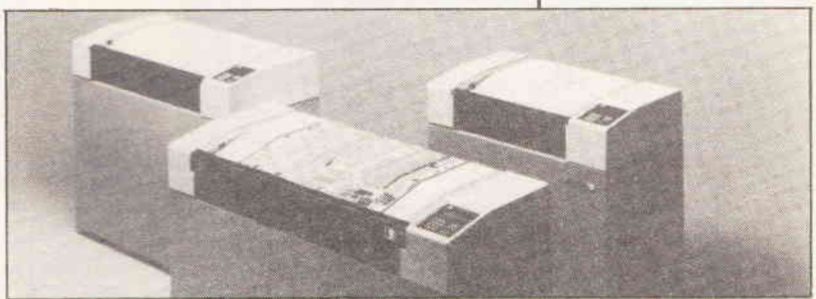


Fig. 4 Thermal transfer mechanism



Electrostatic Plotters

At the high end of the price bracket the electrostatic plotter is making considerable inroads on what used to be pen-plotter territory.

Figure 5 shows the basic mechanism. As the paper passes the writing nibs it acquires a charge under the control of the electronics. As the ink is given an opposite charge, it selectively adheres to the charged areas of the paper. Four passes are

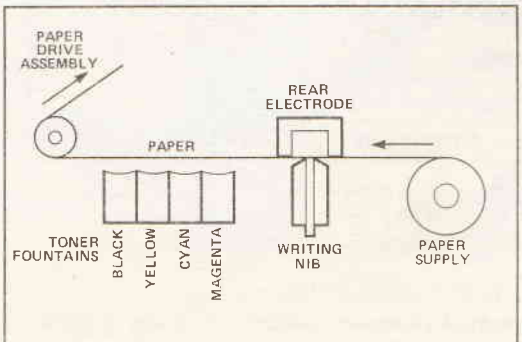
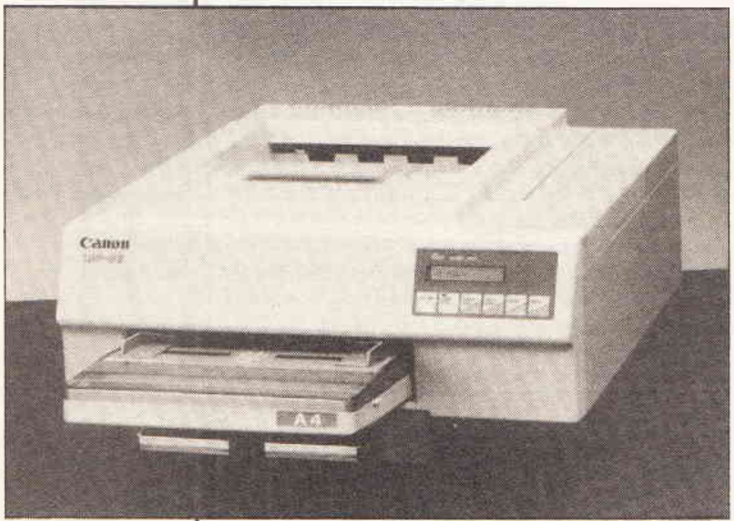


Fig. 5 Colour electrostatic plotter mechanism

made for colour printing, with registration (colour alignment) assured by the placing and optical detection of a registration mark outside the printing area.

Electrostatic nibs are much cheaper than say an ink jet printhead, so electrostatic plotters can have nibs across the entire length of wide carriages (42in. in one common machine) so output is very fast.



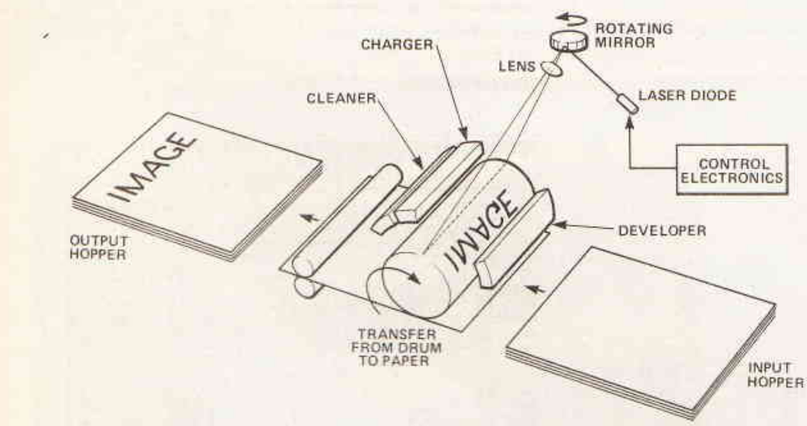
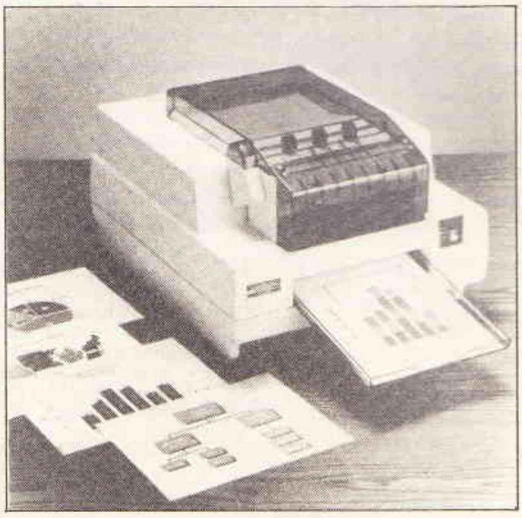


Fig. 6 Laser printer operation



Lasers and Ions

Laser printers are perhaps the most publicised non-impact technology at the moment.

There are large floor-standing line printers, normally attached to mainframes and designed to output monochrome text at 100 pages a minute — and with price tags around £¼million.

Probably more interesting is the desktop high resolution monochrome equivalent (low cost colour versions are under development). Prices are still quite high but the £1000 laser printer may well be a reality within a few years. The attractions of laser printers are the low cost per copy, the speed (low end printers manage 5-20 pages a minute) and the resolution (typically 300dpi).

Figure 6 shows how it operates — it owes much to the office photocopier. The mechanism is based around a rotating drum which is charged with an electrostatic potential. A rotating mirror causes a modulated laser beam to scan and selectively discharge the drum, leaving charge only where the image is required.

As the drum passes the toner dispenser, toner is attracted only to those portions where charge remains. The toner is then transferred to the paper under high temperature before the drum is cleaned for re-charging.

Another photocopier derivative is the LED printer where the light is generated by an array of LEDs across the width of the drum rather than using a single scanned laser beam. In other respects the laser and LED printers are identical.

A further close relative is the ion deposition printer. It operates by creating an electrostatic image on a rotating drum coated with alumina-sapphire. A toner is attracted to the charged areas of the drum from where it is transferred to the paper under high pressure at room temperature (in contrast to the high temperatures used in laser printers).

The way in which the electrostatic image is created on the drum is quite different to the laser and LED machines. Ions are first created as a plasma using a high frequency electric field. They are then accelerated by a second field towards the drum through an array of small apertures in the ion cartridge. As the ions hit the drum a charge is selectively created corresponding to the image required.

Paper Out

It seems that there is virtually no end to the number of ways pigment can be deposited onto paper to give the much prized computer hardcopy. There are direct film devices (which give output onto 35mm slides) and laser photoplotters and no doubt many other technologies which have yet to emerge from the research laboratories.

It is interesting to postulate what the future may hold in the way of innovative new hardcopy devices. Certainly resolution and speed will increase, coupled with a larger range of colours but a recent release by Tektronix may point to the way ahead in the CAD/CAM arena — the 4126 3D graphics terminal.

Unlike previous so-called 3D VDUs and workstations which present the 3D image as a projection into two dimensions, the 4126 creates wire frame and solid models which actually appear in 3D with full perception of depth. This is achieved by creating a pair of differently polarised stereo images which are then viewed through special polaroid spectacles.

As yet there is no way to reproduce this three dimensional image on paper. Perhaps the holographic hardcopy device is the machine of the future! ETI

HART ELECTRONICS are specialist producers of kits for designs by **JOHN LINSLEY-HOOD**. All kits are **APPROVED** by the designer.

LINSLEY-HOOD CASSETTE RECORDER CIRCUITS

Complete record and replay circuits for very high quality low noise stereo cassette recorder. Circuits are optimised for our HS16 Super Quality Sendust Alloy Head. Switched bias and equalisation to cater for chrome and ferric tapes. Very easy to assemble on plug-in PCBs. Complete with full instructions.

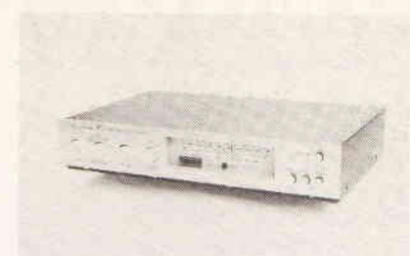
Complete Stereo Record/Play Kit **£33.70**
VU Meters to suit .... **£2.30 each**
Reprints of original Articles .... **75p no VAT**
860X Stereo Mic Amplifier **£8.70**

LINSLEY HOOD 300 SERIES AMPLIFIER KITS

Superb integrated amplifier kits derived from John Linsley-Hoods articles in 'HiFi News'.
Ultra easy assembly and set-up with sound quality to please the most discerning listener. Ideal basis for any domestic sound system if quality matters to you. Buy the kit complete and save pounds off the individual component price.

K300-35. 35 Watt. Discount price for Complete Kit .. **£98.79**
K300-45. 45 Watt. Discount price for Complete Kit .. **£102.36**
RLH4&5. Reprints of Original Articles from 'Hi-Fi News' .... **£1.05 no VAT**

LINSLEY-HOOD SUPER HIGH QUALITY AM/FM TUNER SYSTEM.



Our very latest kit for the discerning enthusiast of quality sound and an exotic feast for lovers of designs by John Linsley-Hood. A combination of his ultra high quality FM tuner and stero decoder described in "**ELECTRONICS TODAY INTERNATIONAL**" and the Synchrodyne AM receiver described in "Wireless World". The complete unit is cased to match our 300 Series amplifiers. Novel circuit features in the FM section to include ready built pre-aligned front-end, phase locked loop demodulator with a response down to DC and advanced sample and hold stereo decoder together make a tuner which sounds better than the best of the high-priced exotica but, thanks to **HART** engineering, remains easy to build. The Synchrodyne section with it's selectable bandwidth provides the best possible results from Long and Medium wave channels, so necessary in these days of split programming. If you want the very best in real HiFi listening then this is the tuner for you. Since all components are selected by the designer to give the very best sound this tuner is not cheap, but in terms of it's sound it is incredible value for money. To cater for all needs four versions are available with variations up to the top of the range full AM/FM model, with any unit being upgradeable at any time. Send for our fully illustrated details.

STUART TAPE RECORDER CIRCUITS

Complete stereo record, replay and bias system for reel-to-reel recorders. These circuits will give studio quality with a good tape deck. Separate sections for record and replay give optimum performance and allow a third head monitoring system to be used where the deck has this fitted. Standard 250mV input and output levels. These circuits are ideal for bringing that old valve tape recorder back to life.
K900W Stereo Kit with Wound Coils and Twin Meter Drive **£65.67**
RJS1 Reprints of Original Articles .... **£1.30 no VAT**

HIGH QUALITY REPLACEMENT CASSETTE HEADS

Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard mountings make fitting easy and our TC1 Test Cassette helps you set the azimuth spot-on. We are the actual importers which means you get the benefit of lower prices for prime parts. Compare us with other suppliers and see! The following is a list of our most popular heads, all are suitable for use on Dolby machines and are ex-stock.

HC20 Permalloy Stereo Head. This is the standard head fitted as original equipment on most decks **£7.66**
HS16 Sendust Alloy Super Head. The best head we can find. Longer life than Permalloy, higher output than Ferrite, fantastic frequency response **£14.86**
HQ551 4-Track Head for auto-reverse or quadrophonic use. Full specification record and playback head **£14.60**
HX100 Stereo Permalloy R/P head. Special Offer **£2.49**
MA481 2/2 Language Lab R/P head **£13.35**
SM166 2/2 Erase Head. Standard mounting. AC type **£8.85**
SM150 2/2 Erase Head. DC Type **£3.60**
HQ751E 4/4 Erase Head for Portastudio etc. ... **£46.80**
Full specifications of these and other special purpose heads in our lists.

HART TRIPLE-PURPOSE TEST CASSETTE TC1

One inexpensive test cassette enables you to set up VU level, head azimuth and tape speed. Invaluable when fitting new heads. Only **£4.66** plus VAT and 50p postage.

Tape Head De-magnetiser. Handy size mains operated unit prevents build up of residual head magnetisation causing noise on playback **£4.54**
Curved Pole Type for inaccessible heads **£4.85**

Send for your free copy of our LISTS. Overseas please send 2 IRCs to cover surfae Post or 5 IRCs for Airmail.

Please add part cost of post, packing and Insurance as follows:

INLAND
Orders up to £10 - 50p
Orders £10 to £49 - £1
Orders over £50 - £1.50

OVERSEAS
Please send sufficient to cover Surface or Air Post as required.

Personal callers are always very welcome but please note that we are closed all day Saturday

24hr SALES LINE (0691) 652894

ALL PRICES EXCLUDE VAT UNLESS STATED

HART ELECTRONIC KITS LTD
4 PENYLAN MILL
OSWESTRY, SHROPSHIRE
SY10 9AF

OSCILLOSCOPES

TELEQUIPMENT D83 Dual Trace 50MHz Delay Sweep. Large Tube with manual £350
S.E. LABS SM111 Dual Trace 18MHz Solid State. Portable AC or External DC operation 8x10cm display with Manual £150
SCOPEX 4D10A Dual Trace 10MHz with Manual £150
TELEQUIPMENT S54A Single Trace 10MHz. Solid State with Manual £90
GOULD/ADVANCE OS255 Dual Trace 15MHz £225 with Manual
HAMEG 207 Single Trace 8MHz. With Manual £50

MULTIMETERS

AVO 8 Complete with Batteries & Leads from £45
AVO 8 MkV Complete with batteries Leads & Case £90
AVO TEST SET No. 1 (Military version of AVO 8) Complete with Batteries Leads & case £65
TEST LEADS suitable for AVO METERS Red & Black with 2 croc-cups & 2 prods (p&p £2) £5
AVO Model 7x Complete with Batteries. Leads & carrying case £40
AVO Model 73. Pocket Multimeter (Analogue) 30 ranges. Complete with batteries & leads £18
AVO - 72 Similar to above but no AC current range. With batteries & leads £10
ANALOGUE POCKET MULTIMETERS Philips & Taylor etc. With Batteries & Leads .... from £10

COMMUNICATION RECEIVERS

EDDYSTONE 730/4 480khz-20mhz with manual .... only £10.00
LABGEAR Colour Bar Generator KG1. 8 Test Patterns. (P&P £4) .... ONLY £40 each

AVO TRANSISTOR ANALYSER Mk2 (CT446)
Suitcase Style complete with Batteries & Operating instructions .... only £35 each (P&P £7)

ISOLATING TRANSFORMERS 240V INPUT
240V Out 500VA £15 (p&p £5) 100VA £6 (p&p £2)
24V Out 500VA £6 (p&p £5) 200VA £4 (p&p £4)

STEPPING MOTORS

Type 1 200 Steps per rev. 4 Phase (5 wire) 12 24V Torque 25oz inch will run on 5V with reduced torque £15.00
Type 2 6/12 Steps per rev. 3 Phase. 12/24V (will work on 5V) .... £2 each 5 off £7.50
Type 3 NORTH AMERICAN PHILIPS 24. Steps per rev. 4 wire 5V 3.3Amps 0.250rpm 0.200 PPs £6 each
Type 4 200 Steps per rev. 120V (3 wire) Torque 25oz inch .... £4 each
Type 7 WARNER 24 Steps per rev. 3 Phase (6 wire) 28V Holding Torque 45oz. inch .... £5 each

SPECIAL OFFERS

COSSOR OSCILLOSCOPE CDU150. Dual Trace 35MHz Delay Sweep. Dual State Portable 8x10cm Display With Manual .... NOW ONLY £180 each
Optional Front Protection Cover. Containing 2 Probes & Viewing Hood £10
SOLARTRON OSCILLOSCOPE CD1400. Dual Beam 15MHz With Manual .... ONLY £85 each
AVO VALVE TESTER CT160 Suitcase style. 22 Bases .... ONLY £25 each (p&p £7)

DISK DRIVE PSU 240V IN 5V 1.6A & 12V 1.5A out Size W125mm. H75mm. D180mm. Cased Un-used only £10 p&p £2?
QWERTY KEYBOARD (as in LYNX MICRO) push to make Cased .... £5 each (p&p £2)
SWITCHED MODE PSU +/-12V 0.25A 5V 15A etc. .... £12 each (p&p £3)
OTHER SWITCHED MODE PSU available. Please enquire.
DISK DRIVES 5¼" - Double Sided. Double Density. 80 track .... From £50

MARCONI AF Power Meter TF893A 20Hz-35KHz 20uW-10W. With Manual (p&p £7) .... only £35
MARCONI RF Power Meter TF1152A/1 DC-500MHz 0.5 to 25 watts 50ohm. With Manual (p&p £7) .... only £45
MARCONI AM/FM Sig Gen TF1066B 10-470MHz £250
MARCONI AM/FM Sig Gen. TF995 range from £150
FARNELL SINE/SQUARE type LFM2 1Hz-1MHz Compact £80
ADVANCE SG62B AM 150KHz-220MHz £80

NEW EQUIPMENT
HAMEG OSCILLOSCOPE 604. Dual Trace 60MHz. Delay Sweep. Component Tester + 2 Probes £575
HAMEG OSCILLOSCOPE 203.6. Dual Trace 20MHz. Component Tester & 2 Probes £314
All Other Models Available

BLACK STAR FREQUENCY COUNTERS P&P £4
Meteor 100-100MHz £99
Meteor 600-600MHz £126
Meteor 1000-1GHz £175
BLACK STAR JUPITOR 500 FUNCTION GENERATOR Sine/Square/Triangle 0.1Hz-500KHz P&P £4 .... £110
BLACK STAR ORION. PAL TV/VIDEO COLOUR PATTERN GENERATOR £199

HUNG CHANG DMM 7030. 3½ digit. Hand held 28 ranges including 10 Amp AC/DC 0.1%. Complete with batteries & leads. P&P £4 .... £39.50
As above DMM 6010. 0.25% £33.50

OSCILLOSCOPES PROBES. Switched x1: x10 P&P £2 .... £11

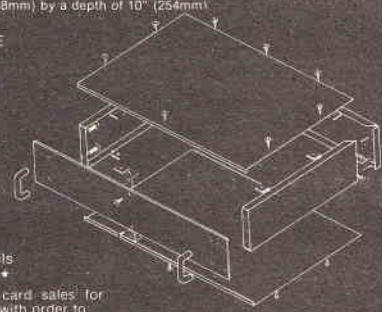
Used equipment - with 30 days guarantee. Manuals supplied if possible.
This is VERY SMALL SAMPLE OF STOCK. SAE or Telephone for Lists. Please check availability before ordering. CARRIAGE all units £16. VAT to be added to Total of Goods & Carriage.

STEWART OF READING
110 WYKEHAM ROAD, READING, BERKS RG6 1PL
Telephone: 0734 68041 Callers welcome 9am - 5.30 pm Mon.-Fri. (until 8 pm Thurs.)

19" RACK MOUNTING EQUIPMENT CASES

This new range of 19" rack equipment cases have been designed with economy and versitility as their objective. These cases are supplied as a flat pack kit with assembly instructions.
The equipment cases feature a black powder coat ⅛" (3mm) aluminium frontpanel with the rest of the case constructed from 7mm or 9mm 'Stelvetite' PVC coated steel. All kits include front panel handles and rubber feet.
They are available in the following popular sizes with all the units having a standard front panel width of 19", and an enclosure width of 17¼" (438mm) by a depth of 10" (254mm).

ORDER CODE	HEIGHT	PRICE
U1	1¾" (44mm)	16.00
U2	3½" (88mm)	18.00
U3	5¼" (133mm)	20.00
U4	7" (178MM)	22.00
M6U Sloped mixer console		£25.50



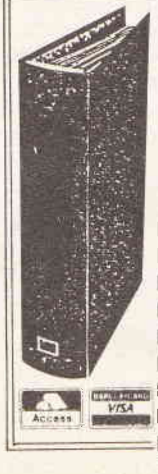
All prices Exclude V.A.T.
Please include £2.50 + VAT. Per Item For Post & Packing.
Flat pack size = 500 x 260 x 32
Maximum weight = 1.5Kgs.

Blanking Panels, Racking Consoles and Rack Cabinets also available.

Please send S.A.E. for further details.
★ *TRADE ENQUIRIES WELCOME* ★

Tel. 0275 823983 for Access/Visa card sales for immediate despatch or send cheque with order to:
RACKZ PRODUCTS PO. BOX NO. 1402, MANGOTSFIELD, BRISTOL, ENGLAND. BS17 3RY

BINDERS



FOR YOUR VALUABLE COLLECTION OF ELECTRONICS TODAY INTERNATIONAL MAGAZINES
• SMART • EASY TO USE • TOP QUALITY
To ASP Readers Services, PO Box 35, Wolsey House, Wolsey Road, Hemel Hempstead, Herts HP2 4SS (0442-41221)

£5.95 inc. P&P

Please supply .. Electronics Today International Binders £5.95 inc. P&P

Total £ ...... (Please make cheques payable to ASP Ltd.)

Years Required — 198........198........198........198........

Name ....
Address ....

Please allow 21 days for delivery

SENO WORKSTATION

Peter Shaw takes a look at a PCB prototyping system for the small pocket

At first sight, the Seno Workstation from Mega Electronics (and available through Cirkit) seemed like just the sort of thing I'd been looking for — a one-stop solution to making PCBs which didn't require any further extension of my overdraft.

The workstation comprises four main elements: PCB art-working materials, five UV sensitive photo-resist boards of different sizes, four lots of chemicals for treating the boards and Seno's own 'etch in the bag' kit, which has been around for some years. There are a number of extras, including a tray to do all the work in without soaking the carpet, a water spray bottle and other items.

I'd perhaps foolishly gained the impression from the information I'd seen that this workstation didn't require a source of UV light — unfortunately it does but this need not present too much of a problem.

To someone who has had the luxury of working at 2:1 for some time using re-positionable crepe tracks, being supplied with 1:1 definitely non-re-positionable transfers (unless you call peeling them off with sticky tape repositioning!) was a culture shock. However, after a couple of attempts, I found I could get results which pleased me and which were not that much larger than the same circuit prototyped from 2:1. But I wouldn't wish to tackle a complex digital circuit this way . . .

Innovation

The major innovation in this kit is in the resist developer, which is *not* sodium hydroxide. In fact according to the literature the chemical used is entirely non-toxic (but that still didn't make me drink a whole bottle to check this out — dedication even to ETI readers has its limits). This and the other chemicals are supplied in a push-sponge applicator (similar to the bottle containing the stuff that I use in my vain attempts to make my trainers some colour other than grey).

The developer seemed to be at least as effective as the conventional stuff. Applying gently then wiping with the sponge quickly made an image appear and got rid of the unwanted resist. After rinsing, the board is ready to etch.

The etch-in-the-bag system, as its name suggests, uses a plastic bag to contain the nasty, staining, irritant ferric chloride. Unfortunately, I'm a rather messy type and I've got the stain on the carpet to prove that the system isn't foolproof (but don't tell my other half, she hasn't spotted it yet). Still, it is a useful advance over slopping the stuff around in a tray next to the kitchen sink. And a really nice touch is that you are provided with a bag of chemicals to solidify the ferric chloride once it's exhausted — but please don't bury it in the editor's new back garden, unless your name happens to be Nirex.

After etching and rinsing, it's back to more of those tasty non-toxic chemicals to strip off the remaining resist, another lot to deoxidise the copper tracks and then after buffing up the tracks with a block of polyfix (supplied in the kit) you can apply flux to aid soldering.

Results

As I've already said, I did get quite pleasing results from this kit, and with no more trouble and rather less risk than using conventional techniques.

There is the problem of the UV source for exposing the board, but even on the worst of English summer days there's an extremely large UV source just hanging in the sky which can certainly give sufficient exposure in a few minutes.

Of course, some experimentation is needed to get the dose right, but the boards seem to have a reasonable degree of latitude.

Also I noticed that the edges of the tracks are well defined with this system — particularly apparent on the holes which don't seem to 'fill in' as readily (when you're using a power-drill which is virtually bearingless and should have been retired some years ago, nice sharp edges to the hole you're just about to drill make quite a difference).

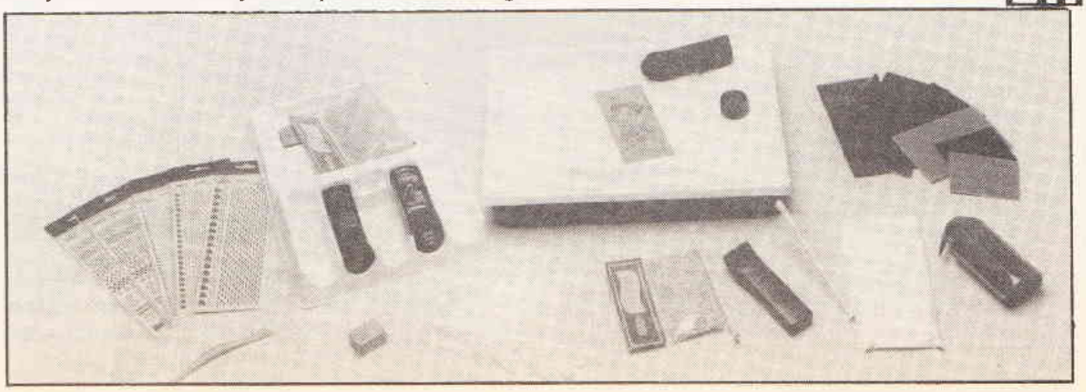
An alternative UV source to the sun is a UV lamp which might be a little more controllable, if not to say more reliable. UV lamps are considerably cheaper than UV boxes and again give a reasonable point source, if placed on the other side of the room.

Gripe Time

Finally, there has to be a gripe. The instruction manual which came with the kit (A4 photocopied and bound) tried to collapse into separate pages from the first time I opened it. A few staples might not have gone amiss (and if I can find the pages I lost I'll certainly apply a few myself).

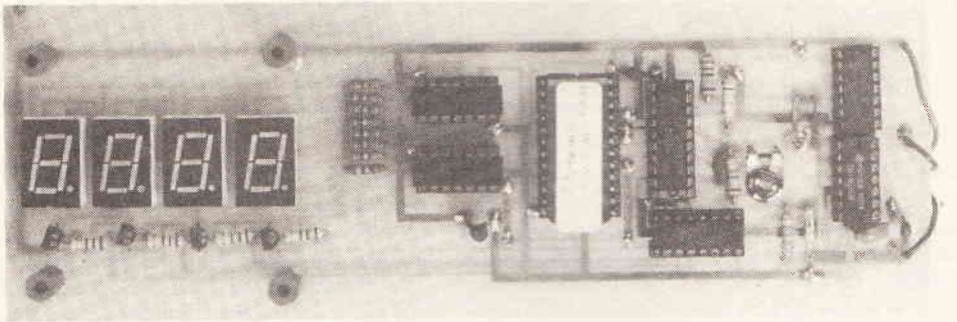
In conclusion, I can commend the kit to anyone who has no equipment for making PCBs. If you do have some gear, I would suggest the resist developer and stripper are well worth adding as they remove one now-unnecessary risk.

The Seno Workstation costs £45+VAT and postage available through Cirkit Distribution Ltd, Park Lane, Broxbourne, Herts EN10 7NQ. Tel: (0992) 444111 or from Mega Electronics Ltd, 9 Radwinter Road, Saffron Walden, Essex CB11 3HU. The author's thanks go to Cirkit for providing a review sample.



PROJECT

UNIVERSAL DIGITAL PANEL METER



Richard Grodzik presents a panel meter that uses programmable logic to display the way you say

Digital panel meter ICs have been out and about for some time. The chances are that if you pull the front off that budget digital multimeter you were given last Christmas you'll find an ICL7106 doing all the work.

The problem with commercial DPM ICs is their inflexibility. They couldn't for example display on a logarithmic or exponential scale, and any specialised display signals are out of the question. Normally you would need to build a mass of logic around your LEDs to switch segments and digits as the conditions dictated or else abandon hope and submit to the industry standards.

This design enables you to overcome these limitations using programmable logic. There are two digital panel meters featured here — one displaying on LED segment bar graphs, the other on LED 7-segment digits. Both follow identical design patterns and are universally programmable for 'one-off' user requirements.

Fig. 1 shows the block diagram for the system. The heart of the system is the EPROM. This stores the patterns to be displayed by the LED digits or bars for each possible 8-bit output from the ADC. The ADC output addresses the EPROM and each bit of its 'data' output controls one segment of a display.

Two higher address bits (A8 and A9) are used to select the image data from the EPROM for each digit. These bits cycle through the four combinations in response to a decade counter clocked by the ADC. These two address lines are also used to direct power to each of the four digits in turn.

In this way the four digit display is multiplexed, with each digit's display independently determined by the contents of the EPROM for each possible output from the ADC.

Lighting The Lights

Obviously the way the display operates depends on how you program your EPROM. The EPROM has enough memory for two complete sets of image data (two completely different ways of displaying the input — say on a linear or log scale). You switch between the two using SW1 to control the MSB (A10) of the EPROM address, switching between &0000-&3FFF and &4000-&7FFF.

We'll look at the bargraph board first — once you've grasped that, the digit display is very straightforward.

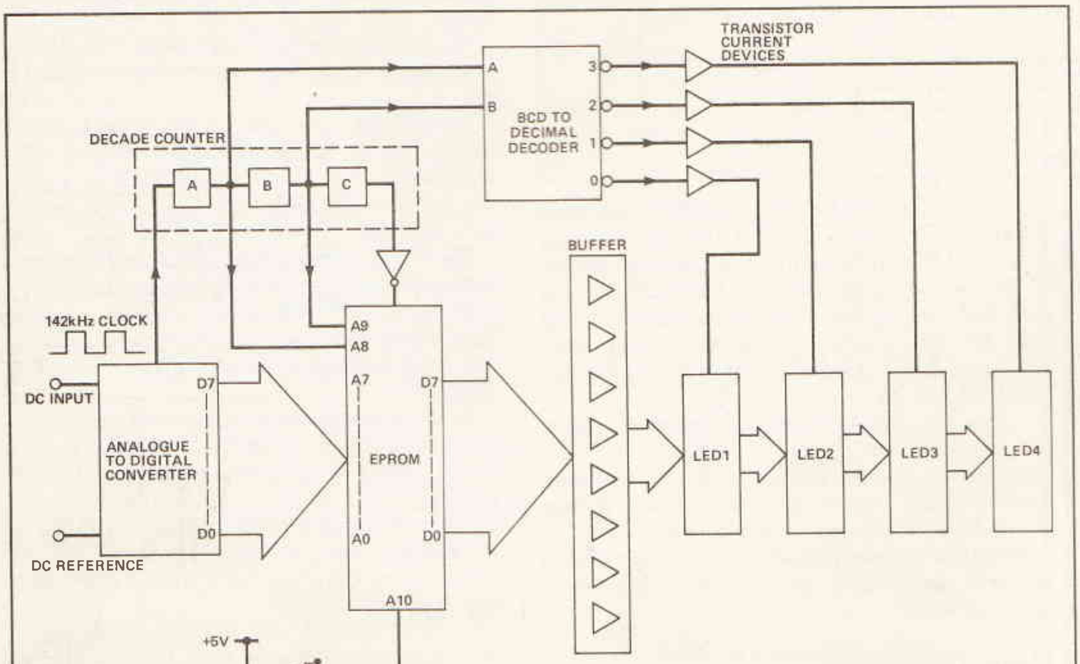


Fig. 1 Block diagram for the Universal Digital Panel Meter

1		2		3		4		COLUMN
38-3F	6.4V	178-17F	12.8V	2B8-2BF	19.2V	3F8-3FF	25.5V	ROW 8
30-37	5.6V	170-177		2B0-2B7		3F0-3F7		ROW 7
28-2F	4.8V	168-16F		2A8-2AF		3E8-3EF		ROW 6
20-27	4.0V	160-167		2A0-2A7		3E0-3E7		ROW 5
18-1F	3.2V	158-15F		298-29F		3D8-3DF		ROW 4
10-17	2.4V	150-157		290-297		3D0-3D7		ROW 3
08-0F	1.6V	148-14F		288-28F		3C8-3CF		ROW 2
00-07	0.8V	140-147	7.2V	280-287	13.6V	3C0-3C7	20.0V	ROW 1

Fig. 2 Bar graph segment addresses

TOP	
D7	7F
D6	BF
D5	DF
D4	EF
D3	F7
D2	FB
D1	FD
D0	FE

Fig. 3 LED dot segment data

An input voltage range of 0V to 25.5V to the panel meter will (after attenuation and conversion) give an addressing range of &00 to &FF for the EPROM.

The image data for the first segment column is stored between &00 and &FF, the image data for the second column between &100 and &1FF, for the third column between &200 and &2FF, for the fourth column between &300 and &3FF.

The segment addresses for a linear scale display are shown in Fig. 2. You can see that for a display range of 0V-25.5V each segment represents 0.8V and is lit from any one of eight consecutive addresses.

The data coding required to enable any individual segment is shown in Fig. 3.

So an input voltage of 19.2V (for example) would address the EPROM at &0BF, then &1BF, &2BF and &3BF in turn (as the decade counter increments). The data is sent to columns 1, 2, 3 and 4 respectively.

In order to light only the 19.2V segment, Fig. 3 tells us that the data in these addresses should be &FF, &FF, &7F and &FF.

The complete hex dump for this scale display is shown in Listing 1. Remember that this will use

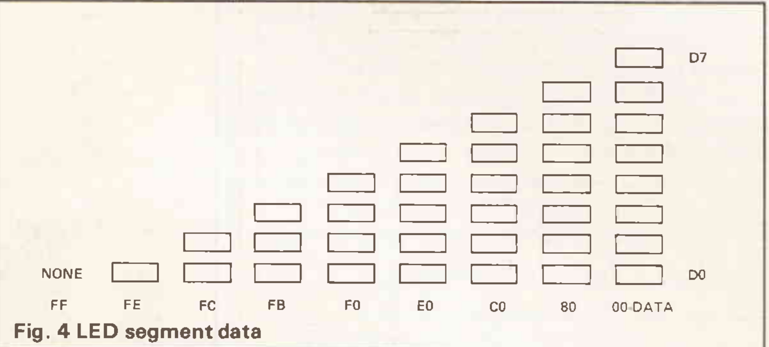


Fig. 4 LED segment data

only half of the EPROM. The other half (addresses &400 to &7FF) can be used for a bar graph display where *all* LEDs up to the input voltage segment are lit. To use the second half of the EPROM, SW1 is switched making the MSB of the address (A10) high so that column 1 now takes data from addresses &400 to &4FF, column 2 from &500 to &5FF and so on.

The data needed to enable all segments up to the required one is shown in Fig. 4 with the resulting hex dump in Listing 2. All addresses from &438 to &4FF contain &00 since for any voltage above 5.6V all column 1 segments should be lit. Similarly for column 2 all addresses between &578 and 5FF contain &00, and for column 3 between 6B8 and &6FF.

Digit Display

Figure 5 shows the required hex codes to produce numeric characters on the 7-segment displays.

D7 D0	HEX	Display
11000000	C0	0
11111001	F9	1
10100100	A4	2
10110000	B0	3
10011001	99	4
10010010	92	5
10000011	83	6
11111000	F8	7
10000000	80	8
10011000	98	9
01111111	F7	—

Fig. 5 LED digit display data

Decoding from the ADC is straightforward since 1 bit has a loading of 0.1V so a maximum input voltage of 25.5V will output &FF from the ADC. The hex dump of Listing 3 displays the input voltage in a standard numeric fashion. If we take an example of the decoding for an input voltage of 12.8V, the following addresses will be generated:

Addresses	&380	&280	&180	&080
Data	&F9	&A4	&F7	&80
Display	1	2	—	8

Construction

The overlay diagrams for the two boards are shown in Figs. 8 and 9. Construction of the PCBs should be straightforward.

IC sockets are recommended for all ICs and should certainly be used for the EPROM and ADC (IC6 and IC1). The ADC is a CMOS device so static handling precautions should be taken.

The main difference between the two boards is that the LED digit panel meter is a double sided PCB and has some 19 through-hole pins. These should be soldered in at the start of construction.

The LED bargraph board has several wire links which must also be fitted early on since some of them sit under resistors. Then proceed in the

HOW IT WORKS

Basically the meter consists of an ADC to convert the input voltage to a digital equivalent, and an EPROM which contains the code conversion required by the LED display.

The block diagram (Fig. 1) is the same for both panel meters and the circuit diagrams are shown in Figs. 6 and 7.

The analogue input voltage is first attenuated by a potential divider formed by R1, R3 and RV1. This attenuates by a factor of 10 to give a maximum voltage of 2.5V for the ADC (IC1). RV1 can be used to set full scale deflection.

The ADC is in free-running mode, continuously converting and providing an 8-bit digital output. Pin 5 of the ADC toggles after each conversion providing a clock signal to the decade counter IC4. When IC4 reaches 100_2, pin 8 goes high, is inverted by IC5 and enables the EPROM.

At the same time the two LSBs of IC4s output are driving IC7 and send pin 1 of IC7 low switching on transistor 1. LED1 is thus powered and driven by the EPROM contents.

Further ADC conversions clock IC4 and select LED2, 3 and 4 in turn, sending EPROM data from the addresses formed by the ADC conversion plus MSBs from pins 9 and 12 of IC4.

Switching SW1 to the 'on' position will enable EPROM addresses &400 to &7FF, thus providing an alternative code conversion for the display.

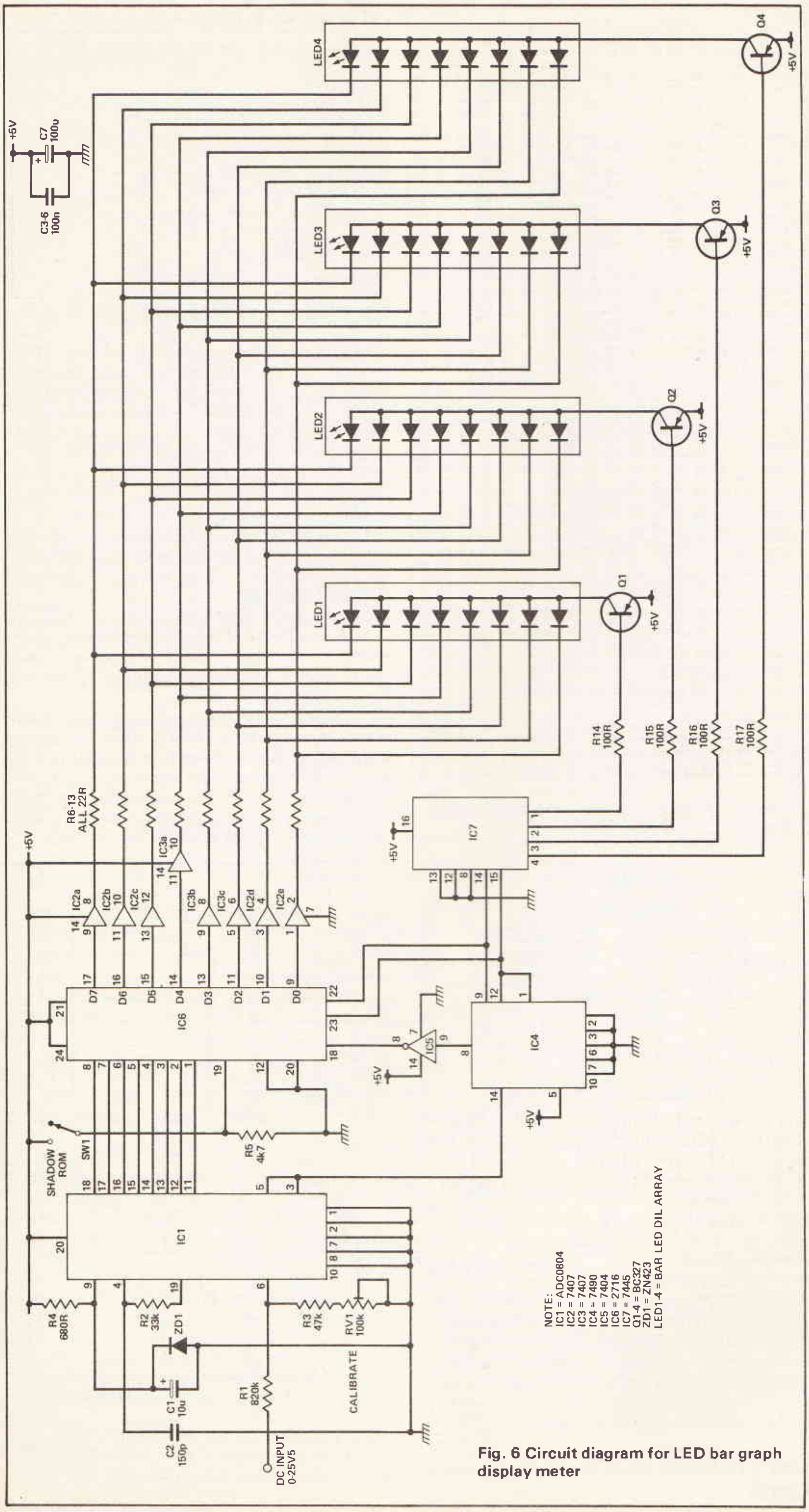
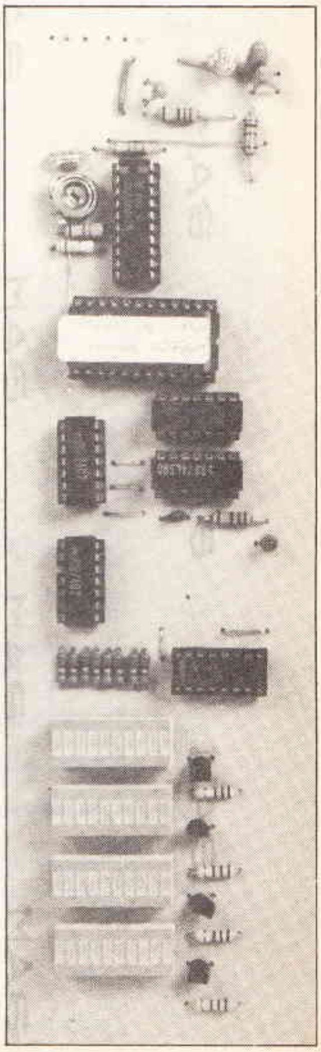


Fig. 6 Circuit diagram for LED bar graph display meter



Address	Data
&0000-&0007	&FE
&0008-&000F	&FD
&0010-&0017	&FB
&0018-&001F	&F7
&0020-&0027	&EF
&0028-&002F	&DF
&0030-&0037	&BF
&0038-&003F	&7F
&0040-&013F	&FF
&0140-&0147	&FE
&0148-&014F	&FD
&0150-&0157	&FB
&0158-&015F	&F7
&0160-&0167	&EF
&0168-&016F	&DF
&0170-&0177	&BF
&0178-&017F	&7E
&0180-&027F	&FF
&0280-&0287	&FE
&0288-&028F	&FD
&0290-&0297	&FB
&0298-&029F	&F7
&02A0-&02A7	&EF
&02A8-&02AF	&DF
&02B0-&02B7	&BF
&02B8-&02BF	&7F
&02C0-&03BF	&FF
&03C0-&03C7	&FE
&03C8-&03CF	&FD
&03D0-&03D7	&FB
&03D8-&03DF	&FB
&03E0-&03E7	&EF
&03E8-&03EF	&DF
&03F0-&03F7	&BF
&03F8-&03FF	&7F

Listing 1 Hex data for scale display

```
0000  C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92
0010  83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9
0020  A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8
0030  80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0
0040  99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98
0050  C0 F9 A4 B0 99 92 83 F9 80 98 C0 F9 A4 B0 99 92
0060  83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9
0070  A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8
0080  80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0
0090  99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98
00A0  C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92
00B0  83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9
00C0  A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8
00D0  80 98 C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0
00E0  99 92 83 F8 80 98 C0 F9 A4 B0 99 92 83 F8 80 98
00F0  C0 F9 A4 B0 99 92 83 F8 80 98 C0 F9 A4 B0 99 92
0100  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0110  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0120  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0130  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0140  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0150  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0160  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0170  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0180  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0190  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01A0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01B0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01C0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01D0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01E0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
01F0  F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7
0200  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 F9 F9 F9 F9 F9 F9
0210  F9 F9 F9 F9 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 B0 B0
0220  B0 B0 B0 B0 B0 B0 B0 B0 99 99 99 99 99 99 99 99
0230  99 99 92 92 92 92 92 92 92 92 92 92 83 83 83 83
0240  83 83 83 83 83 83 F8 F8 F8 F8 F8 F8 F8 F8 F8 F8
0250  80 80 80 80 80 80 80 80 80 80 98 98 98 98 98 98
0260  98 98 98 98 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 F9 F9
0270  F9 F9 F9 F9 F9 F9 F9 F9 A4 A4 A4 A4 A4 A4 A4 A4
0280  A4 A4 B0 B0 B0 B0 B0 B0 B0 B0 B0 B0 99 99 99 99
0290  99 99 99 99 99 99 92 92 92 92 92 92 92 92 92 92
02A0  83 83 83 83 83 83 83 83 83 83 F8 F8 F8 F8 F8 F8
02B0  F8 F8 F8 F8 80 80 80 00 80 80 80 80 80 80 98 98
02C0  98 98 98 98 98 98 98 98 C0 C0 C0 C0 C0 C0 C0 C0
02D0  C0 C0 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 A4 A4 A4 A4
02E0  A4 A4 A4 A4 A4 A4 B0 B0 B0 B0 B0 B0 B0 B0 B0 B0
02F0  99 99 99 99 99 99 99 99 99 99 92 92 92 92 92 92
0300  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0310  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0320  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0330  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0340  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0350  C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0 C0
0360  C0 C0 C0 C0 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
0370  F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
0380  F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
0390  F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
03A0  F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
03B0  F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9 F9
03C0  F9 F9 F9 F9 F9 F9 F9 F9 A4 A4 A4 A4 A4 A4 A4 A4
03D0  A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4
03E0  A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4
03F0  A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4 A4
```

Listing 2 The complete hex dump for the digital display

PARTS LIST

RESISTORS (all ¼W 5% unless specified)

R1	820k
R2	33k
R3	47k
R4	680R
R5	4k7
R6-13	22R DIL
R14-17	100R
RV1	100k preset

CAPACITORS

C1, 7	10µ 16V tantalum
C2	150p polystyrene
C3-6	100n ceramic

SEMICONDUCTORS

IC1	ADC0804
IC2, 3	7407
IC4	7490
IC5	7404
IC6	2716 EPROM
IC7	7445
Q1-4	BC327
ZD1	ZN423T
LED1-4	Either 0.5in 7-segment digit common anode display or 10-bar DIL array

MISCELLANEOUS

SW1	Single pole toggle

Case. Wire. Nuts and bolts. 5V power supply.

usual order — resistors, capacitors, IC sockets, zener diode and transistors.

The LED bar graph columns need a little preparation before mounting. Only the bottom eight segments of each column are used and the anodes of these are bent up or cut short, then soldered together in common anode configuration. These are then connected to the two unused (and unbent) anodes which fix into the PCB.

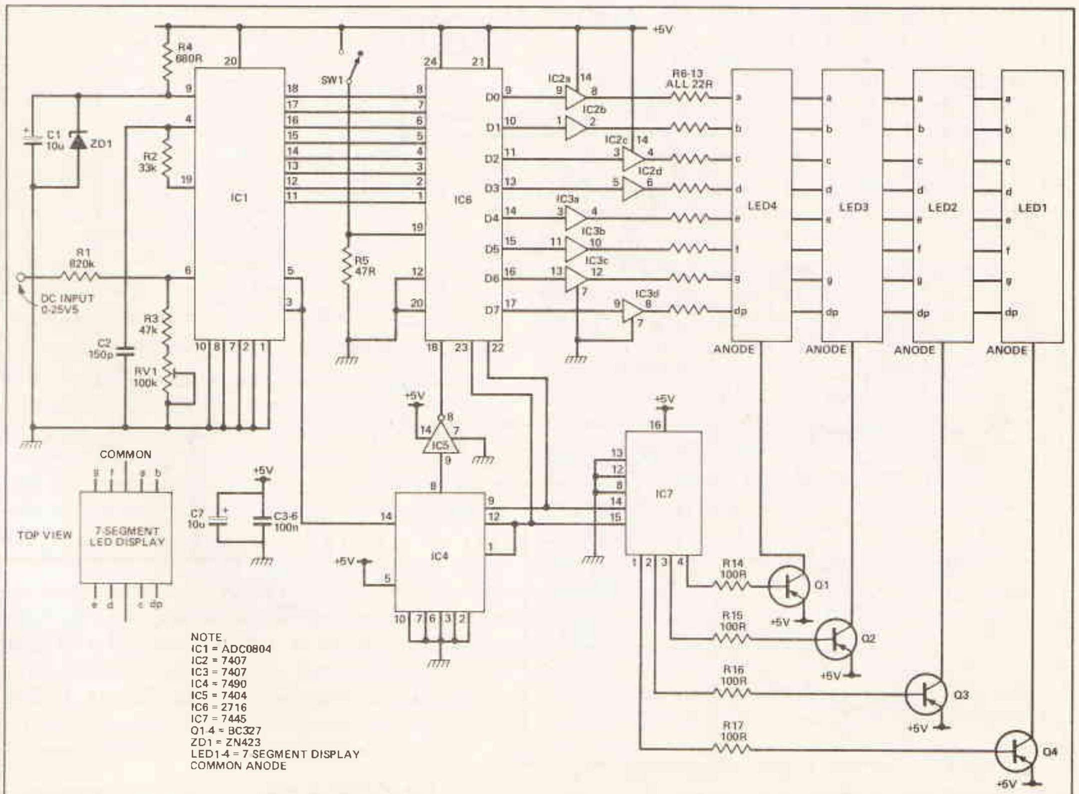


Fig. 7 Component circuit for the LED digit display meter

PROJECT

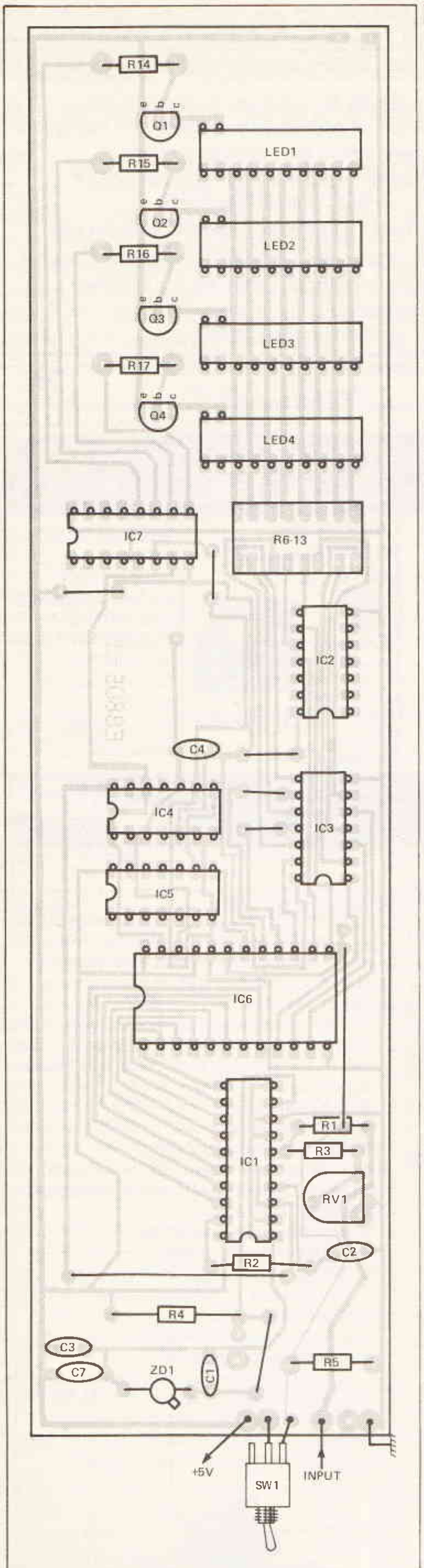


Fig. 8 Component overlay for the bar graph display

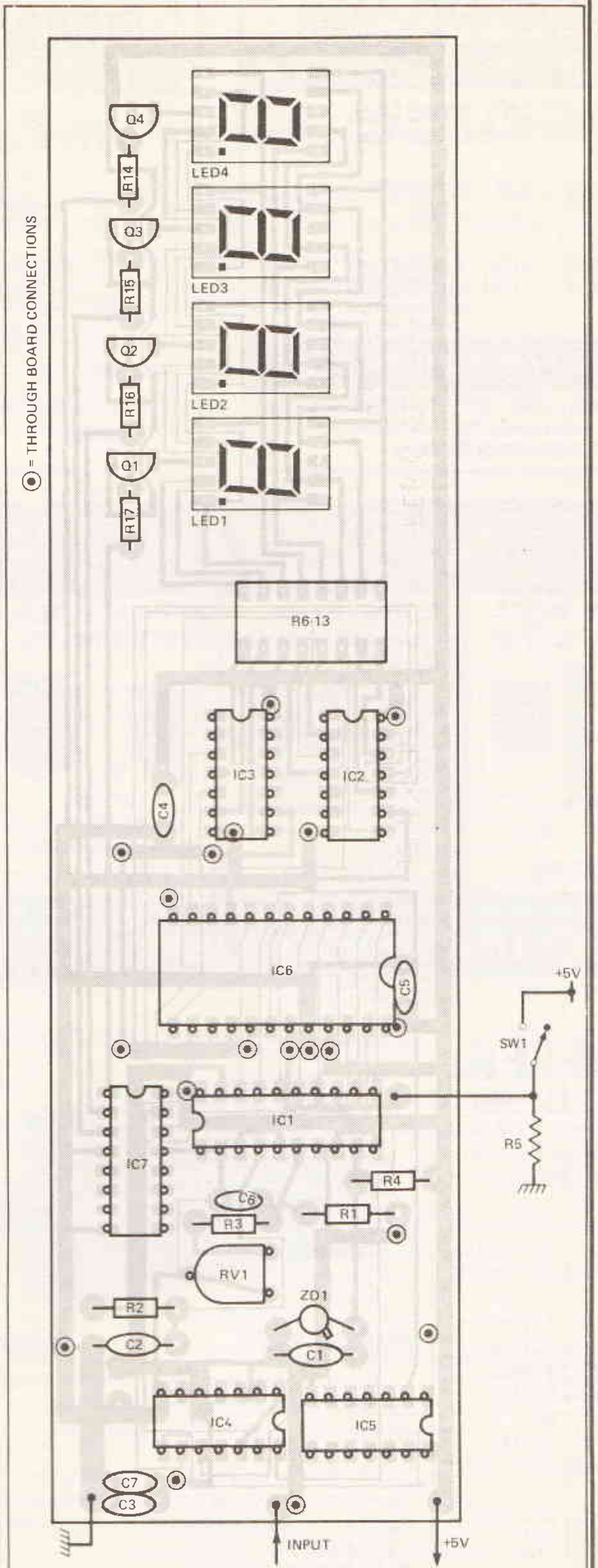


Fig. 9 Component overlay for LED digit display meter

With the LEDs in place you can program your EPROM to behave as you desire, put your ICs into place and enjoy the luxury of your own uniquely personal digital panel meter.

BUYLINES

All components are available from most component suppliers except perhaps IC7 and ZD1.

IC7 is stocked by STC as either a National or TI IC (the National is cheaper — stock No 29350A). STC, Edinburgh Way, Harlow, Essex CM20 2DF. Tel: (0279) 441687.

ZD1 can be obtained from Electromail (stock number 283-233).

ETI

Address	Data
&0400-&0407	&FE
&0408-&040F	&FC
&0410-&0417	&F8
&0418-&041F	&F0
&0420-&0427	&E0
&0428-&042F	&C0
&0430-&0437	&80
&0438-&043F	&00
&0440-&04FF	&00
&0500-&053F	&FF
&0540-&0547	&FE
&0548-&054F	&FC
&0550-&0557	&F8
&0558-&055F	&F0
&0560-&0567	&E0
&0568-&056F	&C0
&0570-&0577	&80
&0578-&057F	&00
&0580-&05FF	&00
&0600-&067F	&FF
&0680-&0687	&FE
&0688-&068F	&FC
&0690-&0697	&F8
&0698-&069F	&F0
&06A0-&06A7	&E0
&06A8-&06AF	&C0
&06B0-&06B7	&80
&06B8-&06BF	&00
&06C0-&06FF	&00
&0700-&07BF	&FF
&07C0-&07C7	&FE
&07C8-&07CF	&FC
&07D0-&07D7	&F8
&07D8-&07DF	&F0
&07E0-&07E7	&E0
&07E8-&07EF	&C0
&07F0-&07F7	&80
&07F8-&07FF	&00

Listing 2 Hex data for bar display

SPECIAL OFFER

FOR SPECTRUM AND BBC MICRO OWNERS

Now your computer can take control for an affordable price. These tried and trusted interfaces from DCP Microdevelopments are offered at **£20 off** the normal price.

Both units are extremely easy to use from both Basic and assembler/machine code and are supplied ready built and complete with all the documentation you need.

To order by post fill in the form below (or a copy) and send it with your remittance to

ASP READERS' SERVICES (RO ET5/6)
9 Hall Road, Maylands Wood Estate,
Hemel Hempstead, HP2 7BH

Please make cheques payable to ASP Ltd.
Overseas orders add £5 (Interspec) or £10 (Interbeeb) for airpost.
Access and Visa card holders can also place their order by phone on (0442) 41221
Allow 28 days for delivery.

Please supply ...... Interspecs (RO ET5) at £29.95 plus £1.95 p&p per order.
Please supply ...... Interbeebs (RO ET6) at £49.95 plus £1.95 p&p per order.

Name ....

Address ....

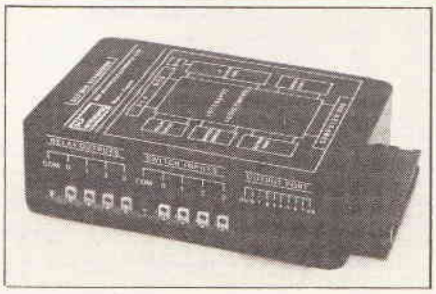
....

....

Please debit my ACCESS/VISA card

No .... **to the sum of**

£ .... **Signed:** ....



INTERSPEC £29.95

The Interspec unit plugs directly onto the expansion edge connector of the Spectrum to provide a full range of interfacing facilities.

The unit is housed in a plastic case approximately 4½x3x1in which contains the top quality double sided PCB and interface connections.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **15-way expansion bus**

All sections of the interface are I/O port mapped and designed for maximum compatibility with existing Spectrum peripherals. Power is supplied through the Spectrum edge connector.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. Connection is by multi-way PCB connector and all the information required for adding further devices is given.

INTERBEEB £49.95

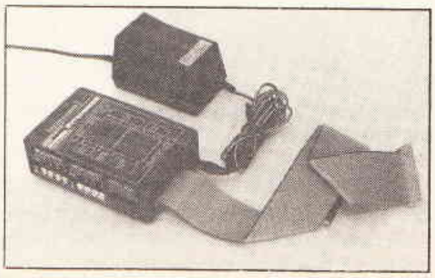
The Interbeeb unit connects to the BBC micro's 1MHz bus expansion connector and is supplied complete with its own power supply unit.

The interface unit is housed in a plastic case approx 4½x3x1in which contains the top quality double sided PCB and interface connectors.

- **8-bit input port**
- **8-bit output port**
- **four switch sensor inputs**
- **four relay-switched 12V 1A outputs**
- **eight channel multiplexed analogue to digital converter**
- **precision 2.5V reference**
- **external power supply**
- **15-way expansion bus**

All sections of the interface are memory mapped in the 1MHz expansion map for maximum ease of use and compatibility with existing peripherals.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. All the information required for using additional devices is included.



READERS' SURVEY

It's survey time again and your chance to win one of 25 six month ETI subscriptions

This year's readers' survey is bigger and more comprehensive than ever. Although some of the questions may not seem to relate directly to the magazine, please complete the whole questionnaire. Your answers not only help us to steer the editorial content of the magazine in the direction you want but they also help us to build up an overall profile of readers to present to advertisers who require such data to select suitable magazines for their products.

Note that no names and addresses will be disclosed to any third party and all information will be treated in the strictest confidence.

As an incentive for your hard work, all entries received by 10th June will be entered in a free draw for 25 six month subscriptions to ETI.

1. If you could make one improvement to ETI, what would it be? ....

2. Please indicate what you think of the following aspects of ETI's coverage:

	Poor	Average	Good
Product News	☐	☐	☐
Industry/Technology News	☐	☐	☐
Diary	☐	☐	☐
Advanced Projects	☐	☐	☐
Basic Projects	☐	☐	☐
General Features	☐	☐	☐
Tutorial Features	☐	☐	☐
Product Reviews	☐	☐	☐

3. Would you like to see a greater or lesser proportion of ETI devoted to the following:

	Less	The same	More
Beginners' Projects	☐	☐	☐
Advanced Projects	☐	☐	☐
Short Projects	☐	☐	☐
Long Projects	☐	☐	☐
Computer Projects	☐	☐	☐
Audio Projects	☐	☐	☐
Music Projects	☐	☐	☐
Radio Projects	☐	☐	☐
Home Improvement Projects	☐	☐	☐
Bio-electronics/Health Projects	☐	☐	☐
Test Equipment Projects	☐	☐	☐
Security/Alarm Projects	☐	☐	☐
Car Electronics Projects	☐	☐	☐
Robotics Projects	☐	☐	☐
Photographics	☐	☐	☐
Novelty/Gimmick Projects	☐	☐	☐
Basic Elementary Theory	☐	☐	☐
Advanced Electronic Theory	☐	☐	☐
General Science/Technology	☐	☐	☐
News	☐	☐	☐
Product Reviews	☐	☐	☐
Letters	☐	☐	☐
Open Channel/Playback/Keynotes/etc	☐	☐	☐
Design/Circuit Ideas	☐	☐	☐
Competitions	☐	☐	☐
Others (please specify)	☐	☐	☐

....

4. Indicate which of the following equipment you use:

	Own	Don't own but regularly use
Home micro	☐	☐
Professional Micro	☐	☐
Hi-fi	☐	☐
Electronic Musical Instrument	☐	☐
MIDI Equipment	☐	☐
PA/Recording equipment	☐	☐
Photographic/Darkroom Equipment	☐	☐
Ham Radio/CB	☐	☐
Satellite TV	☐	☐
Video Camera	☐	☐
Security/Alarm System	☐	☐
Oscilloscope	☐	☐
Multimeter	☐	☐
Other test gear	☐	☐

5. Do you read any of the following magazines:

	Never	Occasionally	Regularly
Practical Electronics	☐	☐	☐
Everyday Electronics	☐	☐	☐
Elektor Electronics	☐	☐	☐
Maplin Magazine	☐	☐	☐
Electronics & Wireless World	☐	☐	☐
Personal Computer World	☐	☐	☐
Byte	☐	☐	☐
Music Technology/ International Musician	☐	☐	☐
Home & Studio Recording	☐	☐	☐
Hi-fi News & Record Review	☐	☐	☐
New Scientist	☐	☐	☐
Scientific American	☐	☐	☐
Do It Yourself/DIY Today/ Practical Householder	☐	☐	☐
Practical Wireless/Radio & Electronics World	☐	☐	☐
Ham Radio Today	☐	☐	☐
Electronics Product News/ Electronics Equipment News/New Electronics/ Electronic Product Review	☐	☐	☐

6. If read, please indicate what you think of the following magazines

	Not as good as ETI	As good as ETI	Better than ETI
Practical Electronics	☐	☐	☐
Elektor Electronics	☐	☐	☐
Everyday Electronics	☐	☐	☐
Maplin Magazine	☐	☐	☐

7. Which of the following do you buy and how frequently?

	Never	Sometimes	Regularly
Electronic Components	☐	☐	☐
Complete Electronic Kits	☐	☐	☐
ETI PCBs	☐	☐	☐
Stripboard/Wirewrap Etc	☐	☐	☐
Cases/Case Materials	☐	☐	☐
Tools	☐	☐	☐
PCB making Equipment/Materials	☐	☐	☐
Pre-programmed ROMs	☐	☐	☐
Computer Software	☐	☐	☐
Floppy Disks	☐	☐	☐
Electronics Books	☐	☐	☐
Data Books	☐	☐	☐
Second Hand Equipment	☐	☐	☐

8. Please indicate what you think of the services offered:

	Poor	Average	Good	Not used
PCB Services	☐	☐	☐	☐
Photocopy Service	☐	☐	☐	☐
Project Errata/Updates	☐	☐	☐	☐
Foil Patterns	☐	☐	☐	☐
Buylines	☐	☐	☐	☐
Technical Advice	☐	☐	☐	☐
Special Offers	☐	☐	☐	☐
Subscriptions	☐	☐	☐	☐
Back numbers	☐	☐	☐	☐

9. Do you watch any of the following TV programmes:
Tomorrow's World □
QED □
Equinox □
Horizon □
Micro Live/File □

10. If you own or regularly use a computer, please indicate which it is:
Spectrum □
BBC Micro/Master/Electron □
Commodore 64/128 □
Amstrad CPC □
Amstrad PCW □
IBM PC Compatible □
Atari ST □
Amiga □
Archimedes □
Cortex □

Other (please specify □
....

11. How many ETI projects have you built in the past 12 months?
None □
1-3 □
4-6 □
7-12 □
More than 12 □

12. Do you find ETI projects:

	Yes	No
Reliable	□	□
Easy to build	□	□
Useful	□	□
Instructive	□	□
Technically understandable	□	□
Work first time	□	□

13. Do you modify ETI project designs?
Not At All □
A Few Mods □
Many Mods □

14. Do you prefer to built ETI projects from complete kits when they are available?
Yes □ No □

15. Do you make your own PCBs?
Never □
Sometimes □
Always □

16. Do you primarily build electronics projects
To save money on commercial goods □
As a satisfying pastime □
As an instructional exercise □

17. As far as electronics design and construction is concerned, do you consider yourself:
Novice □
Proficient □
Accomplished □
Expert □

18. Estimate the value of your electronics test gear and construction equipment as new:
Under £25 □
£25-£100 □
£101-£200 □
£201-£500 □
£501-£1000 □
£1001-£2000 □
£2001-£4000 □
over £4000 □

19. How much do you estimate having spent on equipment and components during the past 12 months?
Nothing □
under £25 □
£25-£50 □
£51-£100 □
£101-£200 □
£201-£500 □
£501-£1000 □
over £1000 □

31. If your copy of ETI is read by other people, please give details of their age and sex:

		Person 1	Person 2	Person 3	Person 4
Age:	9-14 yrs	□	□	□	□
	15-24 yrs	□	□	□	□
	25-34 yrs	□	□	□	□
	35-44 yrs	□	□	□	□
	45-54 yrs	□	□	□	□
	55-64 yrs	□	□	□	□
	Over 64 yrs	□	□	□	□
Sex:	Male	□	□	□	□
	Female	□	□	□	□

20. Are you responsible for recommending/specifying electronic equipment in your job?
Yes □ No □

21. How long do you keep your copies of ETI for:
Less than one month □
One month □
Three months □
Six months □
A year or more □

22. If kept, how often do you refer back to issues of ETI?
Once a week or more □
About once a month □
Once every three months □
Less often □
Never □

23. How long do you spend reading your copy of ETI?
Over 2 hours □
1½-2 hours □
1-1½ hours □
½-1 hour □
Less than ½ hour □

24. How long have you been an ETI reader?
Less than 3 months □
3-6 months □
7-12 months □
1-2 years □
2-5 years □
Over 5 years □

25. How often do you buy ETI?
Occasional issues □
Most issues □
Every issue □

26. How much of ETI do you read?
Read only some articles □
Read most articles □
Read all articles □

27. With regard to the advertisements in ETI, do you?
Read or look through most or nearly all the ads □
Read or look through some of the ads □
Just read or look through the occasional ad □
Very rarely/never look at the ads □

28. Thinking specifically about the advertising content, would you please rate the two main types of advertisement:

	Display	Classifieds
Very useful	□	□
Useful	□	□
Quite useful	□	□
Not very useful	□	□
Not at all useful	□	□

29. Which of the following would you most like to see featured with the magazine? (one box only).
Cover mounted gifts □
Additional supplements □
Competitions □
Money saving offers □

30. Does anyone else read your copy of ETI?
No, only myself □
One or two other people □
Three of four other people □
More than four other people □

32. Are you aware of the scheduled publication date of ETI
Yes □ No □

33. If the answer to the last question is YES, do you normally attempt to purchase the magazine on that day?
Yes □ No □

34. How do you normally obtain your copy?
Chance purchase □
Newsagent shop collection □
Newsagent home delivery □
Subscription □
Passed on copy □

35. If you are a subscriber, on which date did you receive this issue?

□ □/□ □/□ □

36. If you are a subscriber, how long have you subscribed to this magazine?
1-6 months □
7-12 months □
1-2 years □
3-5 years □
6-10 years □
Over 10 years □

37. If you do not obtain your copy by subscription, is it due to one of the following:
Subscription too expensive □
Not every issue required □
Not aware subscription service available □

38. Are you aware that to subscribe to this magazine in the UK costs the same as purchasing it in a shop?
Yes ☐ No ☐

39 Would you like to receive further details on taking a subscription?
Yes ☐ No ☐

40. If you do not subscribe, from which type of newsagent do you most often obtain your copy?
High Street Shop ☐
Estate shop ☐
Corner shop ☐
Travel point ☐

Other (please specify) ☐
....

41. If you have subscribed to this magazine but now lapsed, is it due to:
Subscription too expensive ☐
Every issue no longer required ☐
Lateness in receiving subcription copy ☐
Poor service from our subscription bureau ☐

42. Which, if any, of these sports and activities do you play or take part in nowadays?
Cricket ☐
Fishing ☐
Golf ☐
Rugby ☐
Soccer ☐
Sailing ☐
Skiing ☐
Shooting ☐
Swimming ☐
Squash ☐
Tennis ☐
Weight training ☐
Windsurfing ☐

43. Do you own your own home, rent or live with your parents?
Own ☐
Rent ☐
Live with parents ☐
Other (please specify) ☐

....

44. If you own your own home, what is the approximate value (your principal residence if you have more than one)?
Under £50,000 ☐
£50,000-£74,999 ☐
£75,000-£99,999 ☐
£100,000-£149,999 ☐
£150,000-£200,000 ☐
Over £200,000 ☐

45. Is one or more of your cars a company vehicle?
Yes ☐ No ☐

46. Do you usually buy your cars new?
Yes ☐ No ☐

47. How many cars are there in your household?
None ☐
One ☐
Two ☐
Three or more ☐

48. What cars do you own?
....
....
....

49. How often do you tend to change your car(s)?
Once a year or more often ☐
About every two years ☐
About every three years ☐
Less often ☐

50. Please tick the box which represents the annual total of your gross income:
Under £6,500 ☐
£6,501-£8,000 ☐
£8,001-£10,000 ☐
£10,001-£12,500 ☐
£12,501-£15,000 ☐
£15,001-£19,000 ☐
£19,001-£25,000 ☐
Over £25,000 ☐

51. Name the three television programmes you watch most regularly
....
....
....

52. Do you listen to commercial radio stations?
Yes ☐ No ☐

53. Do you smoke:
Cigarettes ☐
Cigars ☐
Pipe ☐
Don't smoke ☐

54. Do you own a:
Stereo/hi-fi system ☐
Tape player/recorder ☐
Video recorder ☐
TV ☐
None of the above ☐

55. Which of the following do you have?
Bank current account ☐
Bank deposit or savings account ☐
Life assurance policy ☐
Any stocks or shares ☐
Access card ☐
Barclaycard (Visa) ☐
American Express ☐
Diners Club ☐
Unit Trusts ☐
Private medical insurance ☐
Personal Accountant ☐
Building Society account ☐
A mortgage ☐
Any HP agreements ☐
Telephone ☐

56. What is your age?
Under 15 yrs ☐
15-18 yrs ☐
19-21 yrs ☐
22-24 yrs ☐
25-34 yrs ☐
35-44 yrs ☐
45-54 yrs ☐
55-64 yrs ☐
Over 64 yrs ☐

57. Which of the following newspapers do you read?
The Times ☐
The Daily Telegraph ☐
The Financial Times ☐
The Guardian ☐
The Independent ☐
The Daily Express ☐
The Daily Mail ☐
The Daily Mirror ☐
The Sun ☐
Today ☐
None of the above ☐

58. Which of the following Sunday newspapers do you read?
The Sunday Times ☐
The Observer ☐
The Sunday Telegraph ☐
The Sunday Express ☐
The Mail on Sunday ☐
The Sunday Mirror ☐
The People ☐
The News of The World ☐
News on Sunday ☐
None of the above ☐

59. Other than items purchased for electronics, have you bought any other types of goods by mail order during the past 12 months?
Yes ☐ No ☐

60. If the answer to the last question is YES, please state the type(s) of goods purchased.
....
....
....
....

61. What is your marital status?
Married ☐
Single ☐
Divorced ☐

62. Sex:
Male ☐ Female ☐

63. Are you a member of a book club?
Yes ☐ No ☐

64. Are you a member of a record club?
Yes ☐ No ☐

65. Are you:
In full time employment ☐
In part time employment ☐
Not employed at present ☐
Retired ☐
Student — full-time ☐
Student — part-time ☐

66. If in full-time employment, please state your occupation:

....

67. If a student what subjects do you study?
....
....
....

68. Which of the stores listed below have you been shopping in during the last six months?
Boots ☐
W. H. Smith ☐
John Menzies ☐
Dixons ☐
Currys ☐
Laskys ☐
Rumbelows ☐
Burtons ☐
Austin Reed ☐
Hornes ☐
Next ☐
Fosters ☐

69. Where do you buy most of your drink from?
An off-licence ☐
A supermarket ☐
A Public House ☐
Other (please specify) ☐
....

70. If you have children, please indicate their age and sex (give details of the four youngest if you have more than four)

	First	Second	Third	Fourth
Age: 1-3 yrs	☐	☐	☐	☐
4-8 yrs	☐	☐	☐	☐
9-12 yrs	☐	☐	☐	☐
13-16 yrs	☐	☐	☐	☐
Over 16 yrs	☐	☐	☐	☐
Sex: Male	☐	☐	☐	☐
Female	☐	☐	☐	☐

71. How many of the following items do you buy, on average, over a month?

	Less than 1 per month	1 or 2	3 or 4	5 or 6	More	Never buy
A book	☐	☐	☐	☐	☐	☐
A record	☐	☐	☐	☐	☐	☐
A tape	☐	☐	☐	☐	☐	☐

72. How many rooms does your home (or principal residence) have?

	1	2	3	4	5	6
Bedrooms	☐	☐	☐	☐	☐	☐
Reception rooms	☐	☐	☐	☐	☐	☐

73. Please indicate below when you last did any of the following:

	In last week	In last month	Longer ago
Ate out at a Restaurant	☐	☐	☐
Entertained at home	☐	☐	☐
Went to the theatre/opera/ballet	☐	☐	☐
Went to a music concert	☐	☐	☐
Went to the cinema	☐	☐	☐
Attended at sporting event	☐	☐	☐
Visited an art gallery/museum	☐	☐	☐
Went to a pub	☐	☐	☐
Had a short break in a hotel	☐	☐	☐

Overseas holiday (in last 12 months) Yes ☐ No ☐

74. Which of the following do you drink?

	More than once a week	Once a week	Less often
Beer	☐	☐	☐
Lager	☐	☐	☐
Wine	☐	☐	☐
Sherry	☐	☐	☐
Port	☐	☐	☐
Brandy	☐	☐	☐
Gin	☐	☐	☐
Rum	☐	☐	☐
Vodka	☐	☐	☐
Whisky	☐	☐	☐
Liqueurs	☐	☐	☐

Don't drink ☐

75. Do you have any of the following cards either yourelf or jointly with another person?

Cash dispenser card ☐
Retailer card/store card ☐

Thank you for completing the ETI readers' survey. To qualify for entry in the free draw for one of 25 six months ETI subscriptions you must fill in your name and address below, pull out the centre four pages, fold as shown and post to arrive not later than 10th June 1988.

Name ....

Address ....

....

.... Postcode ......

To post, fold on the dotted line A. Fold again at B and tuck B into the flap formed by C.

A

Postage will be paid by licensee

Do not affix postage stamps if posted in Gt Britain, Channel Islands, N. Ireland or the Isle of Man.

BUSINESS REPLY SERVICE
Licence No. WC3970

ETI
Reader Survey,
Argus Specialist Publications Ltd,
No. 1 Golden Square,
LONDON
W1R 3AB

2

C

B

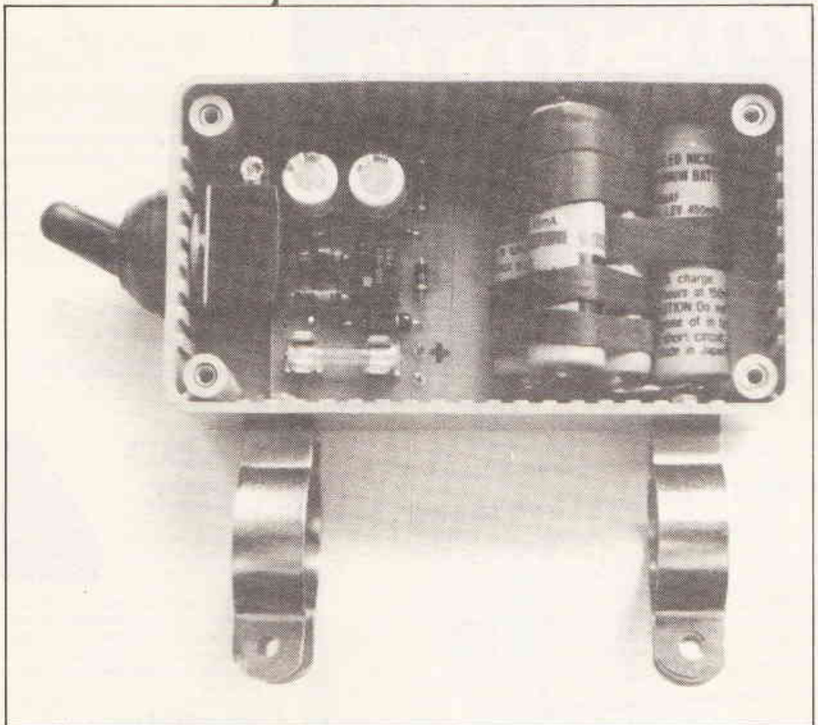
STILL LIFE

Ziad Mouneimne and Nick Flowers are visible at all speeds thanks to this bicycle dynamo backup unit

PROJECT

Dynamo lighting systems for bicycles suffer rather dangerously from the lack of output at standstill — when waiting at traffic lights or road junctions. Apart from this obvious disadvantage dynamos compete favourably with battery-powered lights because they:

- are lighter
- require no costly battery replacement
- provide higher light output (except at low speeds)
- are far more reliable than battery-powered systems. The latter suffer from the infuriating habit of frequently needing a kick before they operate!



Because of the great similarity in the output characteristics of dynamos available on the market (see *Legal Lighting* in *Bicycle* magazine October 1983 for a comprehensive survey) the system described here will operate in conjunction with any dynamo set to provide safe lighting down to standstill. The supply to the front and rear lamps is switched from the dynamo to the rechargeable batteries as the bicycle speed (and so the dynamo output voltage) falls below a predetermined value.

The unit is cheap (about £5 plus the batteries), simple to make and install, and could prove to be a lifesaver.

Features

By using rechargeable batteries in the backup unit, the need for battery replacement is eliminated. The batteries are on charge whenever the dynamo operates.

To keep losses to a minimum, no electronic devices are placed in the source/lamps circuit.

On dynamo systems, the bicycle frame is normally used for the return current by solidly connecting one terminal of the dynamo to the frame. Some commercial backup units require that the dynamo is isolated from the frame — easier said than done. The system described here does not impose such a restriction thus making it easier to install by current and future dynamo users.

The output characteristics of all dynamos are closely matched to the lamp load. On most sets a 3W dynamo supplies a 6V, 0.4A, 2.4W front bulb and a 6V, 0.1A, 0.6W rear bulb. Unfortunately when the front bulb blows the rear bulb follows in seconds. When the rear blows the increase in brightness of the front bulb drastically shortens its life. In fact the authors measured the open circuit voltage of one wheel-driven dynamo and managed to read 180V peak-to-peak on the scope by pedalling in 10th gear!

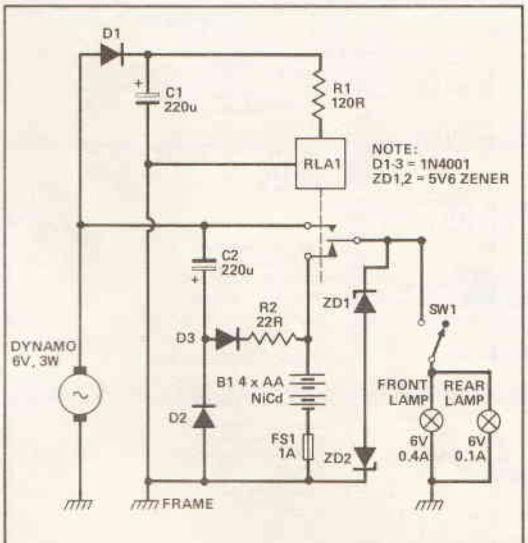


Fig. 1 The circuit diagram

Choosing The Battery

Typical AA-size NiCds have a capacity of 500mAh and recommended charging currents of 50mA and 150mA for 15 and 4 hours respectively. When the bicycle is at standstill, the total current to both lamps supplied by a battery of four NiCd cells is around 0.45A. So a fully charged battery will last for about 45 minutes without dynamo intervention. Obviously the battery will not be used like this in normal circumstances.

Where space is very tight the smaller ½A sized NiCds have the same capacity as the AA size but take up only about half the space.

Non-rechargeable cells can also be used if required. The charging circuit components D2, D3, R2 and C2 may then be omitted. If over-voltage protection is not required the zener's diodes can be also eliminated. The PCB overlay is shown in Fig. 2.

Construction

The prototype is shown in the photographs. The PCB measures only 45×32mm so it was possible to fit all the items (PCB, battery and switch) in a compact box measuring 112 × 62 × 31mm. The unit can be neatly fitted on the bicycle tubular frame by two 25mm terry clips, chrome versions of which are available from any bicycle or hardware shop. Though less attractive (but cheaper) two capacitor clips were successfully used on the prototype.

The best position for the unit was found by the authors to be on the back of the seat down-tube just ahead of the rear mudguard, as shown in the photograph. This gives the unit extra protection from rain — the seat (and rider) acting as an umbrella!

No battery holder is used. Instead, the NiCd cells are connected in series by soldered connections. This is deliberate. It eliminates the problem of bad contact which bedevils all battery systems and it is more compact. Obviously if non-rechargeable AA cells are used, a holder will be necessary and the box made larger.

At the time of writing three units had already been used for two years with excellent results.

ETI

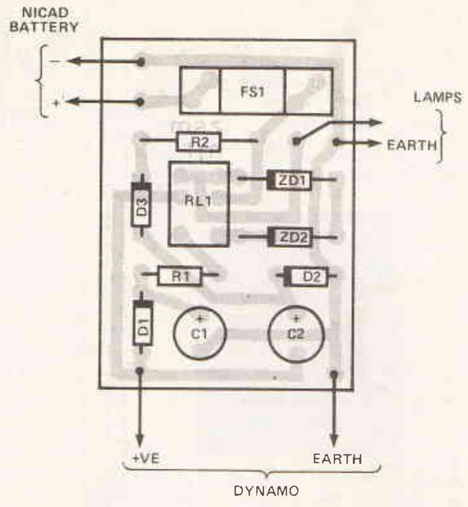


Fig. 2 The component overlay diagram

HOW IT WORKS

Figure 1 shows the complete circuit diagram for the unit. D1, C1 and R1 provide DC supply to the relay coil. The bicycle speed at which the supply to the lamps changes over from the battery to the dynamo is determined by R1. For the dynamo used (a Union model), 120R gave a smooth changeover with the least light flicker.

D2, D3, C2 and R2 constitute the charging unit. Voltage-limiting is achieved by the back-to-back zener diodes ZD1 and ZD2. There are two modes of operation:

a) Normal, SW1 on. When the dynamo is stationary the lamps are connected to the battery. When the dynamo voltage rises, the relay picks up and the lamps are connected to the dynamo. The peak charging current in this mode is about 50mA.

b) Fast charge, SW1 off. If the dynamo is engaged with SW1 off, the charging current increases to about 90mA. This is useful to accelerate the battery charging during daylight riding. ZD1 and ZD2 limit the voltage. Without them the charging current will reach excessive levels and damage the NiCd cells.

PARTS LIST

RESISTORS (all ¼W 5% unless specified)

R1	120R (see *How It Works*)
R2	22R ½W

CAPACITORS

C1, 2	22µ 25V electrolytic

SEMICONDUCTORS

ZD1, 2	1N5339B 5V6 5W
D1-3	1N4001

MISCELLANEOUS

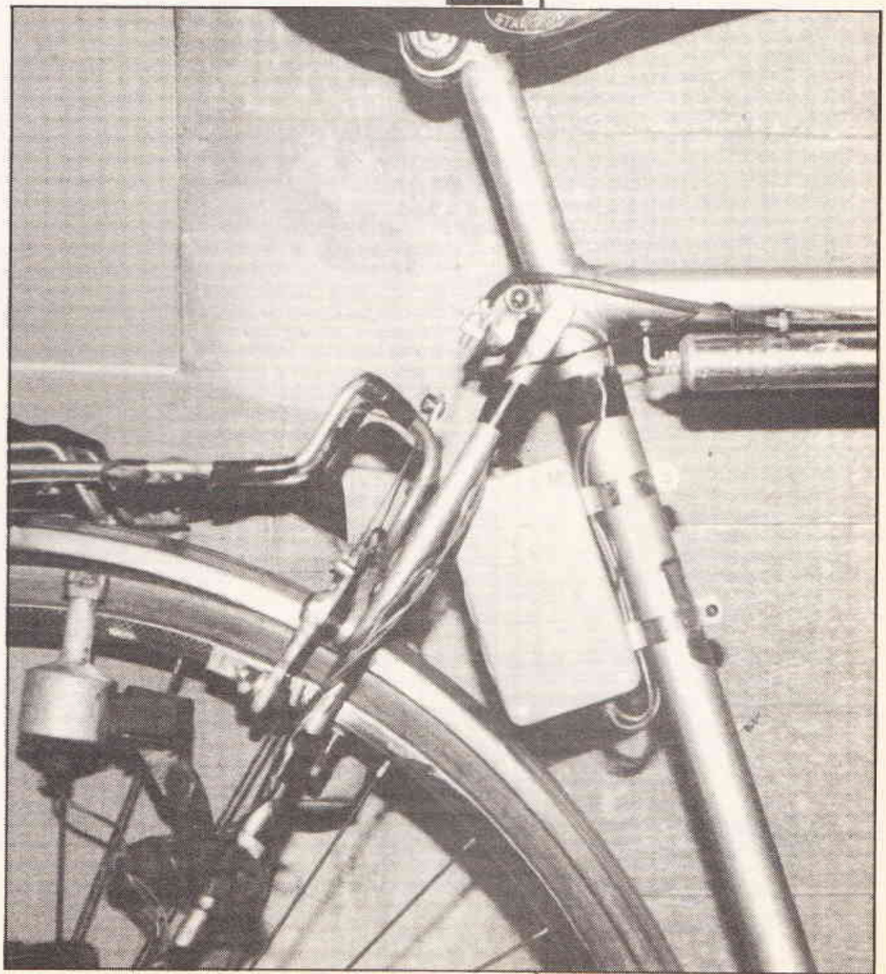
B1	4×1.2V NiCds
FS1	1A anti-surge fuse
RLA1	6V 120R coil, SPDT ultra-miniature relay
SW1	SPST toggle switch

PCB. Case. Waterproof cover for switch. Mounting clips. Fuse clips. Nuts and bolts.

BUYLINES

Most of the components for this project are easily obtainable from normal sources. The relay used in the prototype was from Electromail (Tel: (0536) 204555 part no.345-022) as were the zener diodes (283-148). The ½A size NiCds are also available from Electromail as part no. 592-335.

The PCB is available from the ETI PCB service.



PROJECT

NEW THIS MONTH

★ STAR BUY ★

GREEN SCREEN HI-RES 12" MONITOR CHASSIS
Brand new and complete except for case, the super high definition (1000 lines at centre) makes this monitor ideal for computer applications. Operates from 12V DC at 1.1A. Supplied complete with circuit diagram and 2 pots for brilliance/contrast, & connecting instructions. Standard input from IBM machines, slight mod (details included) for other computers.
Only £24.95 + £3 carr.

SWITCH MODE PSU's
Just arrived – a quantity of Advance high power PSU's – Full details on Bargain list 39.
OF482 130W unit: 5V @ 15A/12V @ 4A: -12V @ 2A: -5V @ 1A (list £110) **£35.00**
P350 250W unit: 5V @ 50A (list £190) **£60.00**
Hiflex 750W unit: 5V @ 130A; 12V @ 20A (List £800= **£250.00**
Hiflex 1000W unit: 5V @ 200A (list £800) **£250.00**

SINGLE BOARD COMPUTER
Z8825 Plessey PME68-1B high performance board. 16 bit 68000 CPU, 128K DRAM, 16K EPROM. Real time clock, 3 serial and 1 parallel 1/0 interfaces. 185 page manual. Brand new and boxed. Originally over £1000. **Our price £150.00.**
Manual £10 returnable deposit

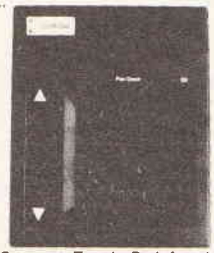
ANALOGUE 1/0 SYSTEM
Z8826 Phillips PG3650. Compatible with and directly interfaces to the VMR bus above. Features: High & Low level inputs, 32 single ended or 16 diff. inputs. Address selectable with whole 16MByte memory space. 12 bit resolution. AMP gains 1-1000 30 page manual. Brand new and boxed **£100.00.**
Manual £5 returnable deposit.

INTERFACE
Z8827 Diecast box 150 × 80 × 50mm. Mounted centrally on top is a 25 way D type socket. This is wired to a PCB within which has 12 × 20mm wire ended fuses & 24 12V 1W zener diodes. A 13 core lead 2m long from this board terminates in a 25W D plug. There is also a seperate earth lead. **£4.00.**

SET TOP CONVERTER
Z8828 Made by Thorn EMI, this was used to receive cable television. 2 part aluminium case 211×158×82mm (no front panel) contains 2 PCB's (a) control board with multi way switch, dual 7 Seg plug in display + a couple of chips. (b) main board with mains transformer, tuner, RF section etc. Rear panel has input and output sockets. 2m mains lead with moulded on 13A plug **£9.00.**

1988 CATALOGUE
OUT NOW 88 pages of bargains from resistors to disco mixers. Price includes latest bargain list, discount vouchers, order form. Don't be without your copy – send £1.00 now!!

SPEECH SYNTH KIT
2315 All parts inc. PBC to make a speech synth for the BBC micro **£4.99**
Z316 De-luxe version – also includes V216 case, 1m 20W cable + connector **£7.99**



Z811 Cumana Touch Pad for the BBC computer. This remarkable add-on enables you to draw on the screen using a stylus with the touch sensitive pad. Supplied with 2 stylii, power/data connecting lead & demo tape with 4 progs. Originally being sold at **£79.95** later reduced to **£49.95** – but we can offer a limited quantity of these brand new and boxed for just **£19.95**

TRANSFORMER
Z023 Phillips, nicely cased. Mains input via 2m lead. 6V 35VA (6A) output to screw terminals **£3.20**

SOLDER SPECIAL!!
★ 15W 240V ac soldering iron
★ High power desolder pump
★ Large tube solder
ALL FOR
£7.95

SOLAR CELLS
Giant size, 90mm dia. giving 0.35V 1.1A output .... **£4** each; 10+ **£3.50**
Mega size – 300 × 300mm. These incorporate a glass screen and backing panel, with wires attached. 12V 200mA output. Ideal for charging nicads **£24.00**

SWITCHED MODE PSU's
Z026 Astec model AC9355. 65W unit. 115/230V AC input. Outputs: +5V 6A; +12V 1.5A; +12V 2.1A; -12V 0.25A. Normally over £70. .... **Our Price £24.95**
Astec type **AA7271.** PCB 50x50mm has 6 transistor cct providing current overload protection, thermal cut-out and excellent filtering. Input 8-24V DC. Output 5V 2A. Regulation 0.2% **£5.00**

RELAYS + LAMPS Over 11,000 just arrived – details on Bargain List 38. E.g.
Z255 6V DPCO plug in relay **80p**
Z327 6.5V 0.15A MES 1 amp 10 ... **£1**

COIN OPERATED MECHANISM
Made by Coin Controls, this will accept various size coins by simple adjustment of 4 screws. Incorporates various security measures – magnet bent coin release etc. Microswitch rated 5A 240V. Front panel 115 x 64. Depth 130mm. Cost £10.85. .... **Our Price £4.00**

REED SWITCHES
K669 A selection of about 15 types from 12 to 50mm long, mostly from A, few from C. Pack of 30 .... **£2.75**
Z797 Min 15.3mm long.
20/**£1.50**; 100/**£6**; 250/**£12**
Z798 Large 50.8mm long.
10/**£1.50**; 25/**£3**; 100/**£10**
Z799 Changeover 40mm long.
5/**£1.50**; 25/**£6**; 100/**£20**

TOOLS
Scoop purchase of high quality surgical instruments ideal for electronics use.
Z308 5" lightweight long nose pliers **99p**
Z309 5½" as above but with ratchet. This enables pliers to be locked together – for holding small components, or as heat shunt etc. **£1.20**
Other types on Bargain List 36

Z810 KEYBOARD Really smart alpha numeric standard qwerty keyboard with separate numeric keypad, from ICL's 'One Per Desk'. Nicely laid out keys with good tactile feel. Not encoded – matrix output from PCB taken to 20 way ribbon cable. Made by Alps. Size 333 × 106mm. 73 keys **£8.95**
Z004 Skeleton Joystick, switch type. Good quality, made by AB. Brass spindle has 44mm long black plastic handle attached. Body has 4 mounting holes. These really are a fantastic bargain!! .... **ONLY £1.00**

ENTERPRISE PANELS
Z658 PCB 325 × 158 with 64k of RAM (8 × 4864), Z80A microprocessor + 21 other chips, UHF modulator, speaker etc. ROM and Nick and/or Dave chips missing supplied with cct and data **£8.00**

VIEWDATA LTU
Z697 Interface Panel 166 × 150 with 3 × LM324, LM339, LM393, 4066, 11 transistors, 3 reed relays etc. 3m lead with BT plug attached. Supplied with comprehensive data and ccts **£2.90**

All prices include VAT; just add £1.00 P&P. Min Access £5. No CWO min. Official Orders from schools welcome – min. invoice charge £10. Our shop has enormous stocks of components and is open 9-5.30 Mon.-Sat. Come and see us!

HOW TO CONTACT US:
By post using the address below; **by phone** (0703) 772501 or 783740 (ansaphone out of business hours); **by Fax** (0703) 787555 **by EMail:** Telecom Gold 72:MAG36026; **by Telex** 265871 MONREF G quoting 72:MAG36026.

GREENWELD
ELECTRONIC COMPONENTS

443A MILLBROOK ROAD
SOUTHAMPTON SO1 0HX

Access

CRICKLEWOOD ELECTRONICS LTD

WRITE OR PHONE NOW FOR OUR FREE, *SPRING* COMPONENTS CATALOGUE

WHEN YOU CAN'T FIND IT ELSEWHERE WE'LL HAVE IT!

from the U.K.'s number one 100% components shop - no gimmicks, no gadgets, no computers, just millions of components, all easily available by mail order, calling at shop, or credit card telephone orders. Just pick upne, or a pen, to get the catalogue (no SAE required) - posted **FREE** to any country on the globe.

CRICKLEWOOD ELECTRONICS LIMITED
40 CRICKLEWOOD BROADWAY, LONDON NW2 3ET
Tel: 01 450 0995 & 01 452 0161 Telex: 914977

VISA Access

19" RACK CASES

★ Suitable for instruments, high quality amplifiers and many other applications that demand strength and professional finish ★ New improved construction and finish ★ Black anodised aluminium front panels ★ Separate front mounting plate, no fixing screws visible on the front and the side of the enclosure ★ Heavy gauge front panel is of brushed aluminium finish enhanced with two professional handles ★ With ventilation slits and plastic feet ★ Rear box manufactured from 1.1mm steel finished in black. Rack mounting or free standing. Comes in quick assembly flat package spare front panels available.

Order Code	Panel Size W H (inch)	Rear Box W H D	Weight	Price £
IU-10	19 × 1.75	17 × 1.5 × 10	2.4kg	**23.50**
2U-10	19 × 3.5	17 × 3.0 × 10	2.9kg	**24.50**
3U-10	19 × 5.25	17 × 5.0 × 10	3.5kg	**26.50**

15% discount on 1U-10 2U-10 3U-10 with this advert.

2U-12	19 × 3.5	17 × 3.0 × 12	3.3kg	**£25.50**
3U-12	19 × 5.25	17 × 5.0 × 12	4.0kg	**£27.50**
4U-12	19 × 7.0	17 × 6.5 × 12	4.6kg	**£29.95**

Please add £3.00 P&P for the first item and £1.50 for each additional item.
No VAT to be added to the price.

TEST EQUIPMENTS

C83A Digital Power Supply/Voltmeter (0/35 Volts 1.5 A)	**£49.50**
C83B Digital Power Supply (0/30 Volts 1 A)	**£40.50**
C89A Function Generator (2 Hz to 200 KHz)	**£43.50**
C86A 60 MHz Counter/Timer	**£55.50**
C87A Autoranging Capacitance Meter (0.1 pF to 99.9 mF)	**£55.50**
MV338 Metal-mains detector	**£4.99**

A range of low cost, high quality, metal cased laboratory instruments. Mains operated and easily portable. Please add £3.00 p/p per item (£1.00 for MV338).

To order send cheque/postal order. Quantity discount available. Customers who require further information please send S.A.E. Trade and overseas orders welcome. Mail order only.

T.J.A. DEVELOPMENTS
Dept. ETI, 19 Welbeck Road, Harrow, Middlesex HA2 0RN.

PROJECT

EVERY BREATH YOU TAKE

En route to the Lucid Dream Machine, Paul Chappell takes your breath away ... and counts it

Last month I hinted how I intended to go about designing the breathing rate monitor. Now, a lot of things can happen in a month — countries can be invaded, dictators overthrown, Steven Hendry can shave at least twice and to cut a long story short, coming straight to the point without beating about the bush, I've ... er ... changed my mind.

The circuit I had in mind last month was perfectly good, it's just that I like the new one better. So as not to leave any hanging plot lines, as they say in the soap opera trade, I'll begin by showing you what I originally intended to do.

Before . . .

I sketched out a diagram last month for a kind of digital-to-analogue averaging circuit and pointed out that although the idea was OK, it was a dud for practical purposes because of the excessive number of ICs. There's nothing wrong with using a shift register, the problem arises from the need to have access to the output of every single stage.

What we're really interested in is the number of 1s inside the shift register chain at any time, so why not tot them up as they go in and cross them off as they come out again? Figure 1 shows how this can be done.

If you imagine that the circuit powers up with the counter and shift register both set to zero, for the first minute the counter will simply clock upwards on each breath. It will end up showing the number of breaths taken in the first minute.

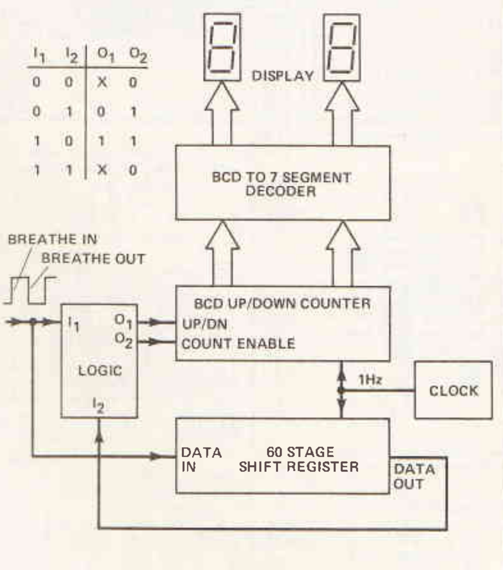


Fig. 1 Breathing monitor using shift register

After that each breath will cause it to clock upwards, whereas each overflow from the shift register will take it one count downwards. If no breaths and no overflow take place, the counter stays put. If a breath and an overflow occur at the same time, they cancel out and the counter also stays put. The result is that the counter keeps a running average of the number of breaths over the preceding minute, updated once a second.

If you fancy turning this idea into a working circuit, bear in mind that the logic is slightly simplified. You'd have to make sure that each input pulse (which could be present over several clock cycles) was only counted once, so static logic won't quite do the job.

Also notice that the SR needn't have sixty stages. As long as all the stages clock through in exactly one minute (adjust the clock frequency so that they do!) and there are sufficient to give the resolution you want, the SR can have as many stages as you like. This makes the choice of IC a little easier!

The circuit can be modified to do away with the shift register altogether, or at least to replace it with a counter and to alter the averaging period — I'll leave you to work out the details for yourself.

After

Now on to the circuit I intend to use, which incorporates one of the more interesting devices available in 4000 series CMOS — the 4527 rate multiplier IC. Strictly speaking it's not a multiplier at all, but a special kind of divider. Figure 2a shows the essential connections to the IC.

In effect the IC takes the clock frequency, divides it by ten, then multiplies it by the number that appears on its BCD inputs. With a clock frequency of 10kHz, for example, a 3 on the BCD inputs would give an output of 3kHz, a 9 would give 9kHz and so on.

In reality, the operation is not quite as tidy as I've made out. The IC creates these different frequencies by missing a certain number of pulses in every group of ten input cycles. Figure 2b shows the output for a BCD input of 5 — it doesn't even miss alternate pulses to give a regular output.

A complete functional diagram for the IC is shown in Fig. 2c. The TC and $\overline{TC}$ (terminal count) outputs mark the end of each group of ten clock cycles, CLR sets the counter to zero, PL sets it to 9, $\overline{CE}$ allows it to count (or freezes it when high), STR and CAS are inputs which allow two or more ICs to be cascaded.

Rated Breath

The notional block diagram for the project is shown in Fig. 3. The clock and divider chain produce an output of 100 pulses per minute. The rate multiplier divides this frequency by 100 and multiplies by the number stored in the BCD counter, which will also be the number shown on the display. The result is an output from the rate multiplier of the same number of pulses per second as is shown on the display. The logic compares this with the breathing rate input. If higher, the counter is clocked down, decreasing the frequency; if lower the counter is clocked up. The action of the circuit as a whole is to continuously try to match the internal frequency (and so the display reading) to the breathing rate.

At its simplest, the logic can simply clock up the counter on every input pulse and clock it down on every internally generated pulse. The trouble with this approach is that even when the two frequencies are perfectly matched, this display will still be stepping continuously up and down. At the cost of a few flip-flops, it can be arranged so that the counter ignores alternate pulses and only responds when two or more of one variety occur between subsequent pulses of the other kind, giving a far more stable display and an equally fast tracking rate.

Another refinement can be made at no cost at all. The ragged output from the rate multiplier section would also disturb the display, but all that needs to be done to cure this problem is to swap the order of the divider and rate multiplier. It will make no difference at all to the final frequency, but since the rate multiplier output will be averaged by the divider network over (in this circuit) almost 2,000 output cycles, the resulting repetition rate will be very stable indeed!

How To Catch Your Breath

The complete circuit of the breathing rate monitor is shown in Fig. 4. The counter and display section (Fig. 4a) needs little comment. The 4543 ICs are BCD to 7-segment decoders to drive the display. Depending on whether link 1, 2 or 3 is made, the circuit will accommodate LED displays of either polarity, or an LCD display. The LCD displays are the obvious choice for battery operated equip-

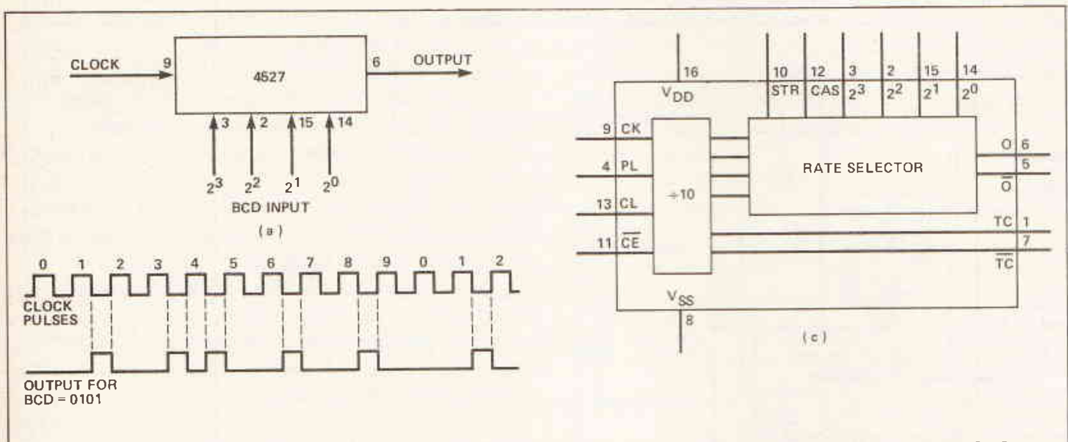


Fig. 2 (a) Connections to 4527. (b) Example operation of 4527. (c) Functional diagram for 4527

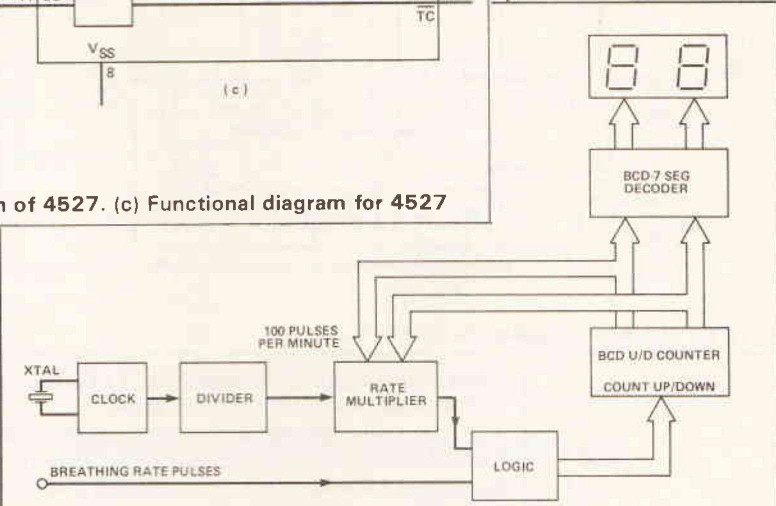


Fig. 3 Block diagram for rate monitor

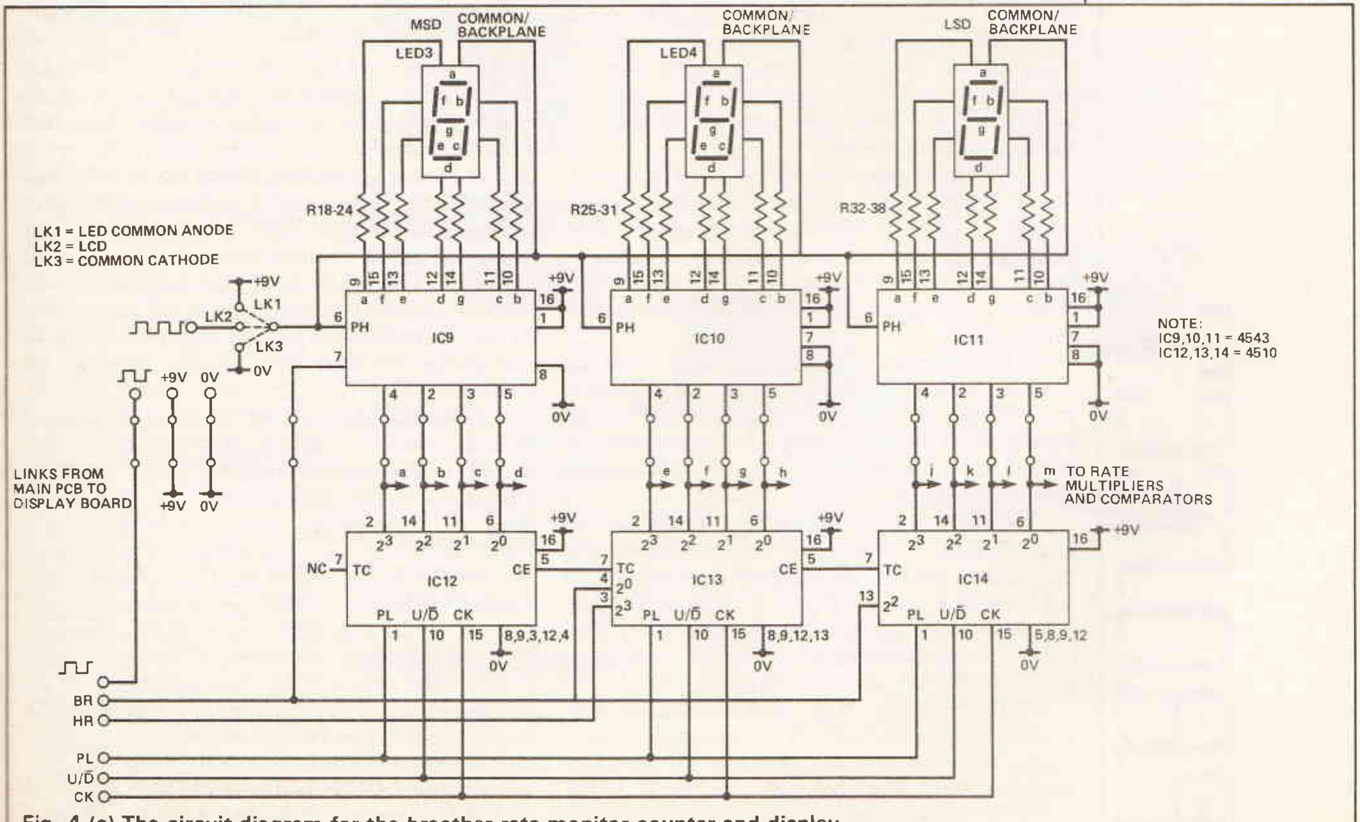


Fig. 4 (a) The circuit diagram for the breather rate monitor counter and display

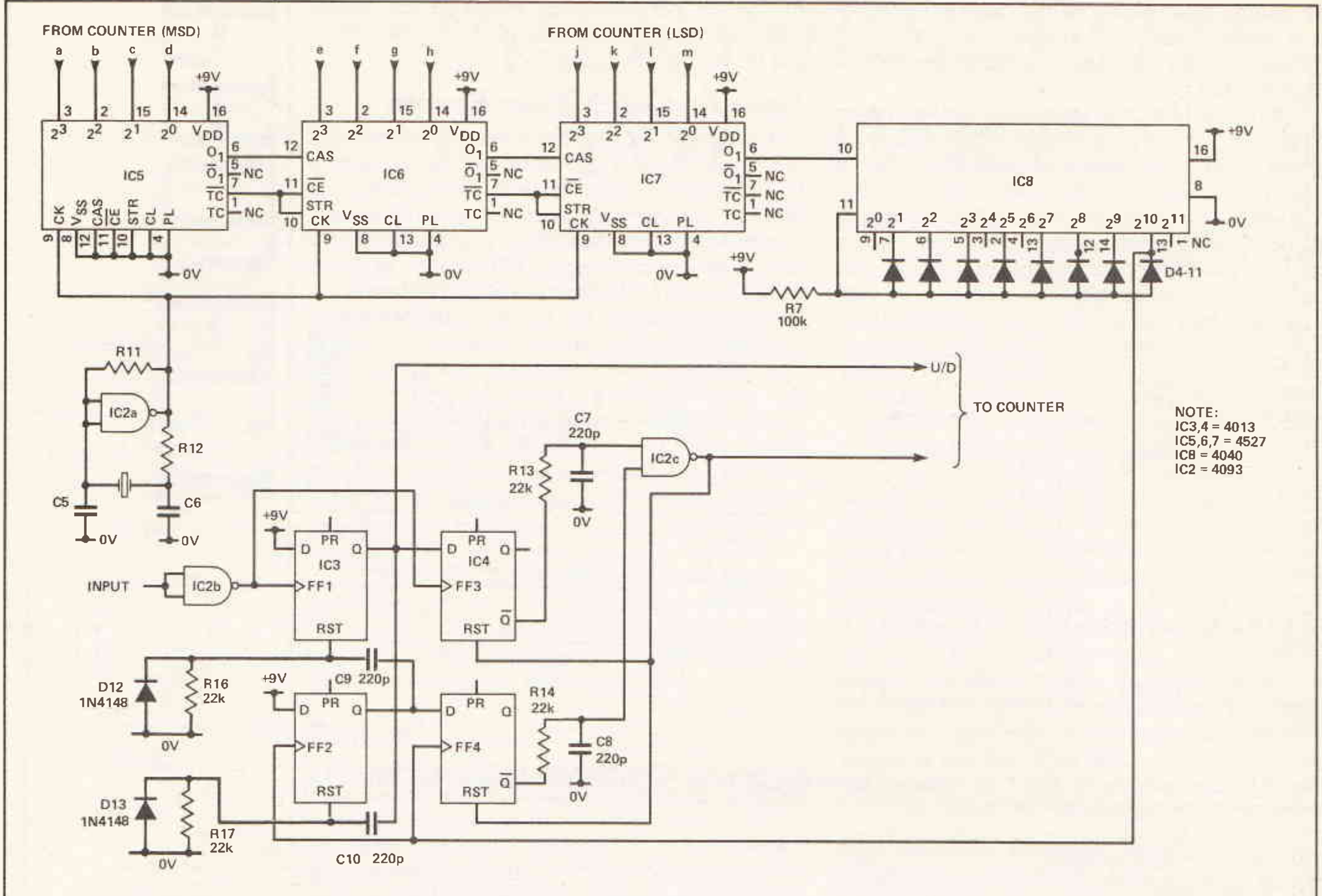


Fig. 4 (b) The rate multiplication circuit

ment, but are more expensive than LEDs and (to my eyes, anyway) don't look as good.

The remainder of the circuit is simply three cascaded BCD up/down counters (cascaded right to left to get the digits in the proper order!) If you're wondering why I didn't opt for one of the combined counter and driver ICs, which would certainly have made the PCB layout easier, it's simply a matter of cost. This is quite a large project and the expense soon mounts up; the half-dozen CMOS ICs are less than half the price of the cheapest counter/driver IC, so there you are. All done for the sake of your pocket.

The meaty part of the circuit is shown in Fig. 4b. As promised, the rate multipliers precede the divider IC. The four flip-flops decide whether two input pulses have appeared between subsequent timing pulses or vice versa, and provide a clock pulse and the appropriate up/down command to the counter.

The power-on reset gives a signal to load the counters with a suitable starting level of 14 breaths per minute, which is the average adult resting breath. With SW2 in position 2, the counters are loaded instead with the number 80 — I'll explain why in a moment.

The rate multipliers take their inputs from the counter. If the display shows 123 for instance, the input to the first 4527 IC will be 0001, to the second will be 0010 and to the third will be 0011. The first IC is required to produce 100 counts for every 1000 clock pulses, the second to produce 20 and the third only 3. The way it works is like this.

All things being equal, the rate multipliers step around their output pattern once every ten clock cycles. One thing that can alter this is if the count enable input ($\overline{CE}$) is held high. The first IC in the chain has its count enable grounded, so will step round continuously. The second has its count enable connected to the terminal count output of the first and since this only goes low for one clock cycle in every ten, it only responds to a tenth as many clocks as the first. The third gets an even smaller share — driven from the terminal count output of the second it only sees one clock pulse in every 100.

Outputs

The maximum number of outputs that any of the rate multipliers can give is nine pulses in every ten. This means that no matter what input is fed to the first multiplier, there will always be at least one 'gap' in the pulse train. Furthermore this gap position — the ninth pulse, if the count is considered to go from zero to nine — is never used in any of the other patterns either. There is always a space on the ninth count, which by a lucky chance (or not) happens to be just the time when $\overline{TC}$ goes low, giving the next IC a chance to make its contribution.

The pulses on the CAS inputs of the second and third ICs slip straight through to appear at the output, so every pulse produced by the first 4527 will appear at the clock input of the 4040. Once every ten clock cycles, the second IC will have a chance to add a pulse to the stream, which will also slip through to the end of the chain. Once every hundred cycles, the third IC gets a chance. So with an input of 123, after 1000 clock cycles the first will have stepped round 100 times, giving 1 pulse each time, or 100 pulses in all. The second will have stepped round 10 times, adding in two pulses each time giving 20 extra and the third IC will only have stepped around once to give its three outputs, making a total of 123. And there will still be a gap on the 999th pulse for yet another IC to be added to the chain!

The analogue section of Fig. 4c serves to detect your breathing rate and turn it into a suitable digital signal to drive the logic circuitry. The sensing part of the circuit depends on the fact that the air you breathe out is considerably warmer than when it went in. If you want to measure the breathing rate of mad dogs and/or Englishmen in the mid-day sun the principle might need some more thought, but for use indoors in chilly England, even with the central heating at full blast, it works well.

The sense element is nothing more exotic than a 1N4148 (or any other type, for that matter) diode. With sub-miniature thermistors (which you need for their low thermal inertia) weighing in at around £2.50 a time, it's another economy measure. And it does the job without fuss!

The input circuit is essentially a differentiator, with the rising frequency response slugged by C4. The output drives a comparator, which in turn drives the logic (via the schmitt of Fig. 4b, which gives good fast edges to the signal). The LED circuit is optional — it lights one or other of the diodes according to whether you are breathing in or out, so is a good test facility to make sure the sense diode is properly positioned and the input circuit functioning. On the other hand it's an extra current drain on the circuit, so the choice is up to you.

The remaining op-amp simply serves to establish a reference at half the battery voltage for the other ICs.

In The Next Breath

As this project has progressed, it has also grown. The thing about something as general-purpose as a rate meter is that there's no end to the additions that can be made to it. I have to draw the line somewhere, but couldn't resist adding in a heart-rate monitor too. This is the reason for the three digits and the initial 80 on the display — about the average resting heart rate of a non-athletic adult. Unless you wake one morning (from uneasy dreams?) to find yourself transformed into a giant rabbit, there's no way your breathing rate will get that high!

I haven't forgotten the lucid dream stimulator either, that's on its way too. Those of you who want just one or two of the facilities can simply miss out the extra components. In the same box then, you can have a breathing rate meter, a heart rate monitor and a lucid dream stimulator. Never let it be said that ETI doesn't have the most comprehensive, exciting (and outrageous?) projects!

ETI

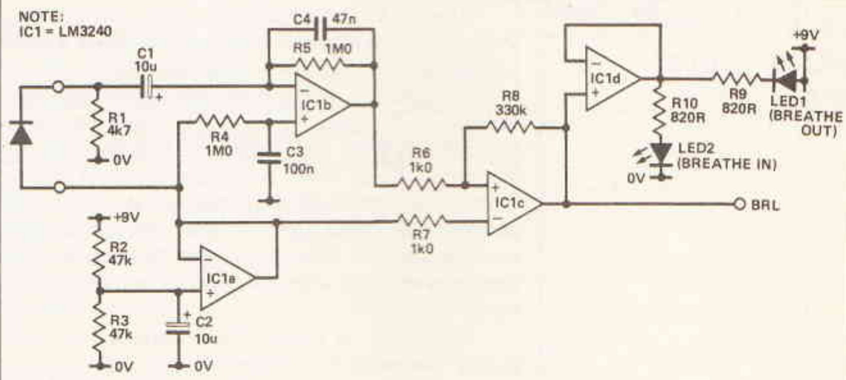


Fig. 4 (c) The analogue breath detection circuit

GOING FOR GOLD

Keith Brindley finds buried treasure and avoids nailing through the water pipes with this simple but effective metal detector

Although this metal detector is certainly small, it does require a few extras. You don't need a car battery for power, a rucksack (to put it all in) and a six-foot dipole aerial to make the project work but you do need a small transistor radio.

The metal detector works by transmitting a weak radio wave carrier signal around itself, which has to be picked up with a nearby tranny.

The carrier signal main frequency is in the vicinity of the lower end of the longwave band (around 120kHz) and is of sufficient strength to interfere with a radio within about a foot or so, tuned into the medium or long wave. The interference is heard as a whistle from the radio's loudspeaker. As the whistle changes frequency, you know the metal detector is approaching a metal or metal-like object.

Sensitivity is pretty good considering how simple the project is. With a remote pickup coil metals can be detected from a distance of six inches or so. Even when the pickup coil is mounted on the project's case (as ours is) metals can be detected from around three or four inches.

Construction

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

On PCB, construction needn't follow any particular order, although it's probably best to leave the transistor and coil till last. Whatever, go easy on the heat. Solder only one leg of each component at a time then leave the component to cool before moving on to solder the next leg.

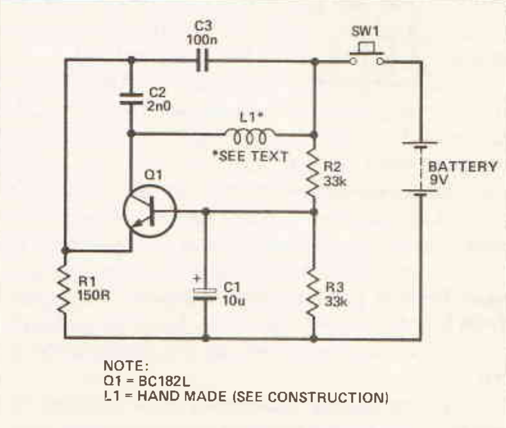


Fig. 1 Circuit of the ETI Metal Detector

On stripboard it's probably best to stick to a conventional order, still maintaining heat precautions. Insert and solder the single wire link, followed by resistors, capacitors and the flying leads to peripheral components. Lastly insert the transistor Q1 and, when you've made it, the coil.

Whichever construction method you choose, check that no unwanted solder links or bridges are present between component leads.

The coil L1 needs to be wound. First, find a former on which to wind it — something with an external circumference of about 220mm, although this measurement is by no means critical. For reference, we used the widest part of a 250ml

HOW IT WORKS

The circuit is a Colpitt's oscillator, formed around transistor Q1 which is connected as a common base amplifier. Positive feedback is applied from collector to emitter via the AC potential divider formed by series connected capacitor C2 and C3.

Capacitors C2 and C3 also form one arm of a parallel LC circuit. The circuit's resonant frequency is given by the relationship:

$$f = \frac{1}{2\pi\sqrt{(LC)}}$$

and is around 120kHz. Conversely, we can calculate from the relationship that the coil inductance is around 0.88mH. Try it for yourself.

Coupled in this way, the transistor amplifier becomes a weak radio transmitter, transmitting a carrier wave frequency of around 120kHz. Now, this is actually slightly below the frequencies which are normally found on the dials of long and medium wave radios (long wave is typically from about 150kHz to 300kHz and medium wave is from about 500kHz to 1600kHz). This means that if the metal detector's transmitted carrier was pure, long wave and medium wave radios could not be used to pick up the oscillations. Fortunately, oscillations are not of a pure sine wave nature, so many harmonics of the resonant frequency are also formed, going right up through the long and medium wavebands and beyond.

The project functions as a metal detector simply because the actual inductance of the resonant frequency's coil varies with the proximity of local metallic bodies. Ferromagnetic bodies particularly concentrate the magnetic flux within the coil, so increasing the coil's inductance and lowering the resonant frequency of the oscillator.

A local transistor radio is used to pick up the weak carrier signals produced by the metal detector, along with a carrier wave of another radio transmission (of a more legal, broadcast nature). The two carriers heterodyne (interfere) to produce an audible beat frequency from the transistor radio's loudspeaker. The beat tone is stable, until a metal object approaches the metal detector's coil. Then the coil's inductance varies, causing the resonant oscillation frequency to vary and in turn causing the beat tone to vary. So the user hears, simply by a change of the beat tone's pitch, that the coil is somewhere near a metal object.

1st CLASS

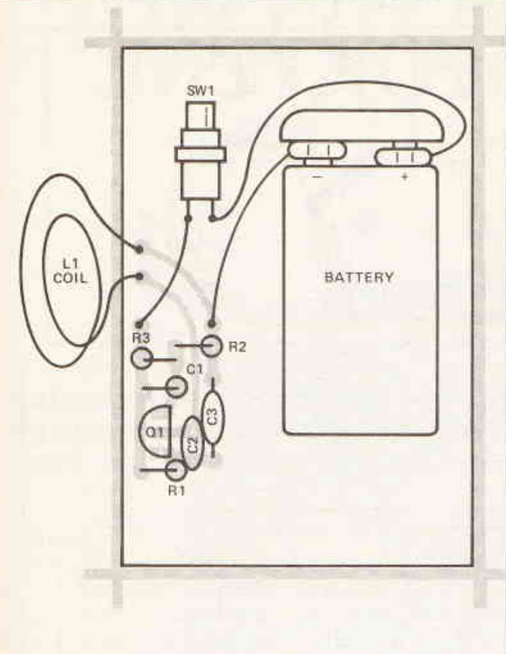


Fig. 2 The component overlay for the Metal Detector PCB

PARTS LIST

RESISTORS (all ¼W, 5%)

R1	150R
R2, 3	33k

CAPACITORS

C1	10µ 16V axial electrolytic
C2	2n2 ceramic
C3	100n ceramic

SEMICONDUCTOR

Q1	BC182L

MISCELLANEOUS

SW1	Push-to-make
L1	Hand-made coil (see text)

PCB. Case. Type PP3 battery and clip. 30swg enamel covered copper wire for coil L1.

BUYLINES

All parts are easily obtained from component suppliers. The case used was a Type 1 general purpose Vero case. The PCB is available from the PCB Service.

bottle of Sainsbury's Baby Lotion — no prizes or guessing who's been left holding the baby! Alternatively, a piece of thick card about 110mm long could be used to hank-wind the coil. Make 100 turns of 30swg enamel covered copper wire, leaving sufficient ends to connect between the coil's final position and the PCB.

When you've wound the coil, fasten it together in two or three places around its circumference with tape and slip it off its winding former. Adjust its shape to suit.

Before you solder the ends of the coil into the PCB, make sure you scrape off the enamel from the copper wire for about 5mm from each end, so they can be soldered. If you are using polyurethane coated insulated copper wire, there is no need to scrape off the insulation as the copper is self-fluxing on application of heat from a soldering iron.

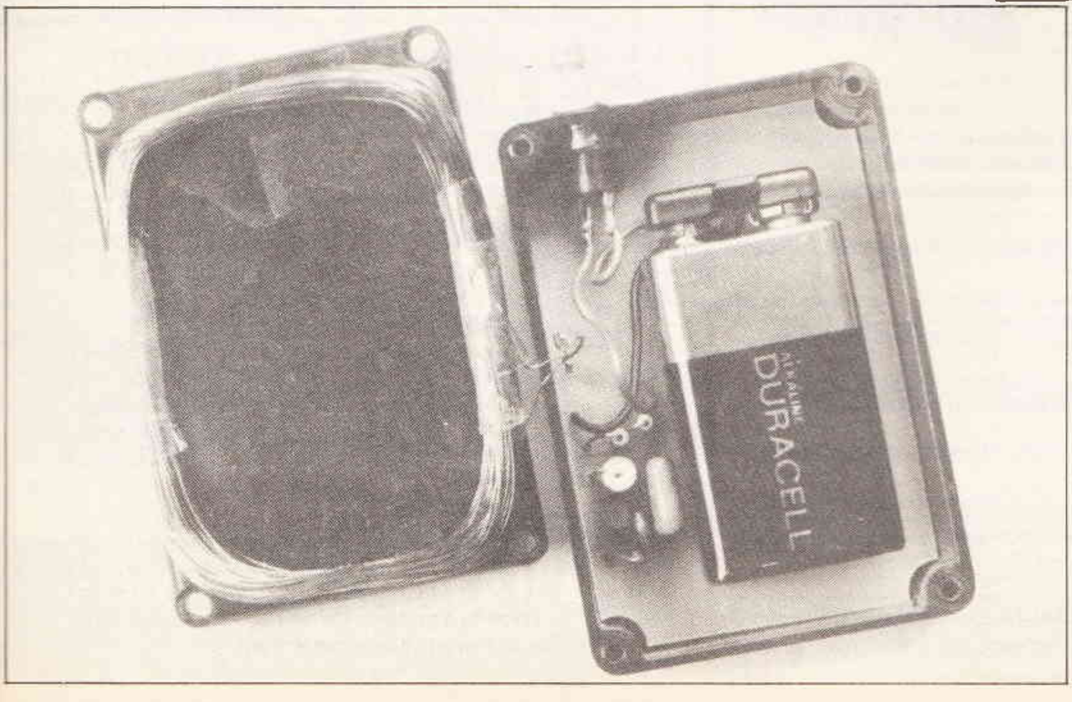
Any suitable sized box can be used to house your project, although the PCB is exactly the right size to fit the box used (see *Buylines*). The only real precaution you need to take is to mount the coil on the outside of the case (if it's on the inside its inductance is fixed primarily by the PCB and associated components — not by metals you wish to detect!) or better still, remotely.

Setting Up

Setting up is simplicity itself. Turn on your radio and, while you press the metal detector's push-button on/off switch, adjust the radio's frequency tuning control until you hear a whistle. When you release the push-button the whistle should stop. If not, the whistle isn't caused by the metal detector and you should re-adjust the radio's frequency tuning control.

Test the metal detector by moving it closer to metal. The whistle from the radio will change frequency.

Now you're all set to find your fortune buried in the compost heap in the back garden. ETI



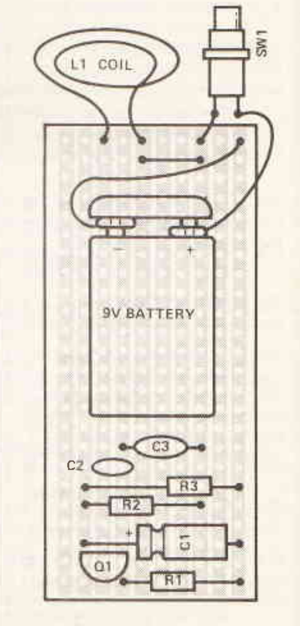
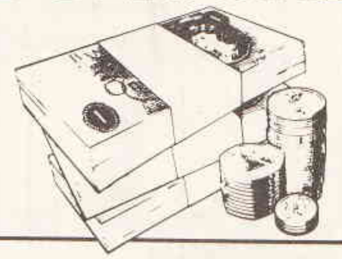


Fig. 3 Stripboard component overlay. Note there are no track cuts required for this design

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.

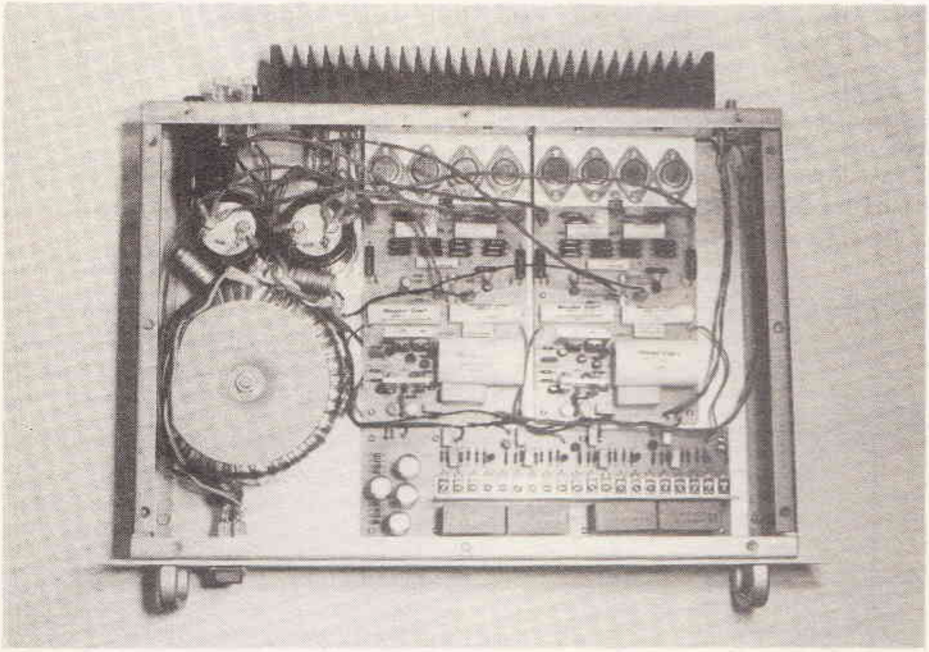
Whatever you can contribute to ETI, take the plunge now. We can offer a modicum of fame and a very reasonable fortune.

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

VIRTUOSO POWER AMPLIFIER

PROJECT

Graham Nalty describes the amplifier board that completes his super-fi project



In the third and final article on the Virtuoso Power Amplifier I will look at the power amplifier board itself and at the decisions that were taken concerning its design. First comes the choice whether to operate in class A, sliding class A or class AB.

The class A output stage (Fig. 1) is always ideal but even the larger version of the Virtuoso case would have barely enough heatsink for much more than 10W per channel into 8R (very high levels of heat are dissipated for small output powers).

The Virtuoso has been designed to operate as a fairly low current class AB.

In a true class B amplifier (Fig. 2) each output transistor drives the load speaker for half the current cycle and no current flows through the transistors under quiescent conditions. In practice a fixed current adjusted by the bias voltage is usually set.

The disadvantage is that switching delays (as each transistor current reaches zero at the end of each half-cycle) cause audible distortion, especially at high frequencies.

Sliding bias can prevent the non-driving output transistor switching off but require a voltage feed from the main supply and can cause ripple rejection problems.

On The Way Out

The output devices of this amplifier are bipolar darlington power transistors. These have a lower output-stage non-linearity than MOSFETs (and so greater signal headroom) and much greater peak output current capability. Also MOSFETs have a high input capacity and require high current from the driver stage for good high frequency performance — hence some MOSFET power amps having an emitter follower or source follower prior to the output.

The next question to be answered is how to arrange the input and output coupling.

Fig. 3 shows the basic circuit chosen, with C1 blocking DC to the input and C2 blocking DC in the feedback so that any DC offset at the input is not amplified at the output. This C2 capacitor is large and expensive (more than £10 in the upgraded amp — C45 in Parts List).

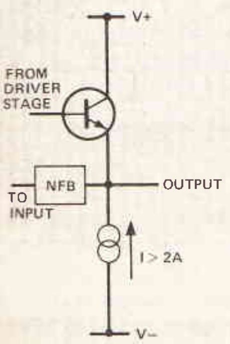


Fig. 1 Class A output stage

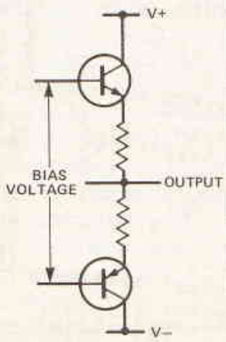


Fig. 2 Class B output stage

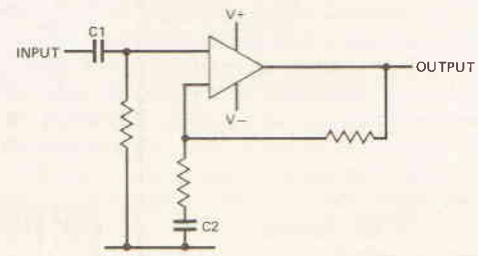


Fig. 3 AC input DC output amplifier

On The Way In

The input stage of the Virtuoso is essentially a differential input long tail pair (see Fig. 4), perhaps the most popular power amplifier input circuit.

Some designers (particularly in the USA) prefer fully symmetrical differential inputs, but using cascode circuitry and increasing the dynamic impedance of constant current sources would make such a design extremely elaborate. Attempting to keep the numbers of transistors practical would affect sonic performance.

The full circuit for the amplifier board is shown in Fig. 6. Its operation is exactly as described in *How It Works* for the simplified circuit (Fig. 5). The individual parts have been expanded to perform their function to a higher standard.

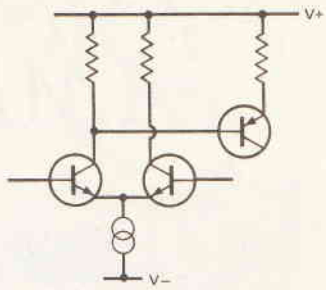


Fig. 4 Long tail pair input

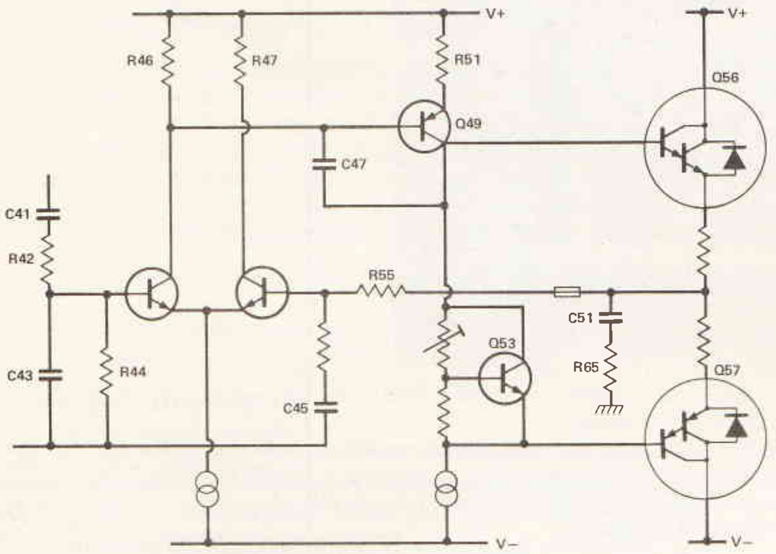


Fig. 5 Simplified circuit diagram of Virtuoso

HOW IT WORKS

The basic circuit of the Virtuoso Power Amplifier is shown in Fig. 5 (component numbering is the same as in the complete circuit Fig. 6).

DC blocking at the input stage is carried out by C41.

A lowpass filter is formed by R42, C43 to prevent very fast high frequency signals reaching the amplifier.

R44 biases the base of the input transistor.

The input stage is a long tail pair fed by a high dynamic impedance constant current source. The output to the next stage is taken from R46 to an amplifier comprising Q49 and Q50. A constant current source provides its load.

The output stage comprises darlington transistors with series emitter resistors. These are biased by a constant voltage network made of RV1, R60 and Q53. High frequency stability is maintained by C51 and R65.

Loudspeakers are protected by a fuse which is within the feedback for minimum sonic distortion.

R41 holds the input of C41 at 0V so that no thump is heard from the speakers when the input is connected. C41 is bypassed by C42 to improve its high frequency performance and together with R44 provides low frequency input filtering. Q41 to Q44 form the input long tail pair.

The darlington arrangement keeps the input base current much lower than with single transistors so that the output DC offset is low even at high values of R44 and R55.

C56 (across Q41,42) is required for high frequency stability (dual matched transistors are used in the upgrade).

The cascode transistors Q45,46 remove ripple from the power supply before they reach Q41-44, improve the high frequency performance and lower the transistor generated distortion in the input transistors.

The second stage amplifier is Q49. Its collector voltage is held constant by cascode transistor Q50 (mounting on a heatsink will reduce temperature generated distortion). A constant current source is provided by Q51, 52 and R58, 59. C54 and C55 provide low high-frequency impedance at the power supply for the output transistors (which are duplicated in parallel for higher output current capability). This prevents high frequency instability of the amplifier.

The quality and value of the emitter resistors (in series with the output transistors) are critical. A fair amount of power is dissipated in these resistors.

When a transistor heats up, its base-emitter voltage decreases. The series resistor provides an increase in voltage with increased collector current. If the resistor value is high enough, thermal runaway is prevented. The use of darlington transistors with two V_{be} junctions requires almost twice the resistance that might be required in a more common circuit with separate driver transistors.

Output Stage Protection

The cost of the output transistors (and in the upgraded version the emitter resistors) mean that it is well worth incurring the additional expense of output stage protection circuitry to safeguard against short circuits or overloading into very low impedances. The circuit used would not usually protect against thermal runaway or high-level high-frequency oscillation.

The circuit is shown in Fig. 7. Diodes D1, D2 protect the collectors of Q1,2 from going to the wrong polarity in relation to their emitters.

The characteristics of the protection circuit for the standard Virtuoso amplifier are shown in Fig. 8. These show a margin of safety up to 40V at 8A. For more current at higher voltages you can add a network made up of a zener diode (15-30V) in series with a resistor, placed in parallel with each of R70 and R71.

Components C52, 53 and R68, 69 are included to increase power dissipation in momentary periods where the power dissipation

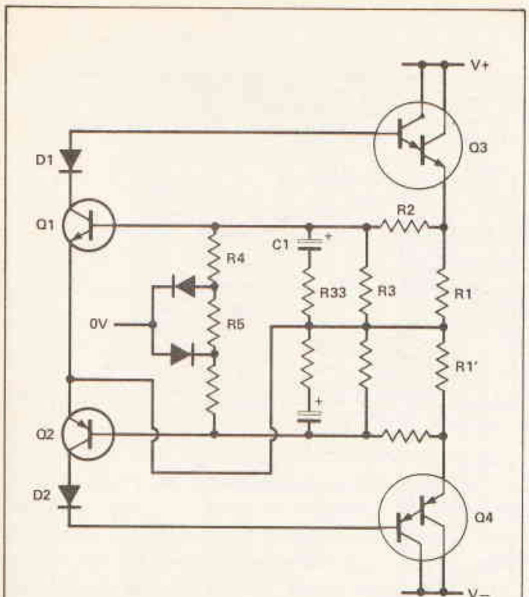
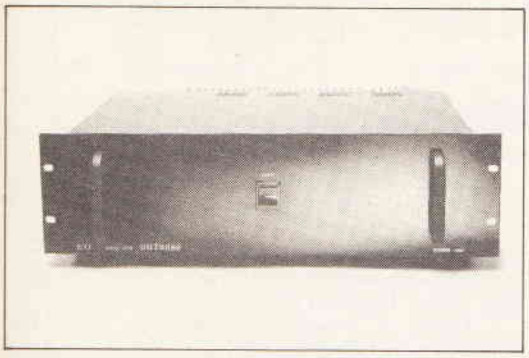


Fig. 7 Output stage protection circuit



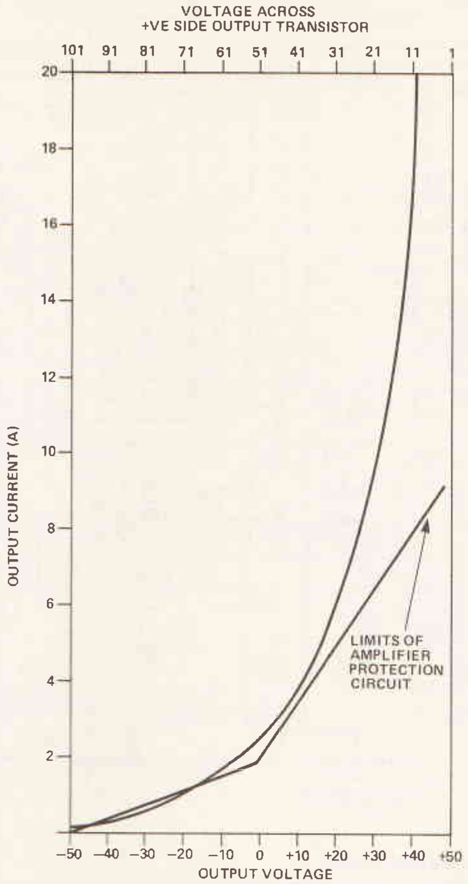


Fig. 8 Characteristics of protection circuit

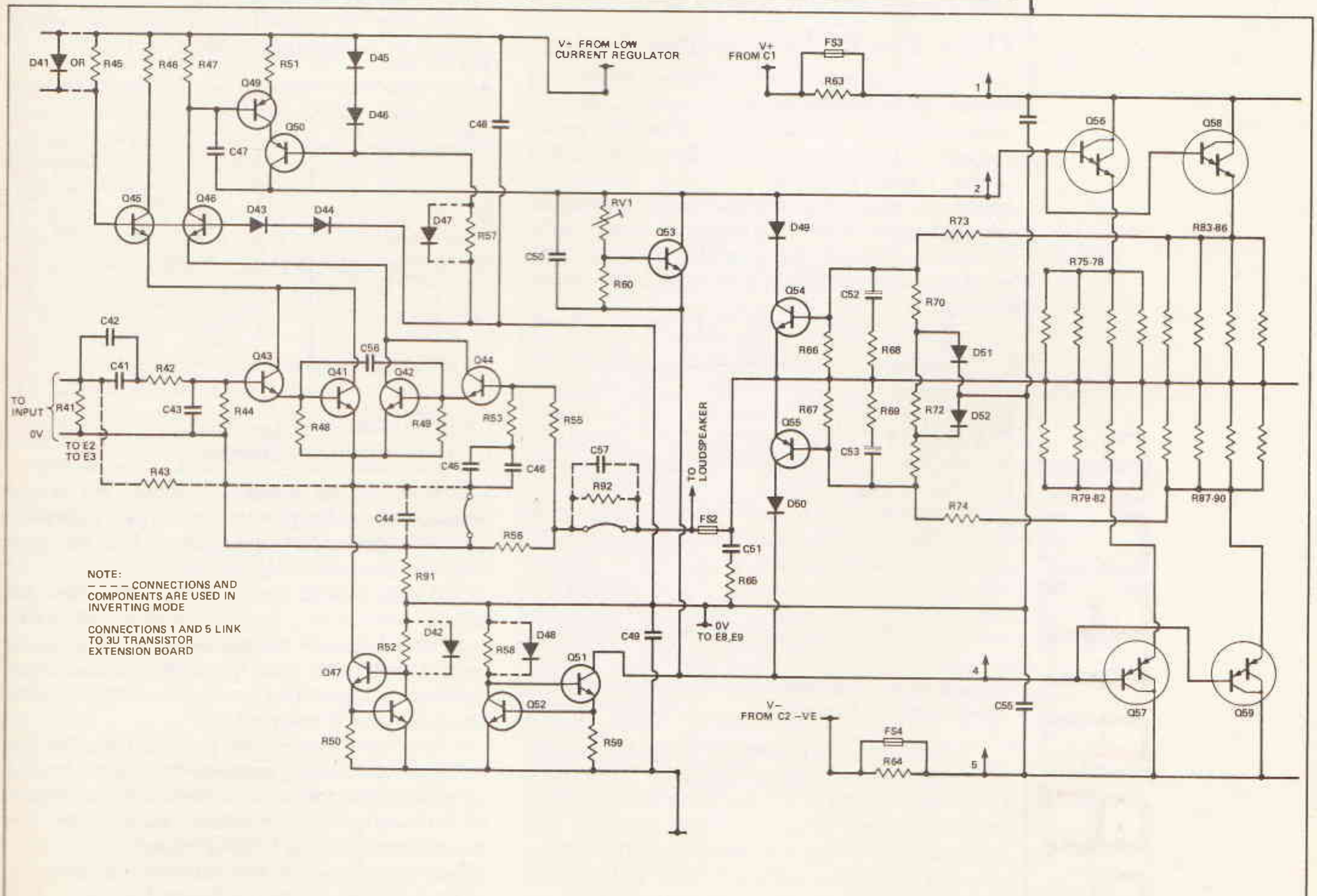


Fig. 6 Complete circuit diagram of amplifier board

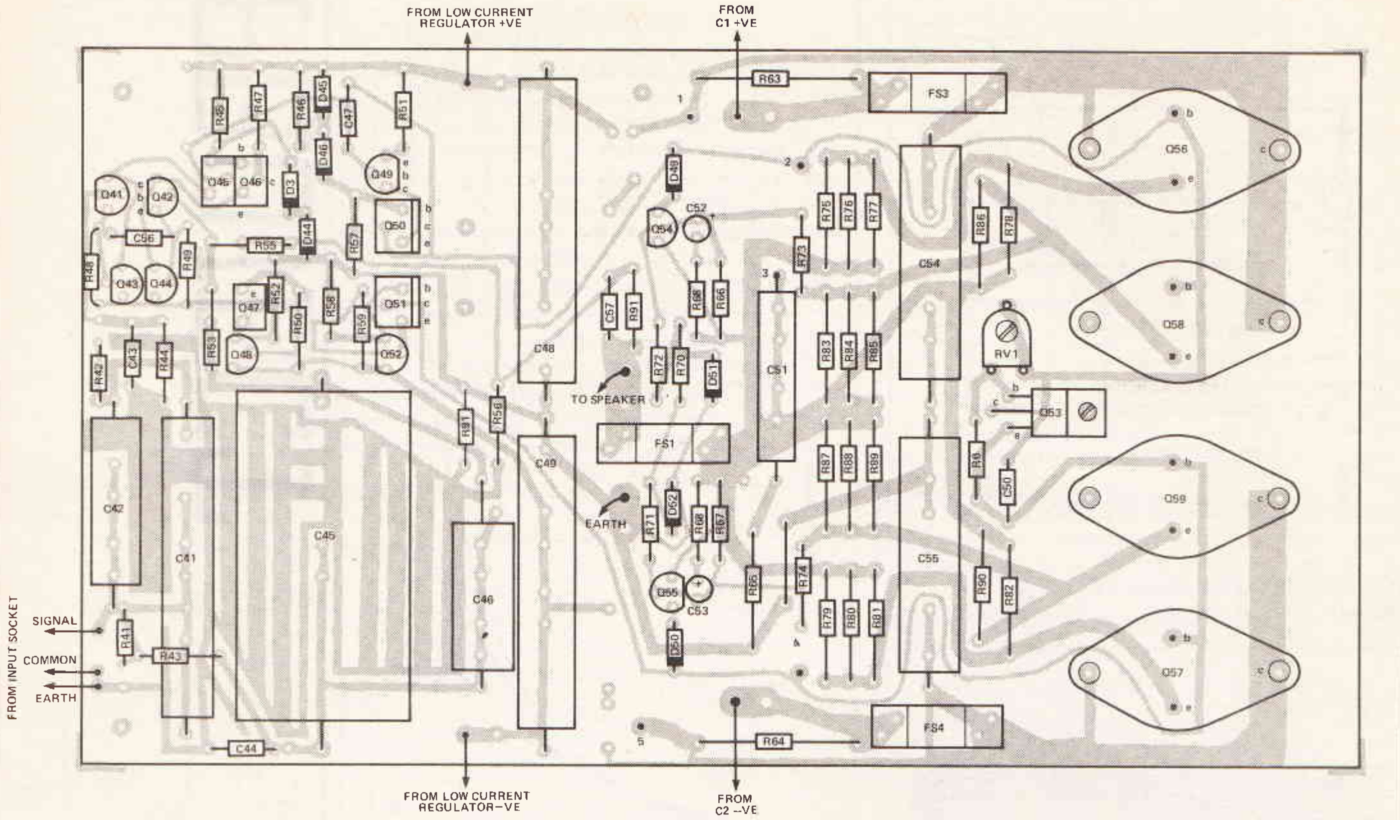


Fig. 14 Component overlay for amplifier board

exceeds the DC safe operating area. Such excursions can *only* be momentary — of the order of milliseconds — and the time constant of R68/C52 and R69/C53 achieves this.

Over The Rickety Bridge

The power output from a bipolar amplifier is limited by its output power transistors. At high collector-emitter voltages, the allowable power dissipation (and current available to drive out of phase loads) is greatly reduced because of secondary breakdown. So even if extra transistors with the necessary voltage rating are connected in parallel, it may not be possible to increase the output power significantly by raising the supply voltage.

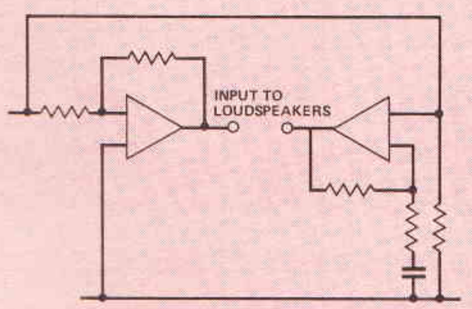


Fig. 9 Bridged amplifier using inverting and non-inverting amplifiers

In such cases it is possible to greatly increase the power driving the loudspeakers by bridging two power amplifiers. This involves simply feeding the audio signal directly to one amplifier and inverted to the second amplifier. The voltage between the two output terminals will be twice that between any one terminal and ground. There are also sonic advantages in that each bridged amplifier has its own power supply so intermodulation effects between channels are eliminated.

Using an inverting amplifier for the audio signal to the second amplifier has sonic drawbacks — this can be avoided by rewiring the second channel in the inverting mode as in Fig. 9.

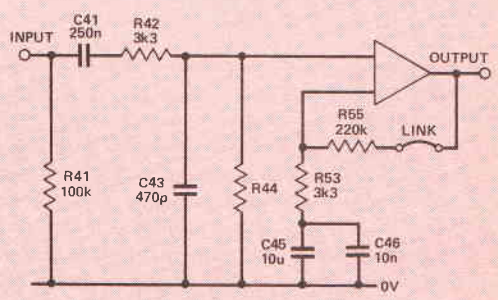


Fig. 10 Components omitted in inverting upgraded amplifier

Bridging the amplifier doubles the output voltage and quadruples the power (the increase is actually slightly less because of the higher current required to drive the loudspeaker).

If you want to double the power output the supply voltage can be decreased to 70% of its original value, with the maximum current output increased to 140%. Thus the output transistors run at lower voltage and secondary breakdown limitations are greatly reduced.

I am not going into great detail regarding building the inverting amplifier as I expect anyone constructing it will have considerable experience of building power amplifiers. Briefly then, the inverting amplifier is built as follows:

- Build exactly as the non-inverting Virtuoso, but leave out all the parts marked in Fig. 10.
- Add the components shown in Fig. 11.

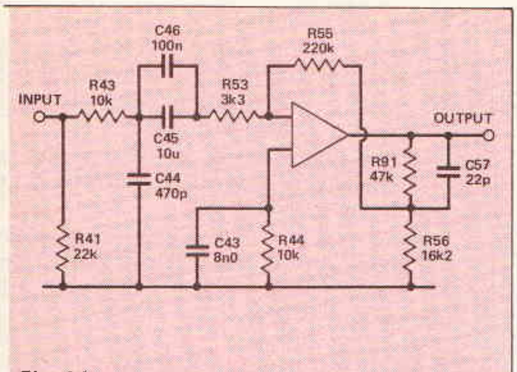


Fig. 11 Additional components in inverted upgraded amplifier

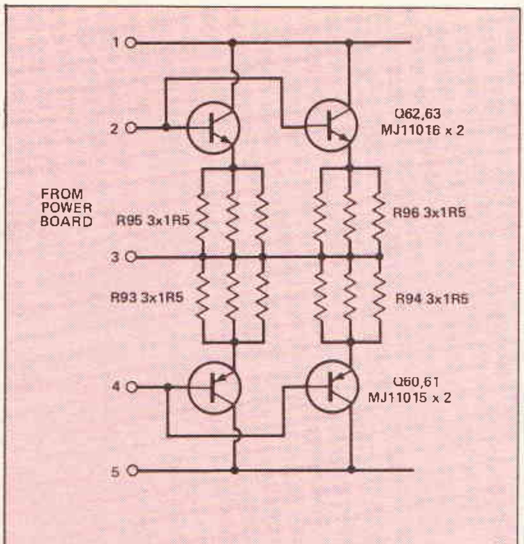
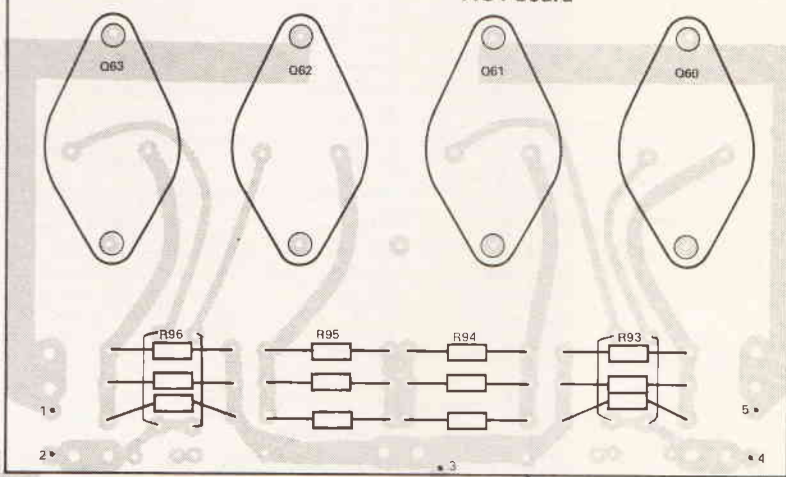


Fig. 12 Circuit diagram of AOT board

Fig. 13 Component overlay for AOT board



If you want to use the bridged Virtuoso into loudspeakers of impedance significantly below 8ohms, you may wish to increase the current capability of the output stage. This can be done using the AOT board (additional output transistors) shown in Fig. 12. The overlay is Fig. 13. Connections are made to the power board as shown in the circuit diagram (Fig. 6) and component overlay (Fig. 14).

Construction

The component overlay for the power amplifier board is shown in Fig. 14.

Unless you are building the inverted version for the bridged amplifier you will not need R43, R54, R56, R91, C44 and C57 (the dotted components from Fig. 6).

Start construction by soldering the PCB pins to the board, including two for the leads from the low current power supply. Next attach the six ¼in blades. The fuses are best installed with the fuse in place, and you may like to solder fuses FS1, FS2 to their cases to improve the contact.

Three wire links are required — one for the earth line near R65, the other two to link across the missing dotted components mentioned above. Then continue mounting diodes D43-46 and D49-52, followed by the lower powered resistors (in the upgrade R45,52,57,58 are replaced by D41,42, 47,48 mounted on transistor pads with flat faces facing the input side of the board). Resistors R75-90 should be mounted so they stand about 2mm off the board so that in the unlikely event of a short or transistor blow, the board will not be burned by a roasting resistor.

Next attach the smaller capacitors C43,47, 51,52,53,57 followed by transistors Q41-44,48, 49,52,54,55 (use transistor pads in the upgraded amplifier for all but Q41, 42).

Transistors Q45-47 are TO126 cases attached to a small aluminium heatsink. Q45,46 have their metal side facing the input side of the board, Q47 the other way. Order of assembly from the input side is ⅜in bolt, bracket, Q47, fibre washer, 6BA nut and bolt, fibre washers, Q45, bracket, Q46, 6BA washer, 6BA nut.

Attach the bracket for Q50,51 with fibre washers underneath and mount the transistors — Q50 is insulated from the bracket by a T0220 insulator.

Now fit RV1 and the main heatsink bracket. The four output transistors Q56-59 are mounted via flexible T03 insulators and the base and emitter pins are inserted through the PCB. Don't solder them in yet. Attach the 6BA×¾in bolts via a washer on the topside of the transistor. Insert an insulating bush from the other side into the PCB, into the metal bracket over the bolt. A 6BA solder tag and

PARTS LIST

	Standard	Upgraded
RESISTORS (¼W 5% unless specified)		
R41	100k metal film	100k Holco H8
R42	3k3 metal film	3k32 Holco H8
R43	used only in inverting amplifier	
R44, 48, 49	220k metal oxide	221k Holco H8
R45	22k metal oxide	see D41
R46, 47	1k0 metal oxide	1k0 Holco H8
R50	330R metal oxide	332R Holco H8
R51	10R metal oxide	10R Holco H8
R52	22K metal oxide	see D42
R53	3k32 Holco H8	3k3 VSRJ bulk foil
R55	221k Holco H8	220k VSRJ bulk foil
R56	used only in inverting amplifier	
R57, 58	10k metal film	see D47, 48
R59	33R metal film	33R2 Holco H8
R60	470R metal film	475R Holco H8
R63, 64	220R 4W w/w	220R 4W w/w
R65	10R 1W metal oxide	10R Holco H2
R66, 67, 68, 69	2k2 metal film	2k2 metal film
R70, 71	2k7 metal film	8k2 metal film
R72	8k2 metal film	22k metal film
R73, 74	150R metal film	470R metal film
R75-78, R79-82, R83-86	0R33 Holco KNA412 3W w/w	each 4 × 1R5 Holco H2

R87-90	1 × 0R33 Holco KNA412 3W w/w	4 × 1R5 Holco H2
R91	10R metal film	10R metal film
R92	used only in inverting amplifier	
RV1	2k2 or 2k5 carbon preset	2k2 cermet preset
CAPACITORS		
C41	470n polyester	250n LCR EXFS/RP
C42	4n7 polystyrene	not used
C43	470p polystyrene	470p LCR EXFS/RP
C44	link across	
C45	10u polycarbonate	10u wonder cap
C46	10n polystyrene	10n LCR EXFS/RP
C47	22p polystyrene	22p silver mica
C48, 49	470n polyester	680n wonder cap
C50	10n polycarbonate	8n LCR EXFS/RP
C51	100n polycarbonate	100n wonder cap
C52, 53	0u47 electrolytic	0u47 electrolytic
C54, 55	1u0 polyester	1u0 siderealkap
C56	100p polystyrene	100p silver mica
C57	link across	
SEMICONDUCTORS		
Q41, 42	2 × BC184C	MAT01GH
Q43, 44	2 × BC184C	MAT01GH
Q45, 46, 47	BD139	BD139-10
Q48, 52, 54	BC184C	BC184C
Q49, 55	BC214C	BC214C
Q50	BD244C	BD244C
Q51, 53	BD243C	BD243C
Q56, 58	MJ11016	MJ11016
Q57, 59	MJ11015	MJ11015
D41, 42	see R45, R52	J507
D43, 44	1N4148	Red LED
D45, 46, 49, 50, 51, 52	1N4148	1N4148
D47, D48	see R57, R58	J511

MISCELLANEOUS

FS1, 2, 3, 4 5A 5×20mm

PCB. PCB pins (5). Vertical PCB ¼in blades and connectors (6). Fuse clips (4). Transistor insulator pads (6) — Silpad 4177 (standard), Silpad K10 (upgrade). T03 bushes (8). T0220 bushes (2). Three brackets (power, driver & input transistors). Nuts, bolts, washers. Upgrade only: 7 transistor pads for D41, 42, 47, 48, Q48, 49, 52.

nut should be attached to the four bolts nearest the end of the board, a washer and nut to the other four (screw them finger tight). Then attach Q53 with a ¾in bolt, small nylon bush, T0220 insulator, bracket, through the PCB to a washer and nut.

Now screw all nine bolts tight and check with a meter for shorts between the transistors and bracket.

Complete the board with C41,42,45,46,48, 49,54,55 (if you are using Wonder Caps in the upgraded amplifier, you can use the offcuts of wire to parallel all the high current tracks).

Solder all the power transistor leads to the PCB and connect the collectors of the T03 transistors by soldering the solder tags to the PCB tracks.

Your power board is now complete!

With the amplifier boards completed, you can fit everything into the case as shown in Fig. 15.

The heatsink brackets are bolted to the sink by two 4BA ⅜in bolts and washers. The boards are bolted to the case with 6BA ¼in bolts.

Internal Wiring

Table 1 shows lengths and colour standards for wiring in the 2U case. High current paths should use 5A cable — some constructors use multi-strand, others prefer single-core.

If you use Kimber cable, use two wires twisted together for high current applications, making sure the direction is correct.

If your reservoir capacitors have screw terminals, connect the wires with insulated crimp terminals rather than solder tags (accidental shorting would be rather unhealthy).

The Trial

Remove FS3 and FS4 from each amplifier board and connect the supply. The 470R resistors between supply and the amplifier (normally bypassed by the fuses) will help prevent serious damage if there is a fault when you switch on. The worst that can happen is that the 470R resistors will get warm.

Before you switch on, turn RV1 on both power amps fully anticlockwise. Now switch on.

If all is well the DC voltages on the high current side should read ±51V (±43V for the bridged amplifier). The low current side should be as they were for the regulator circuit (see May issue). The voltage at the speaker terminals should be less than 50mV.

To make further checks, use a digital meter. The base-emitter voltages of Q41-52 should be 0.5-0.7V. The voltage across each of the diode pairs D43, 44 and D45, 46 should be 1.1-1.2V. If you use red LEDs for D43, 44 the voltage will be 3V — this increases the V_{ce} across Q41-44 enabling them to operate on the more linear part of their characteristics.

Now adjust RV1 clockwise until a voltage of about 20mV can be measured across the output emitter resistors (they may vary slightly). The next test is to check that a signal can be amplified — use a signal generator at the input and scope at the output, or if these tools are not to hand use a preamp and loudspeaker. The sound should be clean at low levels but distort badly above 10W.

If everything seems okay, disconnect the test gear and allow the reservoir capacitors about 10 minutes to discharge. Now insert the fuses FS3 and FS4 on each board (bypassing R63,4) and switch on.

INVERTING AMPLIFIER

Delete R41, 42, 44

Delete C41, 43

R41	22k metal film	22k Holco H8
R43	10k Holco H8	10k Holco H8
R44	10k metal film	10k Holco H8
R56	16k2 Holco H8	15k/16k bulk foil
R91	47k5 Holco H8	47k bulk foil
C43	4n7 polystyrene	8n0 LCR EXFS/RP
C44	470p polystrene	470p LCR EXFS/RP
C57	22p polystyrene	22p LCR FSC/P

EXTRA OUTPUT STAGE

R93,94,95,96,	0.47R Holco KNA412	3×1R5 Holco H2
Q60, 61	MJ11015	MJ11015
Q62, 63	MJ11016	MJ11016

T03 transistor pads (4) — Silpad 4177 (standard), Silpad K10 (upgrade). Transistor bushes (8).

PROJECT

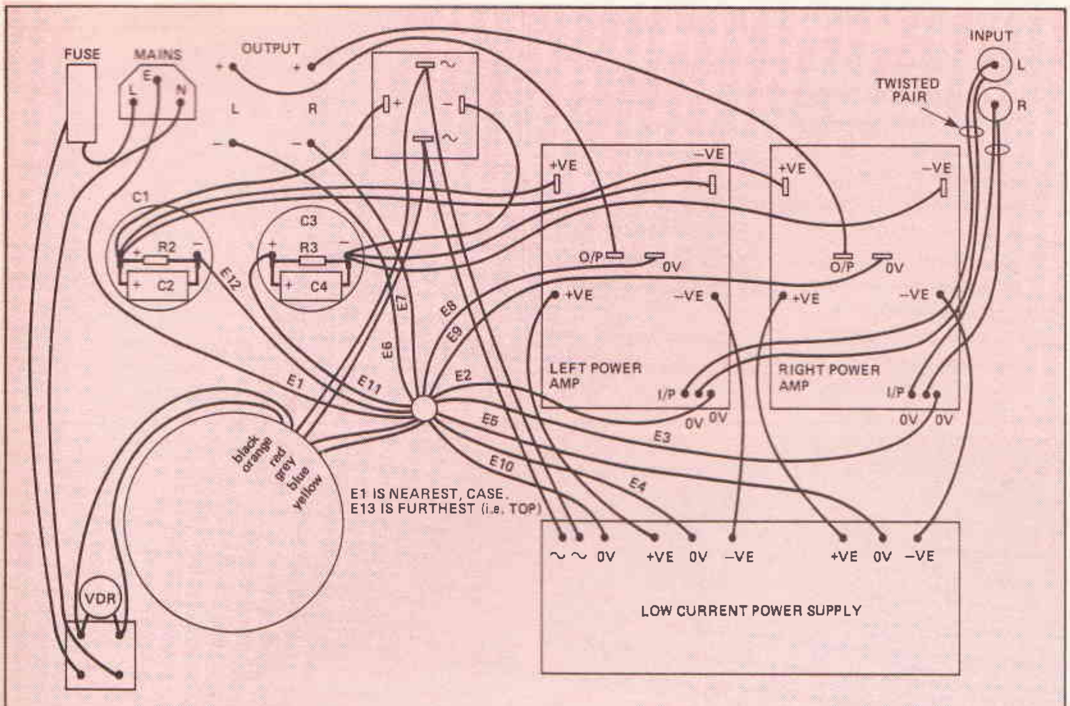
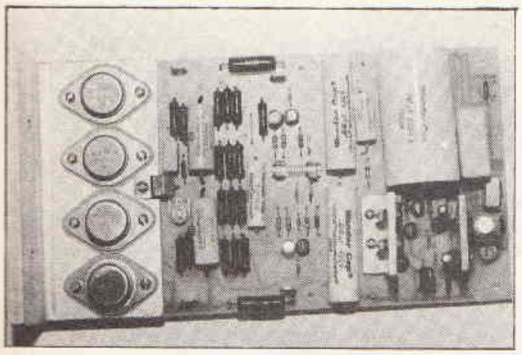
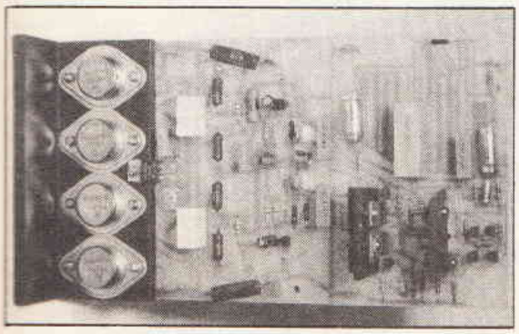


Fig. 15 Wiring diagram for 2U case

If there are no signs of distress you can now couple the amplifier to your other equipment. A precaution I always observe is to connect only the earth side of the speakers to the amplifier before switching on. Then touch the signal lead to the terminal and if the music is coming through then connect it. With the upgraded version make sure the wire or plug doesn't short across the speaker terminals.

Then fetch the port and cheese, sink into your armchair and enjoy the wonderful sound. ETI





Application	Length (cm)	Colour Standard	Colour Upgraded
Earth E1 to Mains Skt	17	Green	Black
L amp signal to earth E2	20	Green	Black
R amp signal to earth E3	32	Green	Black
L reg board to earth E4	29	Green	Black
R reg board earth E5	20	Green	Black
E6 to L speaker	15 + 15	Green	Black
E7 to R speaker	14 + 14	Green	Black
L amp to E8	14	Green	Black
R amp to E9	27	Green	Black
E10 to regulator	13	Green	Black
E11 to C3 +	12 + 12	Green	Black
E12 to C1 −	13 + 13	Green	Black
Mains input L to fuseholder	10	Brown	Red
Fuseholder to mains switch	29	Brown	Red
Mains input N to mains switch	30	Blue	Red
Bridge rect ac to low current reg	23	Brown	Red
Bridge rect ac to low current reg	25	Brown	Red
Low current reg to L amp +	17	Brown	Red
Low Current Reg to L amp −	11	Black	Blue
Low current reg to R amp +	14	Brown	Red
Low current reg to R amp −	9	Black	Blue
Bridge rect + to C1 +	11 + 11	Red	Red
Bridge rect − to C3−	8 + 8	Black	Blue
C1+ to L amp +	15 + 15	Red	Red
C1+ to R amp +	24 + 24	Red	Red
C3− to L amp −	16 + 16	Black	Blue
C3− to R amp −	29 + 29	Black	Blue
L input to L amp Ov	36	Green	Black
L input to L amp signal	36	Red	Blue
R input to R amp Ov	22	Green	Black
R input to R amp signal	22	Red	Red
L amp to L speaker	23 + 23	Red	Blue
R amp to R speaker	32 + 32	Red	Red

TOTAL WIRE LENGTHS

Standard amp	1A	5A	Upgraded amp	Kimber
Green	2.13m	71cm	Black	3.38m
Brown	79cm	39cm	Blue	2.08m
Blue	—	30cm	Red	3.34m
Black	20cm	53cm		
Red	58cm	1.06m		

Table 1 Wirelengths for 2U case

OOPS!

In part one of the Virtuoso in April, capacitors C2 and C3 should be transposed in Fig. 5 (P28). The diagrams for Figs. 6 and 7 should also be exchanged.

BUYLINES

All components for the Virtuoso Power Amplifier are available from Audiokits Precision Components, 6 Mill Close, Borrowash, Derby DE7 3GU. Tel: (0332) 674929.

Audiokits also supply the complete kit for all versions of the amplifier and a full price list of both kits and components can be obtained by sending a large SAE.

UPGRADING THE PREAMPLIFIER

Since I designed the Virtuoso Pre-amplifier (ETI June-November 1986) new components have become available which enable constructors to further improve the sound quality as follows:

- Upgrade the 1N4002 diodes to UF4002 fast recovery diodes — or (better still) to schottky 11DQ4s.
- Upgrade all polycarbonate capacitors to Audiocap polypropylene capacitors (from Audiokits — see Buylines).
- Replace all resistors to bulk metal foil type — especially cartridge loading, RIAA equalisation and negative feedback resistors.
- Upgrade the volume control to a goldplated switched attenuator with Holco or (better) bulk foil resistors.
- Use Kimber cable for all internal cabling. Where screened cable is required use Van den Hull D502.
- Replace the mains transformer with a higher power version in a remote box.

The summed effect of these improvements is to extend the sonic performance of the pre-amp still further, making it a worthy match for the highest grade Virtuoso Power Amplifier.

PROJECT

OPEN CHANNEL

In case you're not aware of it (I wasn't!) the UK is ahead of Europe in at least one aspect of telecommunications. Our existing telecoms watchdog regulatory body, Oftel, is the only one of its kind in Europe. Since our telecoms deregulation programme started a few years ago, the powers of the main telecommunications provider, British Telecom, have been somewhat restricted and Oftel was set up to observe its operations to ensure that BT did not remain in control of its previous monopolising powers.

Going Regular

Effectively, this prevented BT from being a *regulatory* body, one of its previous roles. Instead it is (or should be) purely a provider.

Remarkably, the UK is the only country to have gone down that path in Europe so far. Others will soon be following suit. A ruling by the European Commission expected shortly will force other countries to prevent existing telecommunications regulatory bodies from being telecommunications providers too.Separate organisations, like Oftel in the UK, will have to be set up by the respective governments to ensure this is the case.

This is all part of the recent moves by the European Commission to ensure the total European telecommunications market becomes deregulated, in much the same way that the UK's is. The Commission's idea is that the market will be completely open to all member countries by 1992. Also, the market will become open to foreign traders, with companies such as BT and Plessey able to sell into Europe on a much greater scale than they can do now. Of course, in return, European manufacturers will sell into the UK more than they do now, too. So it'll be swings and roundabouts for a time.

Free Access

One exception to free access within all countries' networks (as is the case in the UK) is that the prime equipment (the master socket) will remain within the control of the network provider. I've voiced my opinion of that in the past and I'll do it again. If that is the case and I've no real objection against the principle, there should be no charge for the fitting of the socket.

A telecommunications network provider is much the same as any mains services provider (gas, electricity, water) in that if the provider wishes the customer to use its service, connection to that service should not be charged to the customer. The customer should be charged for the service itself — making a 'phone call, using electricity, burning gas — but the connection of the gas meter, electricity meter, water meter, master socket, should be the responsibility of the service provider. Perhaps if I say it often enough, Iain Vallance and/or Professor Carsberg will hear me?

After all in the current position, a customer having a master socket fitted is charged for the pleasure and is then *not allowed to touch the socket* other than plugging in approved equipment. That is wrong and unfair.

Where's the Old Telly?

GEC has started operation of its private mobile radio (PMR) network, *National One,* which will use frequencies previously allocated to the old 405-line black-and-white broadcast television service (known as Band III). Can anyone remember it? That was the one with all the snow — and every time a car or bus went past outside, it looked as if the car or bus was going past inside. Hopefully, Band III PMR will be a bit better reception-wise than that!

The GEC network is one of two national Band III operators, the other — a Philips-led consortium called *Band Three Radio* (inventive name, eh?) began service in October of last year, although only 1000 or so users have so far signed up.

There have been two major problems with Band III PMR hence the apparent long delays. The first has been the inevitable wait for usable and approved equipment. This wasn't a fault of the equipment manufacturers. Anybody who is anybody in the radio world such as Motorola, Storno, GEC, Marconi, Tait and Key Radio (a New Zealand based company, gearing up to UK manufacturing) can turn out a new radio transceiver in the passing of a specification.

The fault is the second problem. There has been no specification. The relevant MPT13 standards were only released in February, so any operating prior to this (Band Three Radio) were jumping the gun a little by running a service. However, I suppose Band Three Radio gambled that the expertise gained by starting a network early would give it a favourable position in the race to sell the system afterwards. It'll be interesting to see how they fare after a couple of years when accurate figures of customers are known.

Keith Brindley

CABLE & SATELLITE TV SHOW

Wembley, I suppose, is a reasonable venue for an exhibition of this stature. As exhibitions go, the Cable and Satellite Exhibition isn't large. There again, this year's offerings were a considerable improvement on last year's. If things keep on like this exhibitors are going to be a little crowded in the years to come. Current growth of the industry is such that by around 1990, I reckon Wembley will not be able to stage it.

In many respects this is a good thing. It shows that cable and, particularly satellite TV is finally taking off in the UK. On the other hand, the industry is going to lose a lot of its current friendliness which was evident in the good natured atmosphere at this show. Still, you can't have everything.

Alongside the exhibition, Wembley Conference Centre housed a two-day conference on allied topics, addressing important debates regarding encryption and standards. Representatives from British Satellite Broadcasting, SES (the Astra people), IBA, BT, Eutelsat and others spoke about the future of satellite TV and how it will affect us.

As far as the exhibitors (around 90 of them) were concerned, all the big manufacturing names were there, most of them showing latest developments in equipment. New products particularly eye-catching included the Micro Eye SBR 2050 satellite receiver from BEL-Tronics. Among other things it features a 96-channel memory, synthesised audio tuning and selectable de-emphasis. Unlike existing Micro Eye receivers, the SBR 2050 is intended for more of a mass-market, with a price to suit.

Newcomer to satellite television, Pace was there, with the SR640 receiver (see ETI April issue for a comprehensive review) making quite an impression on the stand.

Salora was showing details about the new receiver, the XLE. Salora and its sister company Luxor, by the way, are major backers of the D2-MAC standard. They are members of the Euromac consortium, together with Thomson, ITT, Logica and Philips, which has been formed with the express aim of convincing all parties concerned with European satellite television that it's the D2-MAC transmission standard we should be looking at, not the D-MAC standard. Although no names were specifically mentioned, the Euromac argument is undoubtedly aimed at the decision by British Satellite Broadcasting to use the D-MAC standard.

Nobody from Euromac would deny that D-MAC is technically a better standard than D2-MAC in its features and facilities. The argument is purely that the D2-MAC standard already exists, so why go to the bother and cost of having to develop a new standard, purely for the British market. The cost of any extra development work has ultimately to be borne by the consumer anyway.

Euromac's impressive stand (organised and staffed by Philips) was set up to show that D2-MAC STV is already in existence. Working D2-MAC receivers from Philips were on show and a number of demonstrations of such niceties as compact disc quality multi-language transmissions and conditional access scrambling were on the stand. In the light of the opposition, BSB may be forced to take a second look at its D-MAC decision.

Of course, it's not only BSB which is against D2-MAC. Most of the existing programme providers are fairly well committed to D-MAC. A number of programme dividers had stands, including MTV, Sky Channel, Premiere, CNN, The Children's Channel, Screensport and Lifestyle. Premiere, interestingly, doesn't class itself as a satellite provider — instead it is purely a cable programme provider, albeit transmitting its signals to the cable head-end systems via satellite link. The distinction is important for film distribution and hence copyright payment reasons. Generally, all providers were happy to give information regarding current and future programmes available on their channels.

Last, but certainly not the least interesting, were the Eutelstat and SES stands. Noticeable by its absence was an input from Intelstat. This would have given consumers and trade alike a forum to see all three satellite providers. Eutelsat was going all out to impress visitors to the stand, showing a 'live' demonstration of all 16 television channels which it currently transmits from its three operational communication satellites. Also featured was a display to promote the next generation of satellites — Eutelsat II. These will have transponders of around two and a half times the power of the current Eutelsat I satellites, which will make them around the same power as SES's Astra satellite transponders.

The difference between Eutelsat II satellites and Astra is that Astra is planned to be up by the end of this year. Eutelsat II satellites are at least three years away. On the other hand, Eutelsat I satellites are already up there, so who's arguing?

Here, at least, the D2-MAC/D-MAC argument was of little consequence. Both Astra and Eutelsat have no bias one way or the other. They'll transmit whatever the programme providers want to transmit, in whatever standard, format or language.

The Cable and Satellite industry is still relatively a baby compared with other parts of the consumer electronics market but this year's Cable and Satellite Exhibition and Conference showed the industry is moving past teething problems and is beginning to walk unaided. If everything (satellite launches, product availability, etc) goes as planned, this year will see the industry really finding its voice.

Keith Brindley

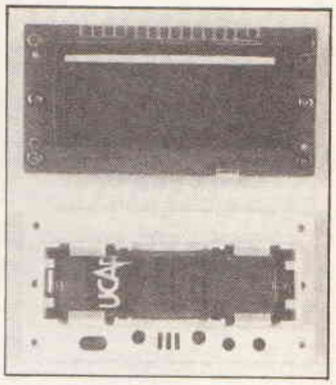
ONCE OVER

In these days of mass produced high tech, it sometimes seems there is little room left for the home constructor. However, sometimes the tables are turned with mass production doing the hobbyist a favour.

Maplin Modules

The subject in question is temperature measurement. Maplin has been selling a range of temperature display modules for a while now so we thought it about time we took a look.

There are two modules on the menu — the straight 'temperature module' and the 'min/max' temperature module. These are pretty similar in many respects and cost £5.95 and £7.50 respectively. The straightforward module has a 12



hour clock built in (for good measure) and the min/max module has memories for the minimum and maximum temperatures reached since the last reset. The other functions are the same and it is the simple module we'll look at here.

First, it is tiny! The sparse circuit board holds just one custom chip bonded directly to the PCB. The whole unit measures only 68×35×24mm — and most of that is battery. A single HP7 battery is used which clips into the moulded holder on the back of the module. This can be removed with six screws to use an external 5V supply although the power consumption is miniscule and the battery should last a year or so.

The display is an extremely clear LCD. As far as I can tell this is a non-multiplexed display and so it is very visible from all reasonable angles. The temperature is given in ½in high figures to one decimal place.

The module can manage a temperature range of about -20° to 70°C with a quoted accuracy of around ±1°C, although this seemed a little far off the truth when comparing with a mercury/glass thermometer.

The display is updated every 10s but this can be altered to every 1s with a connection on the 16-way edge connector.

These connections are also used to select between Centigrade and Fahrenheit display, clock/temperature display and to set the high and low alarm points.

Both Maplin modules have alterable stored over-temperature and under-temperature points which, when reached, produce a 4kHz alarm tone on one edge connection and swing high one of two connections depending whether it is a high or low alarm.

Simple connection of a piezo buzzer or relay with 1-transistor buffering turns the module into a high tech temperature alarm or thermostat.

As if that wasn't enough for your money, the modules have a digital temperature data output too. This is a serial TTL output with the temperature in BCD format along with a clock pulse on another pin.

It is simple enough to rig a shift register to convert to serial output or the stream can easily be read directly into a micro system using interrupts. I tried the latter on my BBC micro with wonderful results.

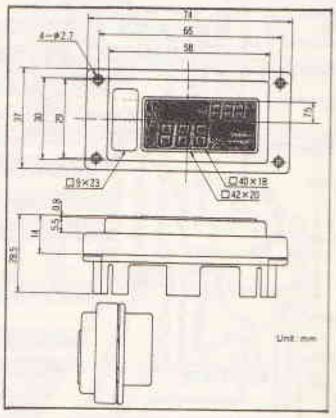
For useful control applications an external sensor is available for £2 which simply solders onto the PCB in place of the existing one.

The Maplin modules really do show what can be done with custom LSI produced in large quantities. There is no way a home built unit like this could be produced for anything like the price. However, at the same time the modules are eminently useful for incorporating into your own projects.

It's The Humidity

When someone next to you says "It's not the heat, it's the humidity," (not that they're likely to in this country) you can put them straight onto the right track with another module, this time from Solex.

The HT-50 appears in many ways like Maplin's temperature modules. Its functions are similar too. However, this little darling can measure humidity as well. Is there no end to the ingenuity of those clever folk in Hong Kong?



The HT-150 is much the same size as the Maplin jobs but has a smaller display with a little grill to the left of it. This is where the air goes in for humidity testing.

The humidity is displayed by ⅓in figures as a percentage relative value with an accuracy of 0.1%. There are many ways of measuring humidity and although I don't know which one is used here, none of them achieve accurate results easily.

The HT-150 also shows the temperature (°C only) on the same display in smaller figures. The humidity and the temperature are both sampled every two seconds but the humidity sensor can take up to two minutes to respond.

Again, high and low alarm points for both temperature and humidity are provided and this module also has maximum and minimum memory.

A serial data output along the same lines as the Maplin modules carries both temperature and humidity data with different timing pins to separate the two.

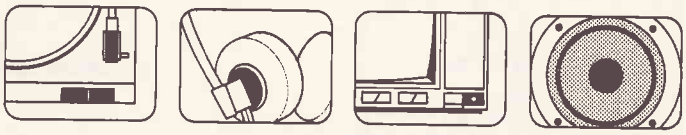
The HT-150 really provides a remarkable number of functions in a very small space. There are just two problem areas. First is the power. Four ½A sized batteries are used. These are not only relatively difficult and expensive to buy but they only last 40 days. An external power supply is a must with this one.

The second problem is the price — £46. Now that is a lot compared to the under-a-tenner Maplin modules but then this is doing a lot more and humidity sensors are not cheap.

Both the Solex and Maplin modules are remarkable pieces of oriental engineering. Designing and building complex control equipment with these becomes a doddle. It's good to see homemade projects getting the chance to use professional building blocks like these.

Malcolm Brown

PLAYBACK



With the advent of colour television broadcasts, the picture quality available on a normal domestic television has declined. This may seem a surprising statement, so I will explain it.

Illuminating

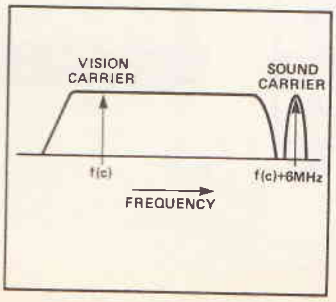
The luminance information, which comprised the entire video signal in the days of black and white, is transmitted with a bandwidth of 5.25MHz. The sound is transmitted on a subcarrier 6MHz away from the vision carrier and the lower sideband of the video information is filtered out at the transmitter, so that the video signal is effectively single sideband at higher video frequencies. All this produces a transmitted signal spectrum as shown in the figure.

To avoid the sound interfering with the picture, most black and white televisions filtered out the last bit of the video information and made use of just under 5MHz of video. In terms of picture resolution, a monochrome television could give a resolution of up to 400 lines. This means that a series of vertical lines could just be distinguished from one another if 400 were evenly spaced over the whole linewidth. The transmitted linewidth is of course greater than what is displayed on the screen which varies from television set to television set, while the transmitted linewidth is constant.

The Real Res

So with a 625 line monochrome transmission, the vertical resolution on the screen might be 550 lines and the horizontal resolution onscreen might be 380 lines. This in itself seems out of proportion, when you consider that the television screen is wider than it is high and so should have over 600 lines of horizontal resolution to match the vertical resolution.

The use of colour makes this much worse. The colour information is transmitted on a subcarrier 4.43333MHz from the main carrier. The reason for this obscure frequency is to interleave the luminance and chrominance sidebands, which will both have peaks at multiples of line frequency (a picture with the same information on each line would have all sideband energy at multiples of line frequency).



Since sidebands are relative to the carrier on which the modulation is imposed, the fact that the colour subcarrier is set half way between two peaks of luminance sideband energy sets the main chroma sideband peaks between the luminance peaks.

Be A PAL

This, of course, makes it easy to separate the majority of the chroma and luminance signals and retain most of the picture definition. All that is needed is a comb filter with the 'teeth' spaced at line frequency multiples (15625Hz), obtained by using a line store, isn't it? Of course not. The PAL television system used in the UK has a further complication — the subcarrier phase reversal for every line which keeps the colours realistic even over a bad transmission path.

Storing Fields

A line store based filter will not separate the sidebands and at least a field store is needed for a fudge solution, or a frame store for a completely 'pure' design.

The result of all this is that the normal television set simply filters off all the luminance information which is interleaved with chrominance information, and typically uses a video bandwidth of 3.5-4MHz. The horizontal resolution is up to about 340 lines, though not all sets manage this.

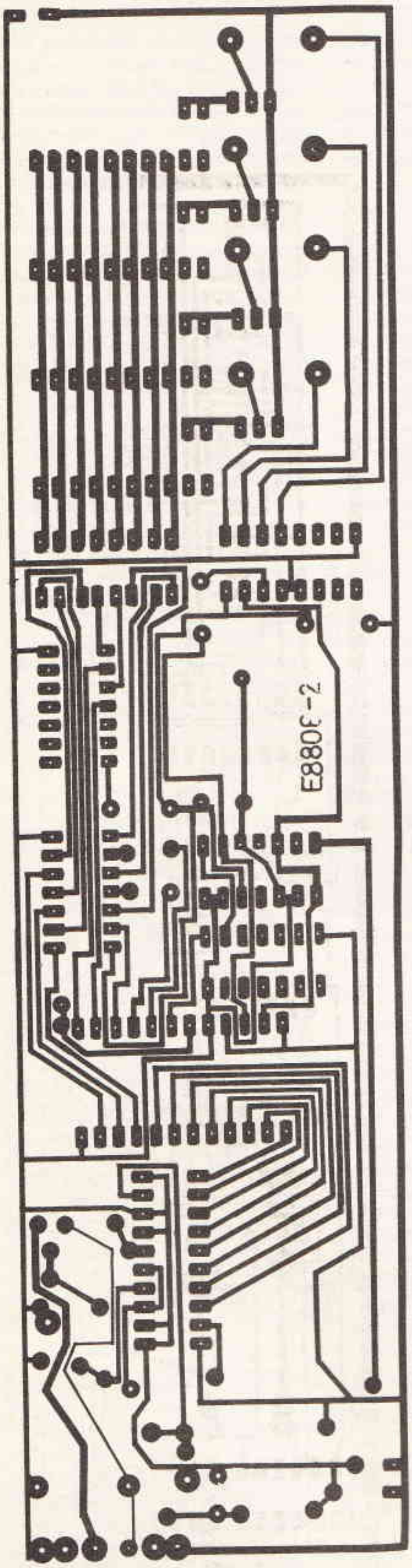
It is this poor resolution which renders VHS video recorders viable. Their 250 lines resolution does not look too bad compared with the picture quality off air. However, at least one TV manufacturer offers a set with a frame store built in and others will follow.

Quality To Come

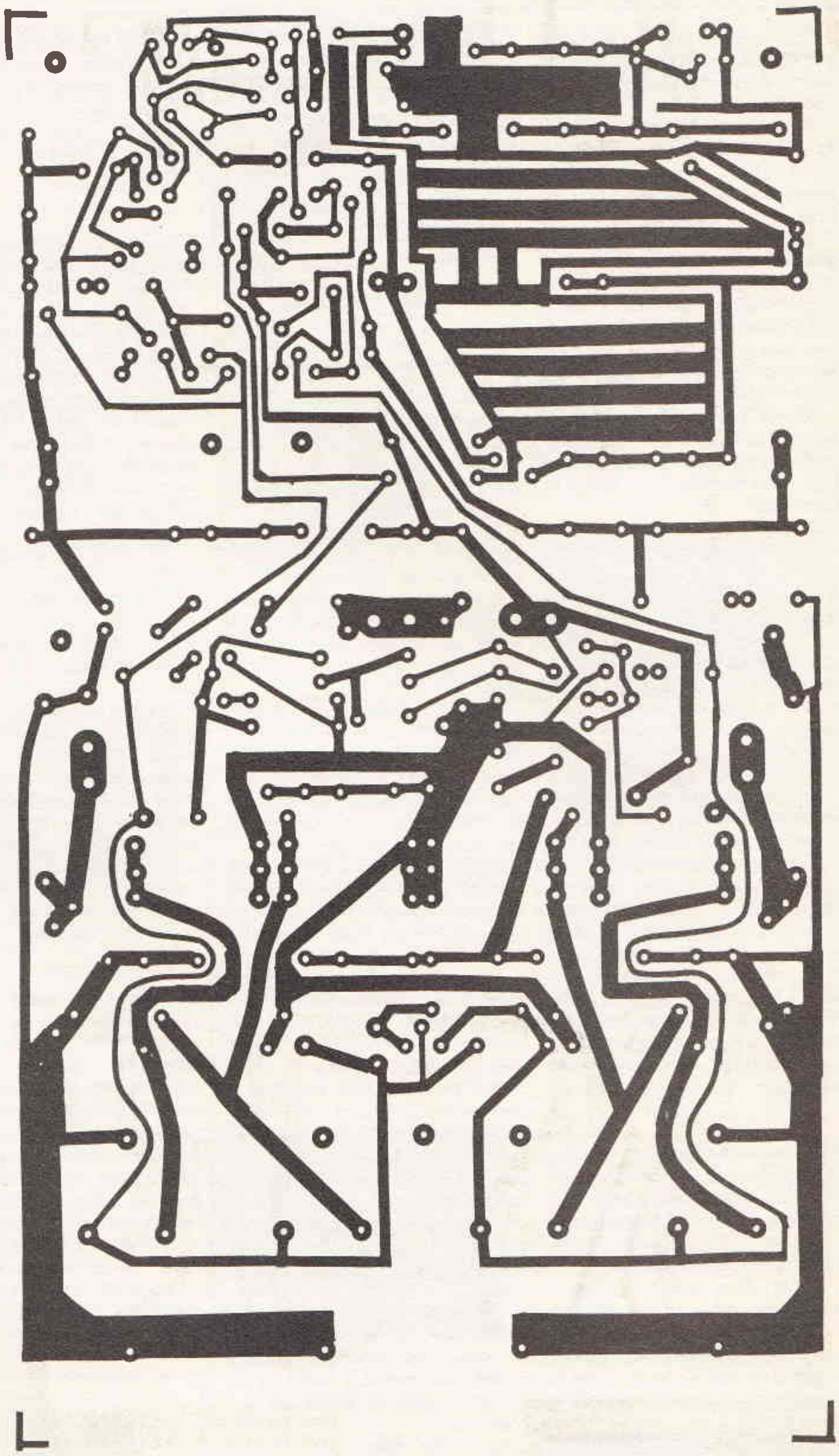
It is not clear from the advertising whether the frame store is used to improve the luminance friendship but surely this facility will soon be available. With top quality modern SAW filters to separate sound and vision information and a frame store separator for luminance and chrominance, it is possible that a resolution of 500 lines could be achieved. This would make VHS video recorders look pathetic by comparison.

Andrew Armstrong

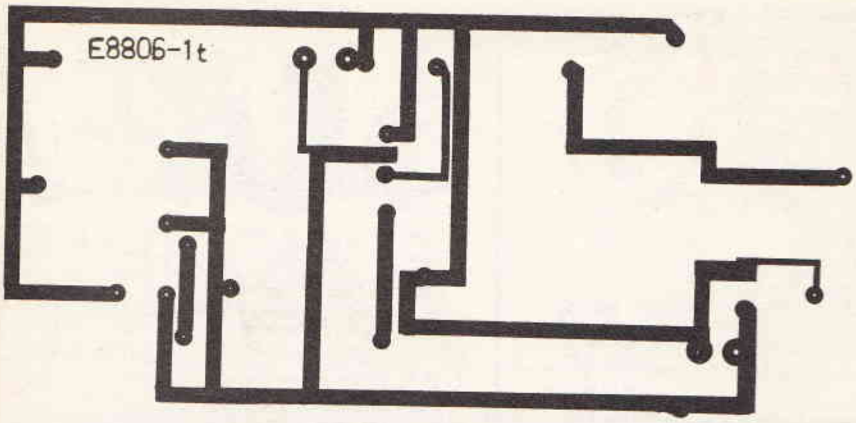
PCB FOIL PATTERNS



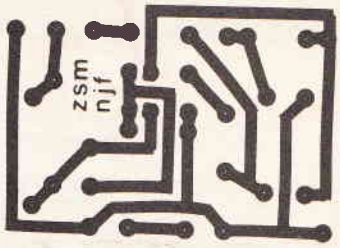
The universal bar graph panel meter foil



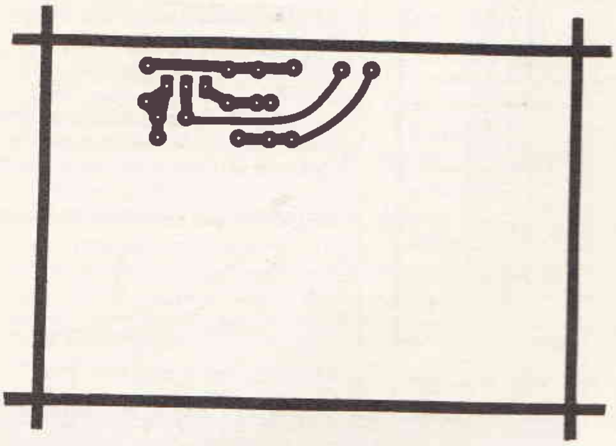
Virtuoso power amp board



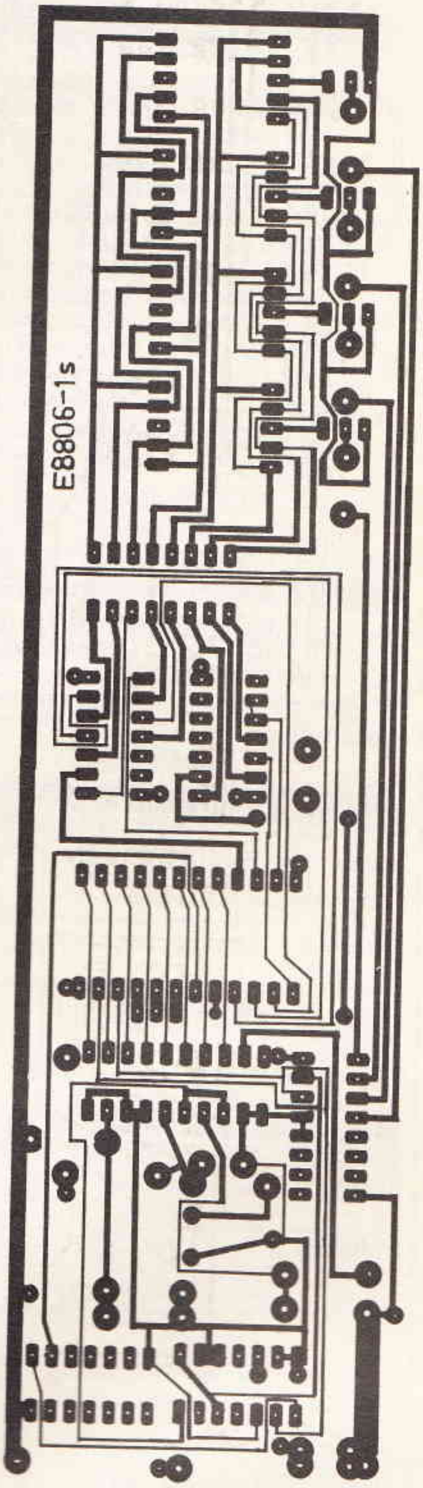
The universal digital panel meter topside foil

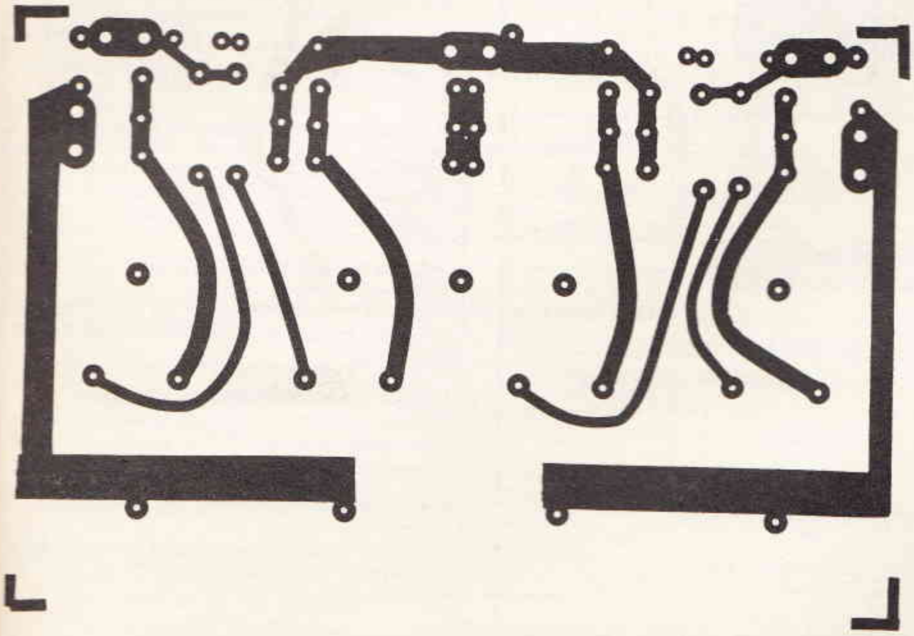


Bicycle dynamo backup foil



First Class metal detector PCB





Virtuoso additional output transistor board

The universal digital panel meter solderside foil

ETI PCB SERVICE

E8802-1 Electric Fencer	E	£3.25
E8802-2 Telephone Intercom	L	£8.80
E8802-2 Transistor Tester (2 bds)	L	£8.80
E8802-4 Spectrum Co-processor CPU board	N	£13.10
E8803-1 Spectrum Co-processor RAM board	N	£13.10
E8803-2 Beeb-Scope (3 bds)	O	£15.80
E8803-3 Jumping Jack Flash	E	£3.25
E8804-1 Spectrum Co-processor Interface Board	N	£13.10
E8804-2 Combo-lock	E	£3.25
E8804-3 Kitchen Timer	E	£3.25
E8805-1 Virtuoso 2U PSU	M	£10.60
E8805-2 Virtuoso 3U PSU	N	£13.10
E8805-3 Bicycle Speedometer	F	£4.00
E8805-4 Dynamic Noise Reduction	E	£3.25
E8806-1 Universal digit panel meter	L	£8.80
E8806-2 Universal bar graph panel meter	K	£7.20
E8806-3 Virtuoso power amp board	N	£13.10
E8806-4 Virtuoso AOT board	G	£4.75
E8806-5 Metal detector	E	£3.25
E8806-6 Bicycle dynamo backup	D	£2.50

A complete list of all boards (back to ETI 1981) is available on receipt of a large SAE.

TO: ETI READERS' SERVICES DEPARTMENT
Argus Specialist Publications Ltd,
9 Hall Road, Hemel Hempstead,
Herts HP2 7BH

Please supply:

No. required per type	Board reference number	Price letter	Price each	Total for board type
	E -		£ . p	£ . p
	E -		£ . p	£ . p
	E -		£ . p	£ . p
	E -		£ . p	£ . p

POSTAGE & PACKING £ 0.75p

TOTAL ENCLOSED £ . p

ORDER TO BE SENT TO: (BLOCK CAPS PLEASE)

Name ....

Address ....

....

....

Postcode ....

(Make cheques payable to ASP Ltd)
ACCESS and VISA credit card orders can be taken on (0442) 41221 (office hours only).

OOPS!

MIDI Master Keyboard (June 1987)
In Fig. 3 and the Parts List there is some confusion as to the correct part numbers for some ICs. These should be: IC17 — 2764, IC18 — 6522, IC10, 21 — 74LS32.

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 Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Transistor Tester (February 1988)
The foil pattern for the main board was printed reversed left-right on the foil pages.

ETI ELECTRONICS TODAY INTERNATIONAL

CLASSIFIED

01-437 0699 Ext 291
Send your requirements to:
Heather Wust, ETI Classified Department,
ASP Ltd., 1 Golden Square, London W1R 3AB.

Lineage: 44p (VAT excl) per word (minimum 15 words)
Semi Display: (minimum 2 cms)
£12.20 per single column centimetre + VAT
Ring for information on series bookings/discounts – and recruitment advertisement rates.
All advertisements in this section must be prepaid.
Advertisements are accepted subject to the terms and conditions printed on the advertisement rate car (available on request)

COURSES

Start training now for the following courses. Send for our brochure — without obligation or Telephone us on

REF: ETI/4/88 **06267 79398**

NAME ____________

☐ City & Guilds Exam 271
☐ Radio Amateur Licence
☐ Micro-processor
☐ Introduction to Television

Radio & Telecommunications Correspondence School, 12, Moor View Drive, Teignmouth, Devon. TQ14 9UN.

MAKE YOUR INTERESTS PAY!

More than 8 million students throughotu the world have found it worth their while! An ICS home-study course can help you get a better job, make more money and have more fun out of life! ICS has over 90 years experience in home-study courses and is the largest correspondence school in the world. You learn at your own pace, when and where you want under the guidance of expert 'personal' tutors. Find out how we can help YOU. Post or phone today for your FREE **INFORMATION PACK** on the course of your choice.
(Tick one box only!)

Electronics ☐	Radio, Audio and TV Servicing ☐
Basic Electronic Engineering (City & Guilds) ☐	Radio Amateur Licence Exam (City & Guilds) ☐
Electrical Engineering ☐	Car Mechanics ☐
Electrical Contracting/ Installation ☐	Computer Programming ☐
GCE over 40 'O' and 'A' level subjects ☐	

ICS
Name ____________
Address ____________ P. Code ______
International Correspondence Schools, 312/314 High St., Sutton, Surrey SM1 1PR.
Tel: 01-643 9568 or 041-221 2926 (24 hrs.) Dept EBS58

COMPONENTS

T-systems ltd
COMPUTER SYSTEMS AND COMPONENTS

Min. toggle switch, on/off	60p
Min. toggle switch, single pole, changeover	69p
Min. toggle switch, as above with centre off	75p
Min. toggle switch, double pole, changeover	80p
Min. toggle switch, as above with centre off	89p
Slide switch, double pole, changeover	25p
Slide switch, as above with centre off	29p
LED's, 3 or 5mm, red, green or amber/yellow	10p
Bulb, 12V, 3mm, red, green, amber or clear	22p
Resistors, 0.25 watt, 5% E12 series	2p
DIN plug or socket, 5, 6 or 7 pin	25p
25 way D plug, socket or shell	85p

★ Prices include VAT, add 25p P&P if under £2. Cheques payable to T-systems Ltd. ★

T-systems Ltd.
The Signal Cabin, 61 High Street, Orpington, Kent BR6 0JF
★ ACCESS Card sales accepted on Tel: 0689 22196 ★

SWITCHES

VOICE/SOUND ACTIVATED SWITCHES easy to follow diagrams and uses only £1.00. Components and P.C.B's available: **Herrington, 63 Home Farm Rd, Hanwell, London W7 1NL.**

KITS

MICRO TRANSMITTER KIT, 500m Range, tunable 88-115MHz, sensitive microphone, £3.95. Cheques/PO's to Quantek Ltd., (ETI), 267 Rednal Road, Kings Norton, Birmingham B38 8EB.

PLANS AND DESIGNS

Design and build your own electronic dashboard
Plans, instructions, circuits, parts lists £4.95 inc p&p

BURLINGTON MOTOR CO. LTD. (G9) ARCH 39M, BATH PLACE, LEAMINGTON SPA, CY3 3AQ.

ELECTRONIC PLANS, laser designs, solar and wind generators, high voltage teslas, surveillance devices, pyrotechnics and computer graphics tablet. 150 projects. For catalogue. SAE to Plancentre Publications, Unit 7, Old Wharf Industrial Estate, Dymock Road, Ledbury, Herefordshire. HR8 2HS.

Market your expertise in ETI magazine. Call Heather Wust – Today
01-437 0626

PROMs - EPROMs - PALs
ANY PROGRAMMABLE IC SUPPLIED OR BLOWN
Typical prices (excluding VAT)
(Data Entry P&P extra)
2716 £4.20 .... 2732 £3.85
2764 £2.85 .... 27128 £4.40
BIPOLAR PROMs from £1.35
e.g. 82S123, 18S030, 74S288
PALs, PLDs etc. from £3.26
e.g. 82S153, 16L8, EP310
Full design and prototyping service.
Any quantity programmed - SAE or phone for details.
P.L.S., 16 Central Road, Worcester Park, Surrey, KT4 8HZ.
Phone: 01-330 6540

ILLUSTRATED CATALOGUE
OF QUALITY ELECTRONIC ELECTRICAL AND AUDIO COMPONENTS AND ACCESSORIES FULL OF USEFUL INFORMATION AND MANY BARGAINS AND SPECIAL OFFERS ONLY 75p.
(REFUNDABLE AGAINST FIRST ORDER)
FAST BY-RETURN SERVICE
STRACHAN ELECTRONICS (ETC)
9 Croall Place, Edinburgh EH7 4LT

We accept
bookings. Phone 01-437 0626 Today.

ALARMS

NEIGHBOURHOOD WATCH BURGLAR ALARM D.I.Y. KIT
will offer a professional system at a DIY price

Ham mini beam 10, 15, 20 metres. Parts integrated circuits, transistors, diodes, valves, resistors, etc.

Service Manual and parts for Spectrum and Amstrad

Send a 8" x 5" SAE for list.

M.J. SEAWARD
(Mail Order)
Dept. (ET), St. Olafs Road, Stratton, Nr. Bude, Cornwall. Telephone: 0288 4892

TERMS & CONDITIONS

CLASSIFIED ADVERTISING TERMS & CONDITIONS

Our terms for new advertisers (semi-display and lineage) are strictly pro-forma payments until satisfactory reference can be taken up (excluding recognised advertising agencies). Cheques and P.O.'s should be crossed and made payable to ARGUS SPECIALIST PUBLICATIONS LTD and sent together with the advertisements to:

The Classified Dept.,
No. 1 Golden Square,
London W1R 3AB.

There are no reimbursements for cancellations. Advertisements arriving too late for a particular issue will be inserted in the following issue unless accompanied by instructions to the contrary. It is the responsibility of the advertiser to ensure that the first insertion of every series is published correctly, and corrections must be notified in time for the second insertion, otherwise the publishers will not accept liability or offer any reduction in charges.

All advertising sales are subject to Government Regulations concerning VAT. Advertisrs are responsible for complying with the various legal requirements in force eg: The Trade Description Act, sex discrimination act & the business advertisements (disclosure) order 1977.

Full Terms & Conditions of Advertising available on request.

KITS

I-TRON's
TOP SELLING KITS

BUG-87 Matchbox sized surveillance transmitter – can be received by any FM/VHS radio £4.95
ROBO-VOX Instantly transforms your voice into Dalek/Robot type also amazing sound effects possible £11.95
ROBOT CIRCULAR Unique radio controlled robot – can also be converted to control via computer £16.95
EDU-SCOPE Build your own oscilliscope with solid state display £39.99
EDU-SCOPE CASE KIT £11.99
THERAMIN MUSIC GENERATOR An electronic device based on an ancient legendary mystical instrument £12.75
RAD-X CONTROL A complete ready built 2 output RADIO CONTROL SYSTEM £14.99

Please add £0.75 per order for P&P. **For FREE Datapack on all our Products/Kits send SAE.**
Cheques/PO's payable to:-
IMAGINA-TRONICS
Aberdeen House, The Street, Charlwood, Surrey RH6 0DS.

SPECIAL OFFERS

O.E.M.'s Clearing B.S. 9,000 quality parts, examples:
LED's axial green 5p
5mm 7p
Surface mount, 3 colour 18p
DMOS transistors RFP 15N05L £1.00
6L £1.25
MJ10012 10a 500v Darlington £2.50
LM324 .... 25p
For surface mount and ordinary ICBs, trans- formers, switches, you name it, our free catalogue has it.
Tel: Galvaroy Ltd. 0241 70172

SHEEP SHAN'T SLEEP!! 100 watt amplifier modules £7, Glass/PCB complete & tested. 8 Cunliffe Road, Ilkley LS29, KIA GIVEAWAY NEXT MONTH, IT'S IRRESISTABLE.

J.P.G. ELECTRONICS
Resistors ¼w 5% carbon E12 1T 1% metal fm E243P)
Resistor Pack 85 different E12 valves plus ohm link, total content of resistor 1,000 .... £8.95
LED's Red/Green 3/5mm 6p each; Yellow 11p each
Cable Ties 75mm 1p ea. £5.95/1,000; £49.50/10,000
Power Transistors T/T 35C, TIP36C 100V, 25A TOP3, Plastic case .... £1.56 each
100db Piezo Buzzer ... £1.50; Standard Buzzer ... 80p
Solar Cells 0.45v 100mA ... £1.48; 700mA ... £3.50
Stepping motor 4 phase 12v 7.5 step 50ohms ... £8.95
Saa 1027 Stepping motor drive chip £3.95
Miniature small Transistor kits 100-108M high quality sound ideal for cordless microphones or guitars etc. £7.48
Metal Latch Key XLR line plug £1.35;
Line Socket £1.48
Ferric Chloride pack for mixing with ½ litre water £1.40
Flux cord solder 500g .... reel £4.95
Automatic Squeeze action wire .... stripper £3.45
SPECIAL OFFERS
Computer grade capacitors with screw terminals 58,000 of 60v £4; 47,000 of 63v £1.50; 38,000 of 20v £1.95; 87,000 of 10v £1.50.
Stereo LW/MW/FM tuner, pre-amp complete with volume/tone control and tuning scale. Brand new in makers box £5.95; Faulty £1.95.
Circuit diagram, description and setting up procedure for tuner assemble described above 50p.
LCD display 16 digit 7×5 dots matrix £2.50
Qwerty keyboard 58 key uncased good quality switches £5.
CMOS TTL 74 MC 74F linear transistor kits, capacitors, resistors, tools etc. always in stock.
Please add 75p +p. per order VAT inc.
J.P.G. ELECTRONICS, 276 Chatsworth Road, Chesterfield S40 2BH. ***Callers welcome.***
Access orders (0246) 211202

CASSETTE MOTORS large and small 2 for £1.00. Mono and stereo cassette tape heads. 2 for £1.00. Microphone small for cass. tel. etc. 2 for £1.00. Telephone buzzers at £2.50 each. Please add 75p p&p no VAT. Access card accepted. Golden Orange Supplies, Brockhollands Road, Woodside, Bream, Lydney, Glos. Tel: 0594 563009.

FREE MEMBERSHIP to the NATIONAL COMPONENT CLUB
For details and a free gift of components worth over **£10**
send only **£1.00** p&p to:
Higher Ansford, Castle Cary, Somerset BA7 7JG

WANTED

Turn your surplus transistors, IC's etc., into cash. Immediate settlement.
We also welcome the opportunity to quote for complete factory clearance.
Contact:
COLES HARDING & CO.
103 South Brink
Wisbech, Cambs.
ESTABLISHED OVER 10 YEARS
Tel: 0945 584188
Fax Number: 0945 588844

IDEAS/INVENTIONS wanted. Call I.S.C. 01 434 1272 or write, Dept ASP 99 Regent St, London W1.

SURVEILLANCE

ESKAN ELECTRONICS
LEADING MANUFACTURERS AND SUPPLIERS OF SURVEILLANCE AND SECURITY EQUIPMENT.
MINIATURE TRANSMITTERS, TELEPHONE MONITORING EQUIPMENT, AND MANY OTHERS.
Send stamped addressed envelope for your free catalogue to:
172 Caledonian Road, London N1 0SG.
Telephone 01-278-1768
Trade Enquiries Weocome

ROOM BUGS
- Ready built, tuned and sealed.
- Whisper sensitive condenser microphone.
- Shock proof capsule 30mm × 20mm × 15mm.
- Range upto 200m on domestic VHF radio.

The most practical and easy to use on the market – full refund if you disagree.
- ETI readers save £2, only **£14.95** each inc.

Please make cheques/PO's payable to:
LONGCROFT SECURITY,
30 Longcroft, Huddersfield, West Yorkshire HD5 8XW.

Classified advertising could be working for YOU!
Tel: 01-437 0626

BOOKS

CIRCUIT DIAGRAMS
Most Makes, Models, Types, Audio, Music Systems, Colour, Mono Televisions, Amateur Radio, Test Equipment, Vintage etc. £3.50 plus LSAE.
State Make/Model/Type with order.
Full Workshop Manual prices on request with LSAE.
MAURITRON (ETI),
8 Cherry Tree Road, Chinnor, Oxfordshire, OX9 4QY.

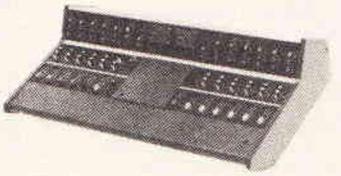
Next Copy Deadline for August issue is 23rd May.

AUDIO

Grundig Infra-Red Remote Control "VIF-K1" consists of transmitter TPV355 and VIF-E1 brand new & boxed .... £4.99 p&p £2
VIF-E1 .... £9.99 for 10 p&p £3
Video Heads (Grundig 2 × 4 Super) with head assembly .... £29 p&p £2 each
2 × 4 Super Panels £5.95 = DTF, Servo, Video, Croma, Sterio-ton, Motor-Board, Modulator & Tuner p&p £1.
Remote Controls Infra-red & Sonic suitable for use with Ferguson, JVC, Philips, Sony, Grundig, AU .... £19.95 each p&p £1
SURPLUS STOCK WANTED
Stan Willets (ETI), 37 High St., W. Bromwich, W. Midlands B70 6PB.
Tel: 021 553 0186

EQUIPMENT

WOULD YOU BUY A CAR WITHOUT A TEST DRIVE? THEN WHY BUY A MIXER WITHOUT A TEST DRIVE?



Thinking about a new project — from a small Mixer to a large studio complex — come and talk over ideas with the people who offer manufacturing and user experience at our new premises:
Unit D, 318 High Road, Benfleet, Essex SS7 5HB
TO TAKE THAT TEST DRIVE — PHONE 0268-793381
(Weekend Committee visits welcome by prior arrangement)

PARTRIDGE ELECTRONICS
Head Office, 56 Fleet Road, Benfleet, Essex SS7 5JN
Telephone 0268-793256

Audio Mixer Kits suitable for Studios, broadcast, discos, cassette copying, churches, MIDI set-ups.
Prices from only £9.92
Send 18p for catalogue to:-
K. Tek, P.O. Box 172A, Surbiton, Surrey KT6 6HN. Tel: 01-399 3990

TO ADVERTISE HERE – RING HEATHER WUST ON 01-437 0699

BRUEL AND KJAER 230S level recorder, pens, paper £185. Marconi TF2337 Auto Distortion Meter £190. Bryans 26000 A3 Plotter £145. Amber 4400 Audio Test Set £625. Bek 2112 Audio Spectrometer £220. Tel: 01 739 5940.

RETAIL OUTLETS

ELECTROMART

LIVERPOOL

PROGRESSIVE RADIO
87/93 Dale Street Tel: 051 236 0154
47 Whitechapel. Tel: 051 236 5489
Liverpool 2
'THE ELECTRONICS SPECIALISTS'

Open: Tues-Sat 9.30-5.30

LONDON

CRICKLEWOOD ELECTRONICS LTD

FOR COMPONENTS
LOTS OF NEW DEVISES
LOTS OF LOWER PRICES
Phone for our catalogue:
01 452 0161/450 0995 Telex: 914 977
40 Cricklewood Broadway,
London NW2 3ET.

SOUTH COAST

Classified advertising could work for you. Ring Heather Wust Today to discuss your plans.

TYNE AND WEAR

ELECTRONIC COMPONENTS AND KITS

ESR

STATION ROAD, CULLERCOATS,
NORTH SHIELDS, TYNE & WEAR NE30 4PQ
091 251 4363

New 1988 Catalogue now available £1.85 incl p&p. MON-SAT 9.30 to 5.30 CLOSED THURS.

ELECTROMART

SITUATIONS VACANT

DEVELOPMENT TECHNICIAN

Modern Vitalcall manufacturers of emergency communication systems for the elderly require a young enthusiastic technician to work in the research and development department.

Duties include the building and testing of prototype products.

Please send your C.V. to:-
**Modern Vitalcall Ltd.,
PO Box 25, Redditch,
Worcestershire BN8 9NS**

Do you need Qualified Staff? Electronics Today International can find them for YOU Ring 01-437 0626 TODAY!

MISCELLANEOUS

HEATHKIT U.K. Spares and service centre. Cedar Electronics, Unit 12, Station Drive, Bredon, Tewkesbury, Glos. Tel. 0684 73127.

SERVICES

ADS repair amplifiers . . . ADS design amplifiers . . . ADS offer 100 watt poweramp modules £8.99 built . . . ADS, 1 Regent Road, Ilkley LS29. Datapack 20p.

PCB'S

Labcenter electronics

PC-B £80

At last, an affordable PCB design tool for your Amstrad PC. Plotting service available.

Send SAE for further details, or £2 for demo disk.

**Labcenter Electronics
14 Marriner's Drive,
Bradford, BD9 4JT.
Tel: 0274 542868**

PRINTED CIRCUIT BOARDS At very competitive rates: 4 pence per square centimetre (less for orders of 10 plus) 1 offs; 100 offs. Enquiries: Watling Wires, 52 Watling Street, Nuneaton, Warwickshire, CV11 6JL. Telephone (0203) 382296.

- **Components**
- **Equipment**
- **Kits**
- **Surveillance**
- **PCBs**

If you can supply Products or Services to ETI Readers Contact Heather Wust on 01-437 0699

CLASSIFIED COUPON

ELECTRONICS TODAY INTERNATIONAL, CLASSIFIED ADVERTISEMENT DEPT, No. 1 GOLDEN SQUARE, LONDON W1R 3AB.

PLEASE DEBIT MY ACCESS/BARCLAYCARD No. EXPIRY DATE

Rates: Lineage 51p per word (VAT inclusive) minimum £7.65 semi-display £12.20 per single column cm. No reimbursements for cancellations. All ads must be pre-paid.

Name ....

Address .... Daytime Tel. No. ....

Signature .... Date ....

☐ FOR SALE ☐ COMPONENTS ☐ WANTED ☐ KITS ☐ PCB'S ☐ OTHERWISE STATE

ADVERTISERS' INDEX

REACH · FOR · THE · SKY part I

A. Receiver bandwidth ☐
B. Single button channel selection ☐
C. Parental channel lock ☐
D. System styling ☐
E. Receiver remote control ☐
F. Baseband output ☐
G. Unobstructed southerly view ☐

Name ....

Address ....

....

....

.... Postcode ....

WHAT TO DO

This is the first part of the ETI once-in-a-lifetime *Reach For The Sky* satellite TV competition. All you have to do for this part of the competition is to place the seven criteria on the coupon in order of importance. For example, if you think the most important feature for a high quality and enjoyable satellite TV system is a *parental channel lock* then write a 1 in the box opposite feature C.

When you have ordered all seven criteria, don't send us the coupon! Keep it safely until next month when we shall publish the final part of the competition. Then you must send both parts together to ETI as your entry.

STV I

REACH • FOR • THE • SKY

WIN A COMPLETE SATELLITE TELEVISION SYSTEM WORTH £1300

REACH FOR THE SKY

See for yourself what all the fuss is about in the electronics world. Enter the ETI Reach For The Sky competition and the lucky winner will be able to pick up multi-channel entertainment, news and sport on their existing TV set.

Satellite TV is here now. Umpteen channels are broadcast everyday from a growing number of satellites positioned high above the Earth's equator. Even as you read this more satellites and more channels are planned. Everything you need to tap into these broadcasts (in addition to your conventional TV) can be won in this chance of a lifetime competition.

The Prize

We've joined forces with Pace – one of the big new names in satellite TV systems – and established dish manufacturer Vivor to offer a complete system of:

- Pace SR640 satellite receiver. A superb piece of equipment capable of receiving all current channels, with infra-red remote control and full 39 channel memory

- Vivor high performance 90cm dish antenna and mount

- Ultra low noise LNB

- IRTE Paris low degradation magnetic polarotor

- Accurate dish actuator to move from one satellite to another

- 30m of connecting cable and the necessary connectors to enable the whole system to be set up with nothing more than common handtools

- Installation and operating instructions

If you haven't already read details of the Pace SR640 receiver (see ETI April 1988) you'll find its specification amazing. This is one of the few satellite receivers which is truly easy to use. Yet it maintains a performance which excites even the most stick-in-the-mud satellite engineer.
With single push button control, you can alter the satellite, channel, polarisation, skew, etc, etc from the armchair in the living room. Once you've correctly installed your prize, the receiver will automatically tune in all aspects of programmes, moving the antenna to point to up to 12 satellites, adjusting the polarotor for the best signal, powering the LNB and all the other tasks with just a single push of a button.

We've picked Vivor, a manufacturer of high quality antenna dishes as the supplier of the dish we're giving away. It's a 90cm antenna complete with mount and actuator to enable it to swing across the satellite belt to point at any satellite up there, now or in the future.

The two main parts of the system are united with an LNB with a noise figure of less than 1.6dB. Coupled with the low degradation Paris polarotor, the systems carrier-to-noise level is kept as high as possible, enabling the convenient smaller dish size to be used but maintaining good reception.

The Competition

The competition to win this top-notch system is in two parts over two issues of ETI. For Part One you have to arrange a list of features of a satellite TV system in order of importance. Part Two is the world's first ever 'spot the satellite' contest. This month's half of the competition is on the page opposite.

RULES

1. All entries must be on the published coupons or on photocopies accompanied by the published tokens.
2. Entry is open to all UK resident readers of ETI except employees and their families of Argus Specialist Publications, Pace Micro Technology and Vivor Satellite Systems.
3. All entries must be received at the ETI Editorial Offices by July 1st 1988.
4. The judges' decision in all matters is final.
5. All entrants to this competition shall be deemed to have accepted these rules.

PROJECTS GALORE FROM /// Maplin

☎ SALES 0702 - 554161

PROTECT YOUR VHS VIDEO PLAYER WITH THIS VHS VIDEO ALARM PROJECT!

A self-contained alarm system disguised as a video cassette. Gives audible alarm if machine moved or cassette ejected. Full details in Project Book 24 (XA24B) Price 85p.

KIT PRICE ONLY £11.95 ORDER CODE LM27E

CHECK THOSE UNMARKED

capacitors with this versatile, low-cost, piece of test equipment. Full details in Project Book 23 (XA23A) Price 85p.

KIT PRICE ONLY £24.95 ORDER CODE LM28F

MOSFET AMPLIFIER

giving 150W of incredible power! High reliability and performance.

Full details in Best of E & MM (XH61R) Price £1.00.

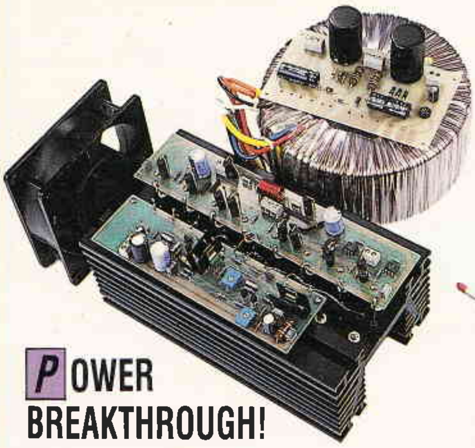
KIT PRICE ONLY £19.95 ORDER CODE LW51F

All prices include VAT. Please add 50p towards postage.

MUSICAL DOORBELL

with 28 tunes and chimes with selectable piano to organ like sounds. Note: case and front panel not in kit. For full details see Project Book 13 (XA13P) Price 85p.

KIT PRICE ONLY £14.95 ORDER CODE LK57M



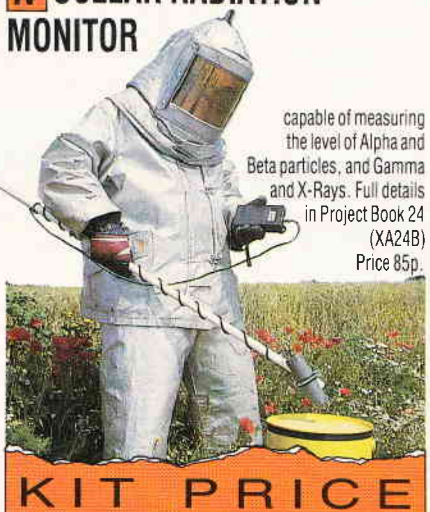
POWER BREAKTHROUGH!

A superb 1kW Mosfet amplifier, a major new source in sound! Full details in Project Book 26 (XA26D) Price 85p. This project is made up from 4 kits.

KIT PRICE

DRIVER KIT	OUTPUT KIT	MONITOR KIT	PSU KIT
LM50E	LM51F	LM52G	LM53H
£11.95	£99.95	£19.95	£89.95

NUCLEAR RADIATION MONITOR



capable of measuring the level of Alpha and Beta particles, and Gamma and X-Rays. Full details in Project Book 24 (XA24B) Price 85p.

KIT PRICE ONLY £99.95 ORDER CODE LM24B

All items subject to availability

/// Maplin Electronics
P.O. Box 3, Rayleigh, Essex, SS6 8LR.

MANY MORE PROJECTS INSIDE!

Pick up a copy of our giant 512 page catalogue from WHSMITH for just £1.60.

Shops at: ○ Sutton New Road, Erdington, **Birmingham.** ○ 302 Gloucester Road, **Bristol.** ○ 159-161 King Street, **Hammersmith,** London. ○ 8 Oxford Road, **Manchester.** ○ 46-48 Bevois Valley Road, **Southampton.** ○ 282-284 London Road, **Southend-on-Sea.**