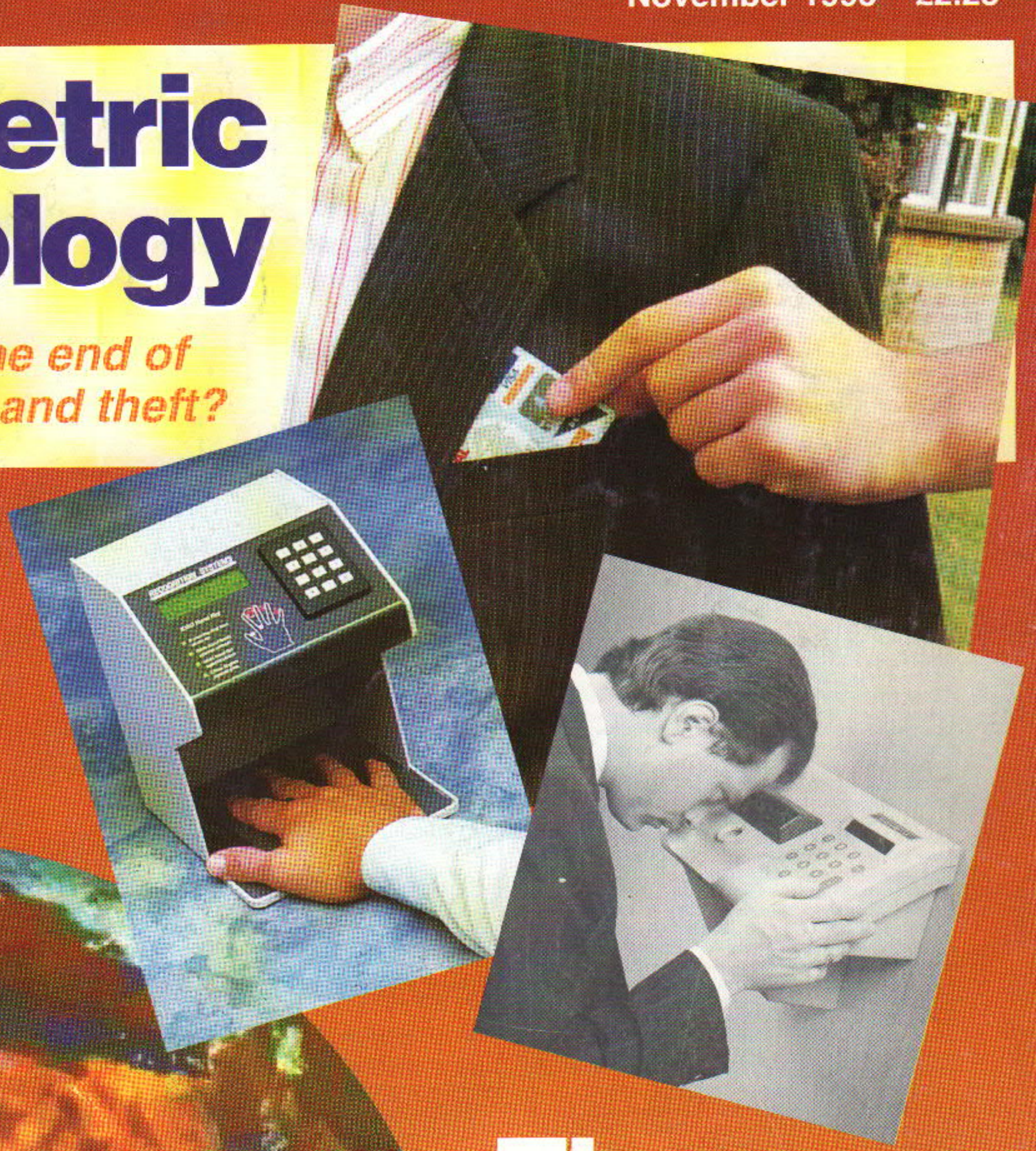
ELECTRONICS in ACTION

November 1993 £2.25



Biometric Technology

Could this be the end of credit card fraud and theft?

The Power behind the MOSFET

The inside story

The Switcher

Solid state routing in your hi-fi

The Restless Earth

Making a sensitive Seismometer

ISSN 0969-3564 11

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. **Now only £4.00 ref 4P151.** Good experimenters board.

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.

12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v.

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**

Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

VIDEO SENDER UNIT. Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless cameral

FM TRANSMITTER Housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R. Good range.

MINATURE RADIO TRANSCEIVERS. A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.

12 BAND COMMUNICATIONS RECEIVER. 9 shortbands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.

CAR STEREO AND FM RADIO. Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. **£19.00ref 19P30**

LOW COST WALIKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.

NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.

TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. New ed. £20.00 ref 20P32R.

GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R

FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.

FM BUG Built and tested superior 9v operation £14.00 ref 14P3R

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

SINCLAIR C5 MOTORS. 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £22.00 ref 20P22R. Limited stocks.

ELECTRONIC SPEED CONTROL KIT .for C5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R. Potentiometer control.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.

ACORN DATA RECORDER ALF503. Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R

VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**

PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £22.00 REF 22P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.

12 TO 220V INVERTER KIT. As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

WIND UP SOLAR POWERED RADIO! FM/AM Radio takes rechargeable batteries. Complete with hand charger and solar panel. £14.00 REF 14P200RA.

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R.

FRESNEL MAGNIFYING LENS. 83 x 52mm £1.00 ref BD827R.

12V 19A TRANSFORMER Ex equipment £20 but OK.

POWER SUPPLIES Made for the Spectrum plus 2 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref Q8P3

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!

LED PACK . 50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52

360K 5.25" DISK DRIVE. Industry standard, ideal replacement or second drive for most computers. £9.00 EACH ref: X9P1.

PPC PSU 13.8V 1.9A (not plug in). £10.00 EACH. REF: X10P1.

MINIMUM GOODS ORDER £5.00. TRADE ORDERS FROM GOVERNMENT, SCHOOLS, UNIVERSITIES, & LOCAL AUTHORITIES WELCOME. ALL GOODS SUPPLIED SUBJECT TO OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30 DAYS.
RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR NOTICE. ORDERS SUBJECT TO STOCK. QUOTATIONS WILLINGLY GIVEN FOR QUANTITIES HIGHER THAN THOSE STATED.

THIS MONTHS SPECIAL OFFERS

SOLAR CELLS

10 WATT SOLAR CELL (3" x 1") 14.5v/700mA

Now available by mail order Coated with exceptionally efficient amorphous silicon these glass solar cells have an almost timeless lifespan and will not suffer with discolouration. There are possibly hundreds of uses for these cells, a few of which could be: for **Car Battery Charging**, for use on **Boats** or on **Caravans**, in fact anywhere a portable **12V** supply is required. Several of our overseas Mediterranean customers with homes in remote hilly sites, use these solar cells as a daytime power source to backup generators. The solar cells can be connected in series or parallel to give higher voltages or larger current capacity. **REF: EA34P1**

PRICED at only £33.95. PLUS an additional £2.00 special packaging charge on this item in addition to £3.00 PP charge.

OTHER SOLAR PANELS:

12V 200mA GLASS SOLAR PANEL.
12" x 12" in dimension **£15.00 EACH. ref: 15P42.**

.45V 700mA SOLAR CELL.
silicon plastic encapsulated. 95 x 65 x 7.5mm in dims.
£3.00 EACH. ref: 3P42.

.45V 400mA SOLAR CELL.
silicon plastic encapsulated. 75 x 45 x 7.5mm in dims.
£2.00 EACH. ref: 2P199.

.45V 100mA SOLAR CELL.
silicon plastic encapsulated. 45 x 26 x 7.5mm in dims.
£1.00 EACH. ref: BD631.

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT

MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY
TELEPHONE ORDERS WELCOME
TEL: 0273 203500
FAX: 0273 323077

VISA

INDUCTIVE AMPS £5.00
Made for amplifying a telephone handset for the hard of hearing. However if you hold one against a piece of wire carrying a telephone conversation you can hear both sides of the conversation! It can also be used for tracing live wires in a wall or detecting cables carring mains etc. Fully cased complete with battery and fixing strap. Aprox 2.5" diameter 1" thick.
Our Price :£5.00 Our Ref :EA5P11

CTM644 COLOUR MONITOR £79.00
Refurbished monitor suitable for many home computers standard RGB input.
Our Price :£79.00 Our Ref :EA79P11

ARCHEMEDIES A3000 PSU £10.00
A compact switch mode PSU with on/off switch, selectable voltage input 110/240. NEW O/P via fly leads. GOOD STOCKS AVAILABLE.
Our Price :£10.00 Our Ref :EA10P11

ANSWERPHONES from only £18.00
Yes its true BT approved push button dialling. These are customer returned units and have two faults. We will supply you with a chip to cure one fault then you have to sort out the other problem! NON RETURNABLE.
Prices:
£18.00 each. REF: EA18P21
£60.00 PKT 4. REF: EA60P21

PORTABLE ALARM SYSTEM £17.00
'PAL' Portable Multi Beam Scanning System. Lockable Stand-alone PIR unit with removable keys (3 supplied). This unit uses a PP3 battery and when activated emits a piercing SHRILL! The unit scans the room and memorises the layout. Should this change, the alarm is triggered. There is a 60 second exit delay.
Our Price :£17.00 Our Ref :EA17P11

PIR MOVEMENT DETECTOR £15.00
Once again we have aquired stocks of this popular line and are able to offer you a very high quality and professional detector at only **£15**. Range: 20m with a 90° arc. Day and Night Mode Dims: 15cm x 9cm x 11cm. New and boxed, complete with installation guide.
Our Price :£15.00 Our Ref :EA15P21

MANY MORE SPECIAL OFFERS
IN OUR REGULAR NEWSLETTERS

WE HAVE HUNDREDS AND HUNDREDS MORE STOCK LINES - TOO MANY TO LIST IN ONE ADVERT ! CHOOSE FROM

AERIAL AMPLIFIERS	FANS
AEROSOLS	FUSES
ALARMS	GLUE GUN AND GLUE
AMPLIFIED SPEAKERS	HEADPHONES
ANALOGUE MULTIMETERS	HEATSHRINK SLEEVING
APPLIANCE LEADS	HI FI SPEAKERS
BATTERIES AND HOLDERS	IONISERS
BATTERY CHARGERS	LED's
BOOKS	LASERS AND LASER PSU's
BOXES AND CASES	LOGIC PROBES
CAMCORDER BITS	LOUD AND MARINE SPKRS
CAPACITORS	MICROPHONES
CAR AMPS, RADIOS & SPKRS	PIR LIGHTS AND DETECTORS
CB SPEAKERS AND PSU's	POWERS SUPPLIES
COMPUTER BITS	POWER AMPLIFIERS
CONNECTORS	RADIOS
DESOLDER PUMP	SERVICE AIDS
DIGITAL MULTIMETERS	SOLDERING EQUIPMENT
DISCO LIGHTING	STEAM ENGINES
DISPLAYS	TRANSEIVERS
DUBBING KIT	TRANSFORMERS
DRILLS	WIRELESS MICROPHONES

IN SUSSEX?
CALL IN AND SEE US!!

TURN YOUR SURPLUS STOCK INTO **CASH**. IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR COMPLETE FACTORY CLEARANCE.

MUCH MUCH MORE IN OUR 1993 **CATALOGUE**. PLEASE SEND 41P , A4 SIZED SAE FOR YOUR FREE COPY.

ELECTRONICS in ACTION

ISSUE 2 VOLUME 1

EDITOR
Paul Freeman-Sear

SUB EDITOR
Helen Armstrong

DESIGNER
Susan Campbell

TECHNICAL ILLUSTRATION
JPD

ADVERTISING SALES
Gilly Martin

CONTRIBUTORS
Andrew Armstrong
Helen Armstrong
Geoff Martin
Mike Meechan
Emma Newham
Brian Padgett
David Silvester
Paul Stenning

Quantum House Publishing Ltd.

PO BOX 600, BERKHAMSTED
HERTS HP4 1NL
TELEPHONE 0442 842069
FAX 0442 842279

Publishing, PCs ...and Gremlins

A big thank-you for all your comments and well wishes for our first edition. From the feedback, it is nice to know we are being read by engineers, academics, constructors and those who just enjoy a bit of light reading. The news trade are certainly enthusiastic about us.

As we are using the latest technology and computer software for the production of this magazine, there were bound to be a few gremlins creeping in on the first issue. That, I suppose is the initial price one has to pay for using new technology, new software and running everything out in an unconventional way.

There must be very few news-stand magazines to be Desk Top Published on a PC. This is due to Apple Mac computers having dominated the print media for many years. That market lead could change over the next few years as the latest software for designing publications is now available for PCs. With PC hardware costs much lower than the Mac equivalent, it makes the attraction of moving over that much greater.

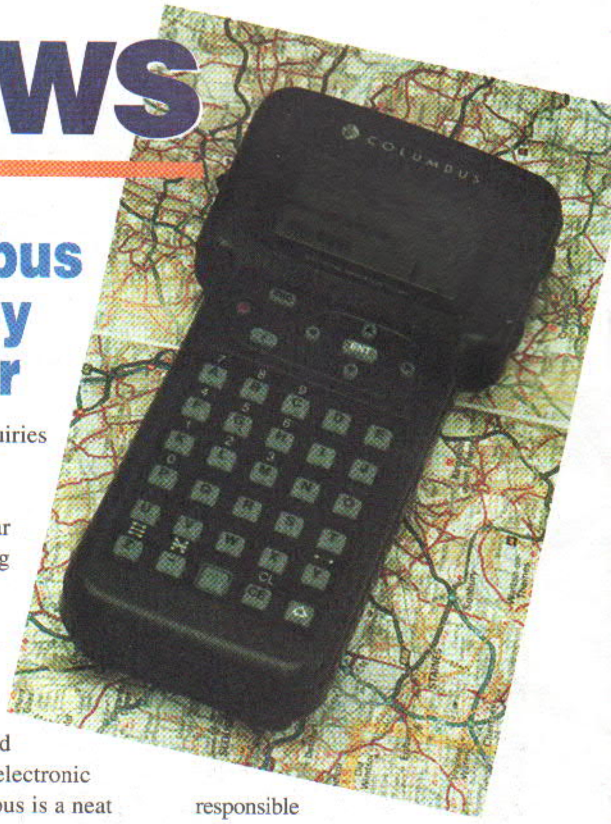
Photo CD will also continue to be featured in the production of this magazine as it is so versatile and cost effective. Again we are at the forefront of the technology in the publishing industry and I'm sure it will be widely used for multimedia presentations whether in business or in education.

Finally, I hope you find plenty of things in this months magazine to interest you.

Paul Freeman-Sear

Published by **Quantum House Publications Ltd**, PO Box 600, Berkhamsted, Herts HP4 1NL. Newstrade distribution by Seymour, Windsor House, 1270 London Rd, Norbury, London SW16 4DH Tel: 081 679 1899. Reproduction by Island Graphics, Chesham, Bucks. Tel: 0494 773082. Printed by Wiltshire (Bristol) Ltd, Philip St, Bedminster, Bristol BS3 4DS. Tel: 0272 760076

NEWS



Columbus Journey Planner

Half a million enquiries poured into the Automobile Association last year for journey-planning information in the UK and abroad. Now UK company Pan Star has launched Columbus, described as the world's first electronic routefinder. Columbus is a neat 510-gm, mobile 'phone sized calculator/processor with 1 megabit of RAM. Routeing information is read from a 3-inch square storage card, processed and the required journey instructions displayed on a small lcd screen.

The Routeing Cards themselves carry information from the AA's database for whole of the UK, or another European country. Most of the main European countries are already available, and other countries - including the USA - are en route. With the right Routeing Card slotted into the back of the machine, and the start and destination points entered, Columbus presents its instructions for the journey with an estimated time of arrival, petrol consumption and journey cost. The trip from Land's End to John O'Groats, for instance, can be planned for minimum time or distance in under a minute.

As if this isn't going far enough, Columbus can alter the chosen routeing to avoid holdups on the road ahead, warn of routes with width or height restrictions (useful for caravan-owners), and plan routes with up to five end destinations at once. Given the right information, it can also check up on your fuel consumption and driving speed, so that you can monitor progress as you go. Fleet Managers and others responsible for motoring on a large scale will be likely early beneficiaries of Columbus's talents.

Pan Star's major triumph with Columbus is packing the information from the AA databases onto compact Routeing Cards which can hold up to 16 megabytes of data. As well as the routes, the AA Great Britain Card carries nearly 12,000 major locations, 27,00 smaller ones and over 40,000 route sections.

Designed as a battery-powered hand-held, stand-alone unit with auto power-down, Columbus can also be powered from an external 8-15 volt DC power supply. Connection to one of most modern PC printers provides a journey printout, and the ultimate plan is to "go live" in connection with AA Roadwatch and Air Call to receive traffic reports as they happen. This needs a small add-on, and news of this is expected later this year.

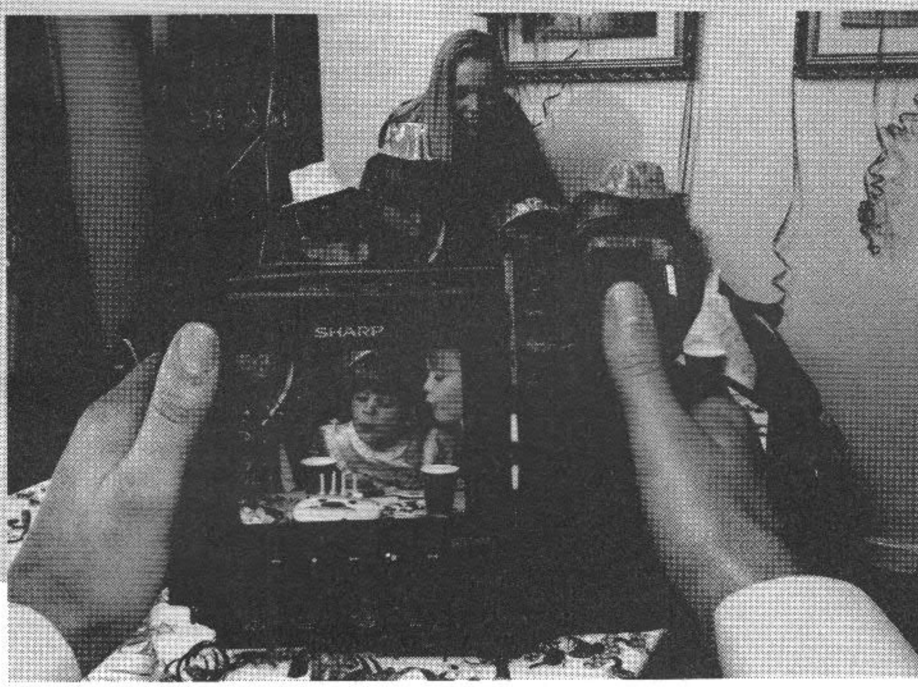
Columbus will be on sale in Innovations and Leading Edge stores (including Harrods and Selfridges), Carphone Warehouse and the Columbus Sales Desk on 081 874 8844. The price quoted for a Columbus with an AA GB Routeing Card is L399. The makers can be contacted at Panstar (UK) Ltd., 40A Hampstead High St., London NW3 1QE.

Viewcam

You've seen the video - now try the camera. Sharp have been making a splash in television advertising with Viewcam, their ground-breaking video camcorder. A revolutionary new design - literally - the body of the Viewcam with its 4-inch colour lcd viewfinder can rotate through up to 270 degrees relative to the lens, allowing the user to record himself or herself while still holding the camera.

The 8-mm format Viewcam's rotating body and large viewing screen allow a degree of flexibility that camera-users on the move have formerly longed for without much hope: the ability to hold the camcorder high in the air to shoot over the heads of a crowd, while still being able to monitor the picture; instant playback on an integral portable-tv-sized screen; posing group shots without losing one member behind the camera. Other facilities like quick indexing to the start and finish of recent shots, a remote control unit with all models, a "snapshot" facility, and even a pivoting lens unit so that you can track shots without moving the lcd viewing screen combine to make a startlingly versatile camcorder. The freedom to follow a shot on the move without the camcorder glued to one eye is going to please many a home video director.

The Viewcam VL-H400H has up to date facilities for automatic exposure and colour-balance, lens and zoom technology, Digital Image Stabilisation and auto-focus from wide-angle to telephoto, a switchable high-speed electronic shutter and 16:9 wide-screen recording for playback through a suitable wide-screen tv if desired. The flagship model uses 4-head helical scan (FM) recording, a one-third inch 470K CCD and f2/f5.8, 46.4mm lens, compared with a 2-head, quarter-inch 320K, f1.8/f4.5 36mm combination for the smaller sister models. A strobe effect is available as well as the 5-second "snapshot", and the VL-H400H has hi-fi sound.



Optional accessories include a waterproof housing (among others), and a tv-tuner which allows you to pick up (but not record) broadcast tv on the Viewcam.

The top-of-the-range VLH400H costs £1399.99, the intermediate VL-E40H is £1099.99 and the compact 3-inch screen compact VL-E30H, £899.99. Connection to a standard television if so desired is via a normal SCART or aerial connector (check with your dealer if in doubt) and the Viewcams will play back standard 8mm video movies.

BT Calltracer

British Telecom this month is piloting Call Return, a new service which allows the last call to be returned even if the number is unknown. The customer simply dials the exchange to be given the last incoming number, and another code to dial up the number automatically.

Alternatively, you can jot it down and return the call (or not) at your leisure.

Around 40,000 BT customers will take part in the trials on digital exchanges in the Perthshire area. Another service, Call Display, is already further down the trial line, and other options based on the identification of the incoming line to the customer are in the pipeline. BT hopes that, among other things, these will help to deter nuisance calls.

Electronics competition to help the disabled

The International Year of Disabled People in 1982 saw the inauguration of a prize offered by the Institution of Electrical Engineers (IEE) for the best "application of electrical, electronics or software engineering" techniques to help disabled people. The 1994 contest - the fifth prize to be offered since 1982 - was launched on 28th September by Tomorrow's World presenter Kate Bellingham.

The aim of the competition is to promote awareness of the needs of disabled people and highlight the role of electrical engineers in meeting them.

Worth £7,000, the competition should be a boon both to disabled people and to engineers in the field. The prize will be awarded to devices which are in active use and helping disabled people.

Previous winners have been a joystick control system to enable severely disabled people to drive; a joint victory in 1985 for a bladder control device for paraplegics and an eye-gaze operated computer; and a Swedish-distributed electronic newspaper for blind people, which has since been taken up by the Royal National Institute for the Blind in the UK. The prizewinner in 1991 was Handy 1, a robotic eating aid developed at the ever-active Keele University.

Applicants need not be IEE members, and can come from any part of the world. Details of the prize and how to apply can be obtained from Billie Clarricoats, IEE, Savoy Place, London WC2R 0BL. Tel. 071 344 5446.

Telespecs

Bad news for couch potatoes: hands-free portable TV may be with us by Christmas. If you thought Sunday afternoon telesport was a good reason to postpone the gardening, start revising your excuses. Virtual television has arrived.

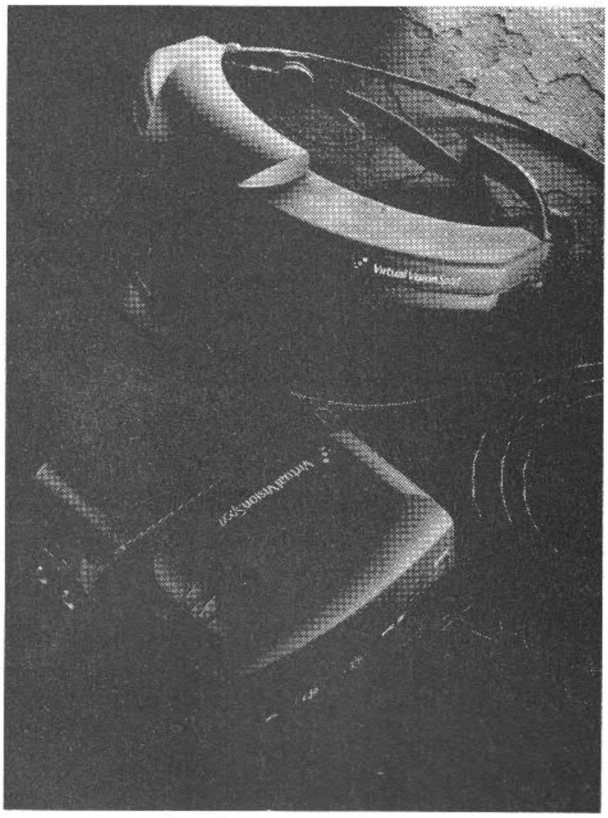
For those whose lives are not so well organised, this may be good news. Virtual Vision™ Sport is a genuinely portable, eyeglass-based television receiver which reflects a televised image to the wearer's dominant eye just below the normal field of vision. Using the dominant eye to receive the image helps to produce the impression that the image is being seen by both eyes at once and (ideally) floating several feet in front of the viewer.

The idea is that you switch from watching the world at large to watching the televised image simply by glancing down - much the same principle as bifocal reading glasses, but a bit more popular with Joe Cool.

The tv tuner and retractable aerial are carried in a compact beltpack, and the eyeglasses weigh a mere 5 oz, light enough for most activities. Virtual Vision Inc. even suggest that you might wear it to the dentist's to keep your mind off the drilling. Check first that they aren't showing Marathon Man.

But this is only the start. Groaning under the weight of trademarks and encouraging slogans ("Reality Now Comes With The Chance To Change Channels.™"), Virtual Vision's plans for the future include link-ups with laptop, palmtop and video game computers, news and stock market monitoring for businesses, and close-up video images of their work or allied data for working surgeons and engineers. The question will eventually be raised whether people doing high-precision tasks are ultimately capable of monitoring dual sources of information in this way. But the human perceptual system is remarkably adaptable, and it is possible to envisage a time when many people will feel under-informed if they only have their immediate environment to refer to.

In the meantime, Virtual Vision Sport will be offering the opportunity to follow two cricket matches at once, and it will also function as a remote colour viewfinder for video camcorders. The system should be available from more specialised electrical retailers by Christmas at around £700.



SCIENCE FOR LIFE

We return to Keele for more news on the Science For Life Conference reported last month.

Virtual Reality may - mercifully, you might think - have dropped out of the media hype spotlight for the time being, but behind the scenes the long-term investors in AR, intellectual and financial, are working away at getting it into the industrial and scientific repertoire where they believe it belongs.

But it took Professor Bob Spence - who was not lecturing about Virtual Reality at all - to draw the parallel between what is commonly thought of as virtual reality now, and the Second World War Link Trainer, a flight simulator used to train Spitfire pilots for the Battle of Britain. The Link Trainer, a machine bolted to the floor of a 3000-foot deep coal mine, persuaded its occupant - for valuable minutes - that he was in a small, mobile, heavily-armed aircraft high above Home Counties Britain.

The value of minutes spent in a flight simulator, particularly in wartime, can be estimated in lives as well as pounds sterling or operational time. An extreme example, perhaps, but a good illustration of the way accurate simulation enables difficult, complicated, expensive or dangerous processes to be tested without the associated risks.

Robert Stone of Advanced Robotics Research Ltd., speaking on Thursday afternoon, described ARRL's VRS (Virtual Reality and Simulation) programme, aimed as keeping British Industry informed about developments in Virtual Reality over a 2-year period, while simultaneously attempting to demonstrate its commercial value.

Burdened with the inevitable publicity about arcade games, VR developers are apparently having a hard time convincing industry that there are serious applications. Co-ordination of effort in Europe seems to be ragged, and funding famine-stricken. Even so, the VRS programme is being funded by UK industry, including ICI Chemicals and Polymers, British Nuclear Fuels and Vickers Shipbuilding and Engineering. Some of the applications already under development cover aircraft engine design, nuclear repository design, microtechnology, minimally-invasive therapies and intelligent architectural simulation.

Rolls Royce's Digital Pre-assembly department is looking at the potential for using VR alongside CAD (computer-aided design) to assess the maintainability of aircraft engines in design, before the hugely-expensive fabrication stage springs unexpected surprises on the designers. Conventional CAD still offers a very limited "live" view of its object. Eventually, fully immersive VR (the user seems to enter the environment and "move about" inside it) may give planners an early chance to try out the service layout of a new engine and anticipate potential difficulties.

Stone stated forcefully the importance of involving "people who know" - applications developers, ergonomics experts and what he called "the critical onlookers and authors" - in the initiatives to develop and exploit

Virtual Reality, a technology in which Europe still has a strong presence. Not just sales persons, distributors or even academics, said Mr. Stone firmly.

Applied Virtual Reality

Earlier in the day, Dr. Colin Bridgewater of Imperial College's Department of Civil Engineering approached the whole subject from the opposite end. The UK construction industry, he said, is commonly seen as fighting changes to "archaic working practices" and admittedly suspicious of computerisation.

The construction industry is not usually associated with the space-age pizazzing of Virtual Reality, but Dr. Bridgewater set out to demonstrate the practical advantages of combining VR techniques to existing CAD methods. Much research has been done by the departments of Cybernetics, and Construction Management and Engineering at the University of Reading. Among other things, an experimental workstation incorporates data gathered by a remote PUMA 560 robot, armed with cameras and microphones, into a CAD image. The emphasis seemed to be as much on developing a modular, semi-automated building system for commercial buildings as for researching and testing problems in individual designs. It's noteworthy, even so, that nuclear, undersea, microtechnology and near-space appeared again as especially suited to VR applications.

Creative displays

As we noted earlier, Professor Bob Spence on Wednesday evening only touched Virtual Reality lightly in passing as he pursued a swarm of ideas for making computer screens a medium for the imagination. Applications were never far away. The history of creative computer graphics, starting with Ian Sutherland's Sketchpad system in the 1960s, led on to "squashed" images which compress, for instance, the contents of your In-tray, or the whole of the United Kingdom, highlighting just the bit you need to know at the time. So the maze of roads between your hotel and your aunty's place are highlighted while the rest of the country waits in the wings until you want it. The desktop highlights a memo newly arrived from your boss which might require earliest attention. And so on.

This naturally leads on to hypertexts and the furthest extension of this type of structure so far, hypermedia. Take the model of a museum: the visitor does not know in detail what he or she needs to know. They may also wish to be entertained. (One of these reasons is probably what brought them to the museum.) With interactive compact disc (CD-I) as the most likely tool, the visitor can choose a display and follow a branching and interconnected series of subject headings in any number of directions. Text, images and sound are equally available. Ultimately, the museum itself could be "stored" inside an information retrieval system. Not only would the information on the displays be selectable, but the display itself, and even the shape and appearance of the display environment. Without stating the point, Prof. Spence came round again to a point where immersive AR could combine with (almost) unimaginably large information systems to create an environment bounded only by the imagination.

Shedding light on medicine

Earlier on Wednesday, Professor David Philips of Imperial College's Chemistry Department shed light on the greater dilemmas posed by actual reality - in this case in the field of medicine. Phototherapy is an elusive and until recently neglected branch of medicine that uses the direct action of light to treat illnesses. Anxiety in recent years about the damaging effect of too much sunlight, and the contribution of ultra-violet rays to forms of skin cancer, has not entirely removed sunlight from its position as a source of wellbeing. New phototherapies, however, are as likely to exploit the destructive possibilities of light as the regenerative ones.

Prof. Phillips' paper homed in on the gradual development of chemical compounds - complex porphyrins including sulphonated phthalocyanines are the main group in question - which can be initiated by light to release (or further trigger from some other source) a destructive agent into surrounding tissues. Concentrated in cancer tissue, and triggered by the carefully-directed application of light, these chemicals could be used to attack malign tumours without highly invasive surgery.

Although ultra-violet (UV) light has the villain's reputation for damaging skin tissue, it is the longer wavelengths of infra-red and near-infra-right that have the penetrating power to affect several layers of tissue. A light-triggered drug would ideally respond to red light. Microsurgical techniques for delivering light (through optical fires) precisely to a location are already well-developed.

A photosensitising drug injected into a sufferer's bloodstream must be capable of concentrating in cancerous tissues. Ideally, it would also be water-soluble, fluorescent (for easy tracing), non-toxic, and "an efficient generator of cytotoxic species, usually singlet oxygen." The first excited state of molecular oxygen (singlet oxygen) is produced by an interaction with the sensitiser and the tissue, and will destroy tissue. For toxicity, it is important that the drug does not photosensitise other tissues to visible and UV wavelengths, leaving the patient vulnerable to sunlight damage.

Fully developed, phototherapy could give another answer to deep-tissue cancers, for which we can only be grateful. And it's unlikely to appear as a video game in the meantime.

Our News pages cover a variety of topics including new products, events and academic research from around the country - If you have news from college, university or from industry, we would like to know about it.

Signal to NOISE

A selection of your views and thoughts

Congratulations..

Firstly, I would like to congratulate you on the launch issue of EIA. I'm particularly impressed with the emphasis on encouraging creative dialogue between innovative individuals and industry - a crucial area which I believe most of us would agree has traditionally been sadly neglected in this country.

As an aside, I must at this point disagree with the comments expressed by Professor Heinz Wolff as reported on page 7. I believe experience should teach us that "small is beautiful" as far as innovative projects are concerned. Of course some projects, e.g. particle accelerators, space probes and semiconductor research programmes must by their nature involve multi-national collaboration and multi-billion pound budgets, and I agree with an element of public funding for exciting fundamental research which might not otherwise take place, given purely commercial considerations.

However, when it comes to firing the imagination and squeezing profit from unusual applications of existing technologies, and their extension into new and worthwhile areas I believe public funding for individual enterprise to be necessary, productive and, overall, less risky (from a purely eggs & baskets viewpoint) than investment in projects and collaborations involving supposedly "safe" (track record), "established" (large scale) enterprises.

Furthermore, funding decisions for small enterprises requiring little investment can be made on individual merits, at a local level by competent people, without unnecessary need for committee approval (with the inertia, undue caution and lack of imagination attendant to such decision making).

More Opinions

Whilst the financial arguments for public investment in small-scale technological enterprises may be compelling, I would contend that social considerations at this time demand it. Consider: Society is becoming ever-increasingly de-skilled. Must we become superfluous observers of the inexorable march of technology, required merely passively to consume the fruits it offers?

I doubt if Watt, Faraday, Edison, or even Wolff himself could ever be satisfied with a vicarious involvement in technology through press releases and hype from a technocratic elite, or 2nd hand via a multimedia playground (audio-visual simulations may provide powerful tools for understanding and manipulating data, but used indiscriminately as educational aids may lead to some damagingly stereotyped, sterile and restricted views of the world). Innovation has often come through familiarity with some previously overlooked aspect of the world encountered, and skills acquired, in everyday life.

Political and market forces will largely safeguard the big, collaborative efforts. Small enterprises are those which must be encouraged. We fail at our peril to nurture individuals with a personal sense of involvement in the future - a sense of the possible.

...and Feedback

Anyway, enough opinion for one letter. I would just venture a suggestion on layout: A consistently clear indication where articles conclude, or are to be continued. As a personal preference I like to see I.C. part numbers on schematic diagrams, although I dare say I could get used to referring to the "shopping list" box if this is consistently easy to find. Obviously with pressures of launch etc. a number of grammatical errors have crept in, particularly in the editorial pages. Whilst I would not be particularly put off if the quality is otherwise good (goodness knows, one or two of your competitors let 'em slip on occasion), I think it would be a shame if some potential readers of the calibre you wish to attract were put off for no better reason than this.

Hopefully, as readers begin increasingly to contribute (on disk?) full project and feature articles etc. for inclusion, editorial control will become less pressurised. I certainly think the interactive philosophy of the magazine is an excellent idea. Who knows, you may be nurturing some teenage Penfolds or Asimovs (of an electronic kind) to help attract and maintain a dynamic (and active) readership.

Wish you well.

Jeremy Fleming
Profile Electronics

Thank you for your kind comments regarding the magazine. Your points have been noted. Judging by the feedback, we are heading in the right direction and hopefully towards many creative ideas being published.

*By the way, we have taken on the services of a sub editor to minimise any mistakes. - **Ed.***

Congratulations on producing an excellent magazine! I bought the first copy and will certainly subscribing to the magazine.

It's good to see a publisher launching a title that tries to communicate the excitement of new technology. If I have any criticism of the magazine it applies solely to the seeming restriction (from the title) of the content to electronics. I think that you would be well advised to look at the way of attracting and keeping the interests of advanced engineering optics enthusiasts - disciplines that will have as much effect on the emerging 'cyberspace' as electronics.

Well done for an excellent effort - keep up the good work.

Peter Whear
Tetbury
Gloucestershire

*You have no idea the trouble we had in selling the magazine to the news trade in the first place. We went through many titles before they accepted us. - **Ed.***

Please send any correspondance to:
The Editor, Electronics in Action
PO Box 600, Berkhamsted
Herts HP4 1NL

Enter the fourth dimension
Next month in Electronics in Action we investigate Deutsche Grammophon's new 4D recording process which brings a new clarity and depth to the world of recorded music
Plus...
In celebration of this breakthrough in recording technology we will be giving away over fifty remarkable sampler CDs containing over 72mins of music
Don't miss it...
On Sale
18th November

Build a sensitive seismometer to detect the strange activity beneath our feet. A report by David J. Silvester

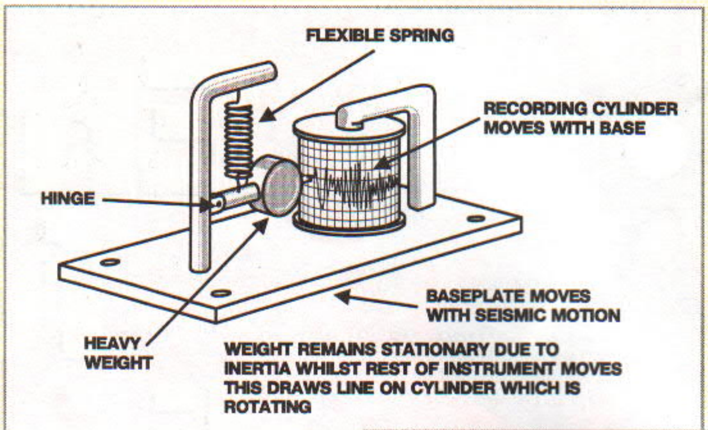


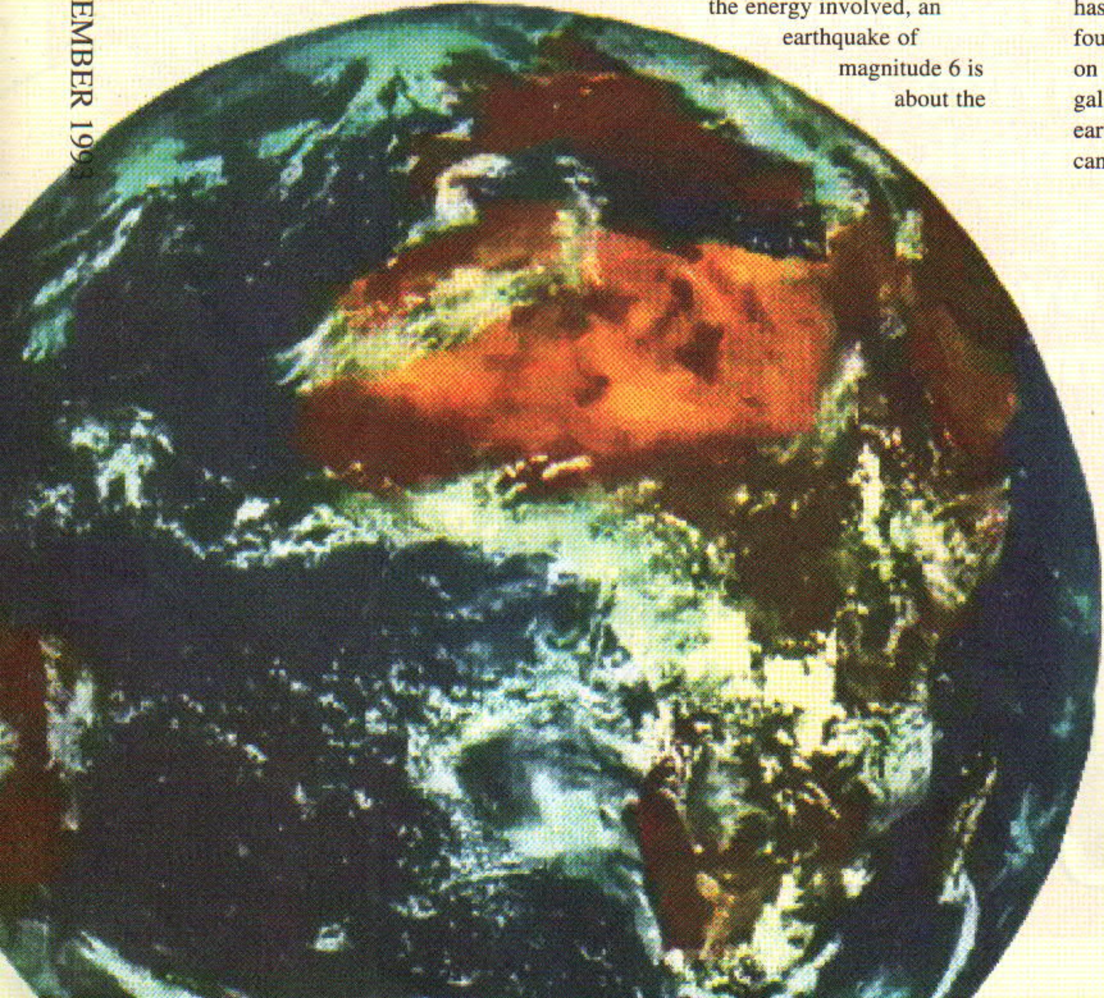
Fig.1 Mechanical Seismometer

On the 20th September 1985 one of the worst natural disasters of this century ocurred. Within two minutes Mexico City was devastated by an earthquake. Man has for many years tried to learn to avert or at least predict such events for his own safety.

So what happens during an earthquake? Heavy traffic passing close to a building is often felt as ground vibrations which can eventually damage those buildings. With their vastly greater energy the vibrations resulting from an earthquake can be transmitted over great distances, all over the world in fact. Small earthquakes occur in Britain - twice in Wales in 1984 and again in 1986 - but luckily Britain is in a relatively stable part of the earth so we do not see the devastating types that occur in other parts of the world. Why do earthquakes take place? Why does solid rock buckle and fracture? The answer is that the earth is not solid when looked at on the geological time scale of millions of years. As the plates on which the crust of the earth rides are carried around the surface of the earth by underlying currents, the upper rocks are strained where the plates rub along each other, are squeezed together or are pulled apart. Eventually the force is too much, the rock snaps and the in-built strain is released in a short burst of noise and vibration. As a rough idea of the energy involved, an earthquake of magnitude 6 is about the equivalent of exploding a 1 Megaton bomb, and there are over 100 of these magnitude 6 earthquakes every year on average. The earth is a very violent place on which we live.

The earth is a very violent place on which we live

The science of earthquakes is known as seismology, from the Greek word for shaking. The shock waves from a major quake can cause churchbells to ring by themselves even up to 1000 miles away from the place at which the earthquake occurred. However there occurs a point further from the source where only instrumental detectors will work. These instruments are called seismometers. Seismometers work on a simple principal, see Figure 1, in that a heavy weight if flexibly suspended will remain still due to inertia whilst the remainder of the instrument will move with the ground as the earth shakes. The Science Museum in London has just such a seismometer attached to foundations via a concrete post and its on view to the public in an upper gallery. The actual motion of the earthquake received at the seismometer can be either a pressure motion like a



The Re Ea

sound wave in air or an up and down shaking motion like the waves on a pond. The drainpipe seismometer weare about to build will respond mainly to earth movements that produce a vertical movement at the earth's surface. The limitation of any seismometer is that it must respond only to earthquakes and needs to have a secure foundation or at least rest on a very solid surface. Without this it will respond to footsteps or passing vehicles, which is not the effect required.

The Seismometer

The detector unit itself is based around a section of 68mm drainpipe that was purchased from the local Great Mills store. Figure 2 shows the detector's design. The major elements in Figure 1 are here. Initial trials with a single suspension elastic gave a system that was too unstable for use, as it tended to swing for long periods. The four suspension strings currently used prevent swinging and the seismometer stabilises within 20 seconds. The mechanically driven pen recorders are too difficult to build at home and so a drainpipe type detector is used with a magnetic pickup. The permanent magnet hanging in a coil of wire gives no output unless the magnet moves relative to the coil. If it does, a voltage is induced in the coil of wire. The heavy weight is a 2oz (60g) fishing weight suspended from a small magnet supported in the centre of a coil of wire (the coil is in fact a winding of a transformer with the metal core removed). This is in turn suspended on a four strand elastic 'spring' (pieces of fishing pole elastic). So building this project means a trip to the local hardware and fishing stores.

Now providing that the seismic detector is securely connected to the earth, then when the ground moves the weight will remain still whilst the main part of the unit will move with the ground. Thus the coil will be moved around the magnet and according to Faraday's Law the coil will have a voltage induced across its ends. This signal is taken to a high stability amplifier and then to an electrical chart recorder for the plotted results. The only problem that remains is that once the weight starts to move it will tend to bounce for some time. Thus damping has to be added to the system. This damping comes in two forms. The four string suspension will stop side to side swinging whilst resistive damping from the low voltage transformer coil cuts down electromagnetic oscillations.

The amplifier is based on the use of an instrumentation amplifier chip, the characteristics of which are covered in another part of the magazine. The main circuit is shown in Figure 3 with all of the power supply system. You will note that the resistor Rg has not been given a value in the circuit since it may be varied to select the gain of the amplifier. Table 1 shows gain to resistance values, closest 1% tolerance resistors, the nearest common value and the gain it gives. In the prototype and in the PCB layout Figure 4 a DIL switch with six positions gives seven gain options (all 'off' is gain times 1 and then with switches 1 to 6 'on' gives gains of 2, 5, 10, 20, 50, and 100. Only one switch is to be on at a time to get an accurate gain).

The high common mode rejection of the in-amp is used to remove 50Hz mains hum that may be picked up by the coil. The amplifier output passes to a 1mV recorder and since it is possible to see 0.01mV drift over long time intervals the amplifier has to be of a special design. Initial building trials using a TL074 chip failed miserably as can be seen in the article on Instrumentation Amplifiers. The recorder was chosen as the only simple

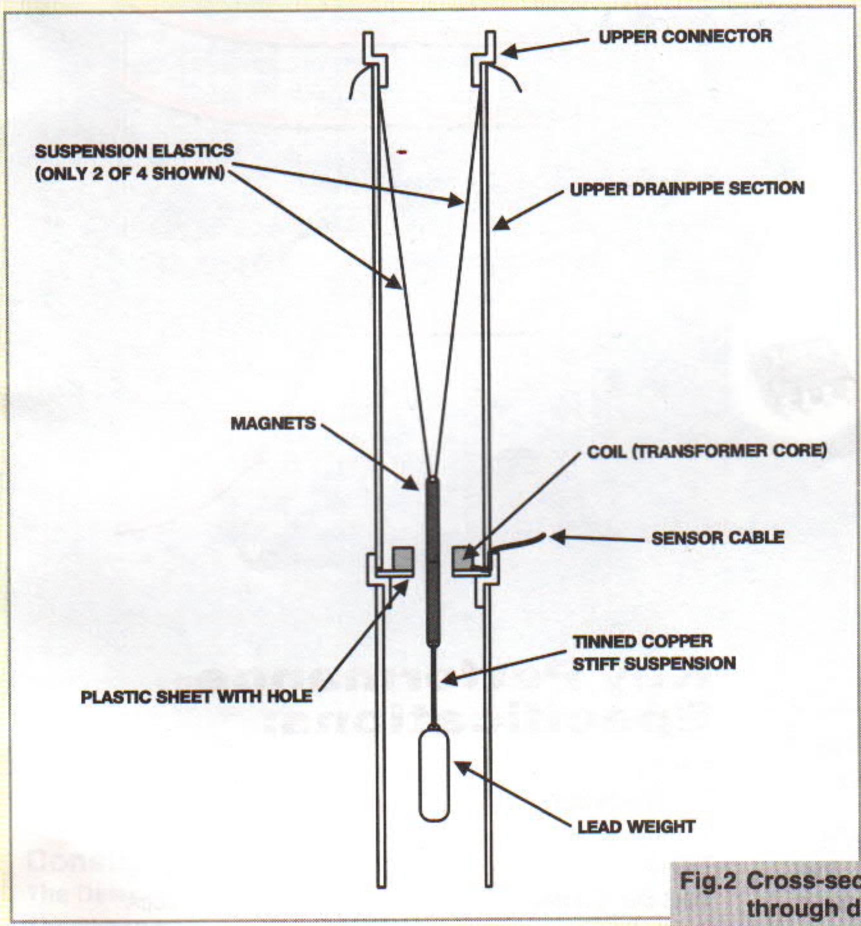
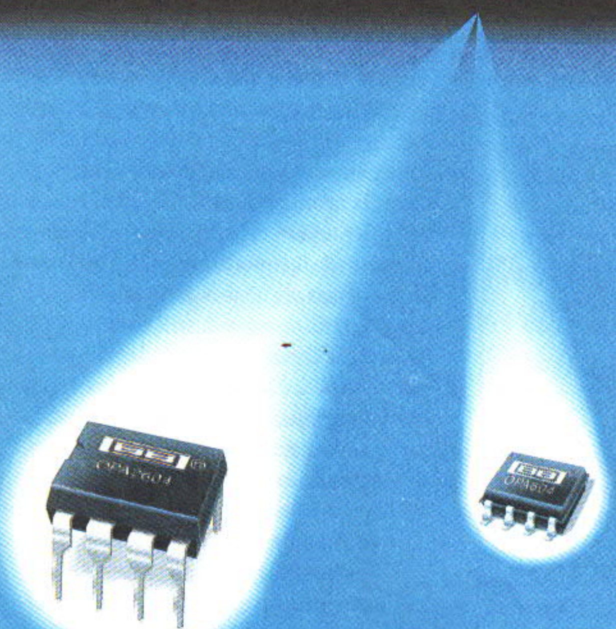


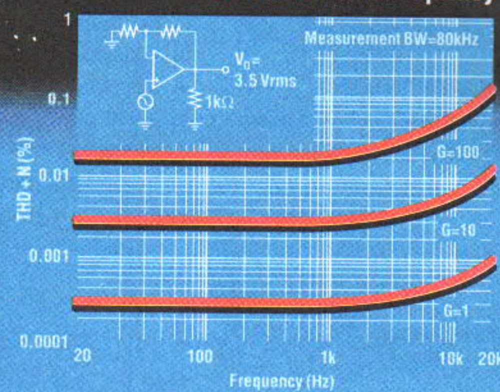
Fig.2 Cross-section through drainpipe showing detector

stless
rth

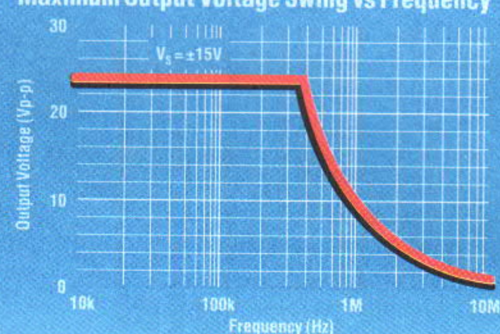
Two Op Amps Deliver High Speed, 0.0003% THD+N



Total Harmonic Distortion+Noise vs Frequency



Maximum Output Voltage Swing vs Frequency



More for Less

With our new single OPA604 and dual OPA2604 FET-input op amps, you'll get 20MHz gain-bandwidth, 25V/µs slew rate, and very low harmonic distortion. Just right for active filter, spectrum analyzer, and transducer amplifier applications, and more. They're also pin compatible with the "industry standards". Just drop it in and power it up. If you're working in dynamic signal processing, you should be working with the OPA604 and OPA2604. Better performance at a super price is hard to beat.

Great for Audio

The sound quality of the OPA604 and OPA2604 is excellent. Their low noise, low distortion, and low price make them ideal for professional audio equipment, compact disc players, and digital/audio tape player/recorders. And, their wide supply range and ability to drive 600Ω loads is a plus.

Key Performance Specifications:

Slew Rate	25V/µs
Gain-Bandwidth	20MHz
Noise	10nV/√Hz
THD+N	0.0003%
Input Bias Current	100pA
Supply Range	±4.5V to ±24V

Unity-Gain Stable

8-pin Plastic DIP, 8-lead Plastic SOIC

For further information contact the sales office on (0923) 233837 or Fax: (0923) 233979.

Burr-Brown International Limited
1 Millfield House
Woodshots Meadow
Watford
Herts WD1 8YX

BURR - BROWN®

way to produce a permanent record in graph form of the amplified output. Other options may be possible like computer data logging but the cost of such will very likely be higher. The chart recorder is in any case a very versatile output device where slow changes, or transient signals occur. My first long-term recording was for ten days on a single sheet of paper that cycles through the recorder. There will be on average only one seismic signal of magnitude 6 every three days so the seismograph will be recording for days at a time if useful results are to be obtained and may become a year round venture. To allow for offsets in the amplifier circuit a zero control was added to correct these by offsetting the reference terminal of the instrumentation amplifier. This offset voltage must be very stable if the recorder output is not to drift significantly. It uses two very stable 2.5V reference sources supplying the ends of a 20 turn potentiometer. The potentiometer tap will be between +2.5 and -2.5 volts and this is divided by 1000 before passing to the low drift op-amp IC3. This IC provides the offset voltage required but in addition has a very low output impedance, an essential requirement if the common mode rejection of the instrumentation amplifier is not to be seriously degraded.

Construction

The Detector

The seismic detector is based on the hanging weight principal where the suspension is on a springy cord. Cut two 18inch (0.5m) sections off of the drainpipe.

Take the PCB mounting transformer and remove the metal laminations. This will require a large force in the early stages, but it pays to be careful in order to preserve the coils. Cut a disc of plastic so that it fits inside the wide end of a drainpipe connector and it rests on the shoulder that the drainpipe would sit on in normal use. Drill a hole in the centre of

Fig.3 Drainpipe Seismometer circuit

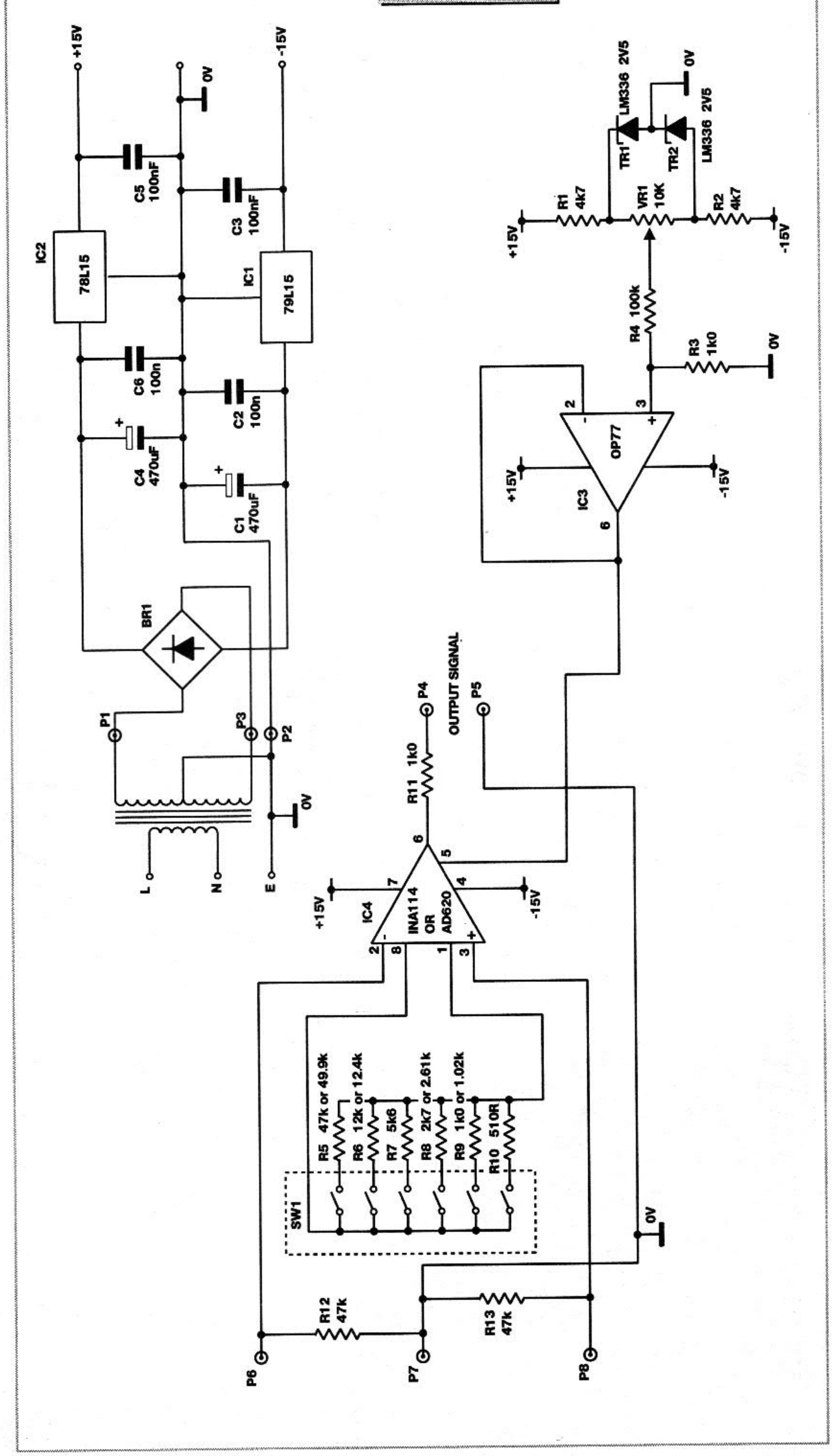
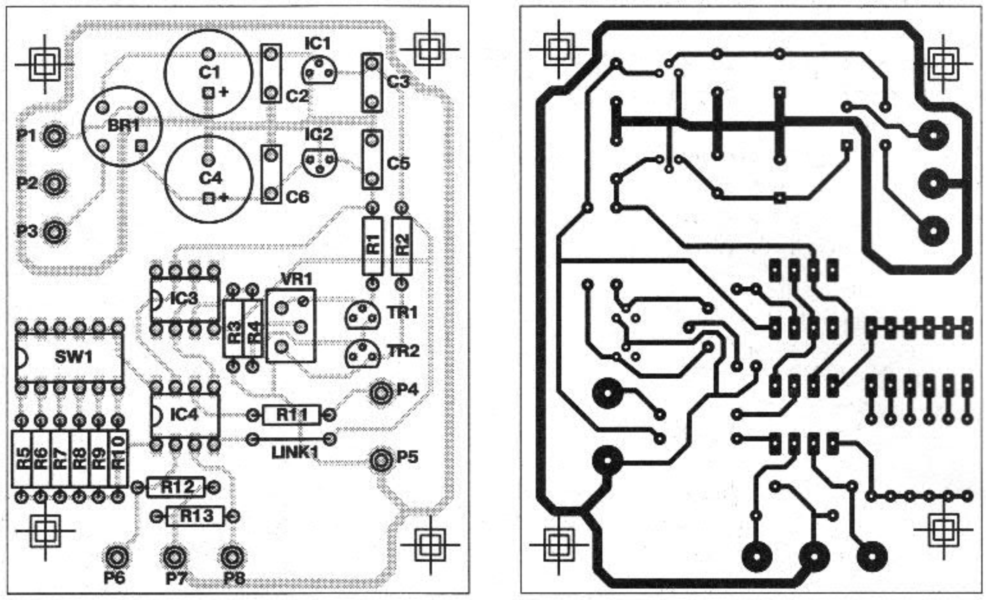


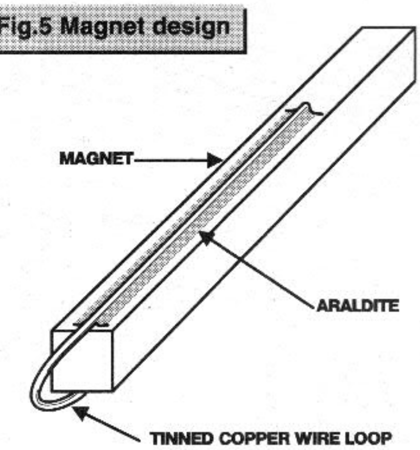
Fig.4 Component positioning and foil

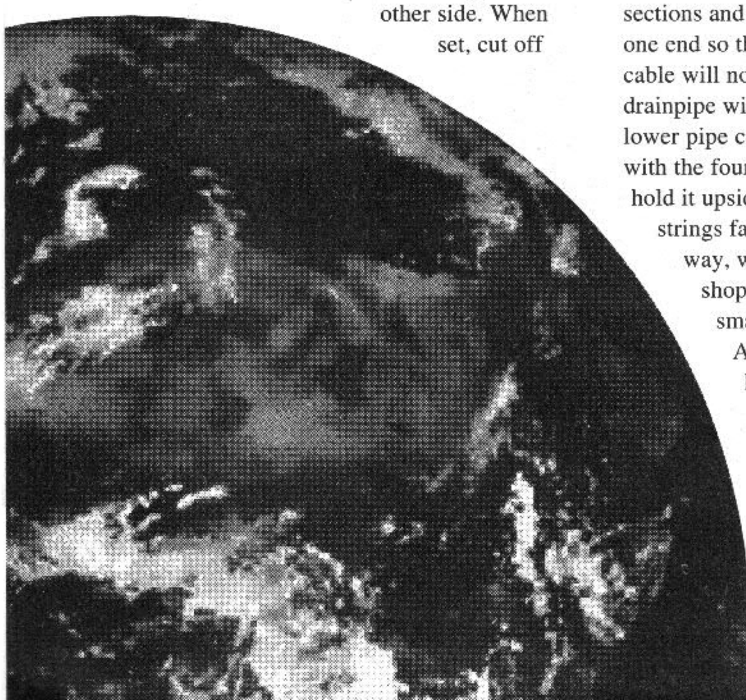


the plastic disc and widen this out until the hole is the same size as that of the transformer coil. If you are lucky, the coil former will have projections to locate it in the hole within the disc. Solder a 22 ohm resistor across each of the low voltage windings. Glue the coil onto the disc of plastic and the disc into the drain connector. Leave this to set. Drill a hole in the side of the connector to take the twin core plus screen cable, bear back the screen and connect the two cores to the 240V coil ends leaving the screen unconnected. Cut off an 8 inch section of this cable as you will need it inside the amplifier box. Fit the stereo jack plug to the other end of the two core cable from the coil.

To ease assembly, the magnet is actually two magnets that pull together in the final stage. Take both magnets and find which ends pull together. Take them apart and without losing the orientation Araldite a 6 inch piece of about 26 gauge tinned copper wire along one of the flat edges of each magnet with the ends pointing away from each other. When the Araldite has set fold the wire back up the opposite face leaving a loop at the end and Araldite the wire up the other side. When set, cut off the excess wire. You should now have two magnets looking like the illustration in Figure 5 and they should pull together as a single unit with a loop at each end. Take an 8 inch length of the same wire, pass this through the loops on one of the magnets and the lead weight. Pull the wire through so that it meets in the middle and twist the wire so that the finished section looks like Figure 6. Cut two 3ft (1m) sections of the pole elastic and without stretching them, find the centre and tie the other magnet to the centre point. The easiest knot is to push the elastic through the magnet's wire loop then push the magnet back through the elastic. Take one of the 18 inch drainpipe sections and cut a notch in one end so that the two-core cable will not be compressed and the drainpipe will rest on the disc in the lower pipe connector. Take the magnet with the four elastics connected and hold it upside-down so that the elastic strings fall straight, Fig7a. By-the-way, whilst in the fishing tackle shop you may like to buy a small pair of artery forceps. Anglers use these to remove hooks since they give a secure grasp and they lock into place by themselves. For our project the locking makes it much easier to hold all of the elastic strings together at one time. Take hold of these strings at the furthest end in one hand or with the artery forceps and turn the right way up. Attach the lead weight and other magnet and hold up the assembly close to the upper drainpipe section and the sensor-connector, Figure 7b. You can now mark a position on each of the pieces of elastic that show the top of the upper drainpipe with the magnet hanging central to the coil with the elastics equally stretched. Remove the upper drainpipe from the sensor-connector, drop the weight and magnets down the upper drainpipe section and whilst holding the elastics at 90 degrees to each-other set the points marked on the elastics at the upper drainpipe edge. Push the upper connector into the other end of the drainpipe section locking the elastics in place. You do not need to push hard or the elastic will break. Check the position of the magnet

Fig.5 Magnet design





hanging in the upper drainpipe, roughly half of the magnet attached to the lead weight should be showing, the rest being inside the upper drainpipe. Adjust the magnet's position if necessary by pulling equally on the elastic strings.

Pull the two magnets apart, holding onto the upper magnet, feed the lower magnet through the sensor coil then snap on the second magnet with its weight.

The final set-up depends on how far you are prepared to go with the installation. The ultimate is to cement the lower drainpipe section into a concrete block within the earth so the detector stands upright of its own accord. A more simple solution is to screw a single drainpipe support bracket onto a house wall and to stand the bottom pipe section on a concrete floor. An inside wall of the garage would be good for this as it is out of the way. Once the top end is held in place the bottom can be moved to ensure that the detector is vertical and that the magnet is in the centre of the coil but not touching it at any point. Simpler still is to rest the whole assembly against an outside wall, again using the drainpipe support bracket to get the detector in a vertical position. This works reasonably on concrete floors; try it on an upstairs

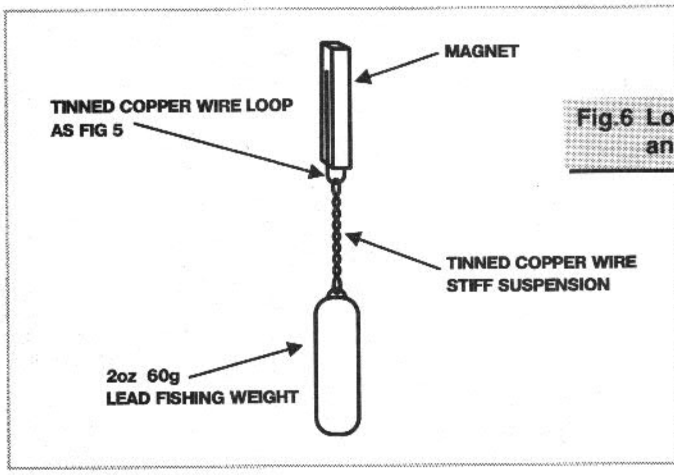


Fig.6 Lower magnet and weight

floor and you cannot walk quietly enough to stop the seismograph going into violent oscillation. When you are certain the magnet hangs exactly in the centre of the coil without touching then you can cover the top with a plastic sandwich bag to keep out drafts which would otherwise set the sensor in motion.

The Amplifier

The reasons for the type of amplifier chosen are given elsewhere. The amplifier has a differential input from the 240V coil and a single ended output. To allow offset correction the stage around IC3 is included. For experimental purposes the amplifier was given a switched gain with SW1 and the gain setting resistors R5 to R10. This allows the gain to be set from 1 to 100 very easily, although the range 20 was found to be most useful in the prototype. Due to the design characteristics of the instrument amplifier the gain setting resistors come from the 1% tolerance range. It would be possible to use resistors from the 5% range that are commonly available to amateur constructors. This results in the gain errors shown in Table 1.

Construction of the amplifier is very simple. Due to the cost of the two amplifier chips it was decided to use

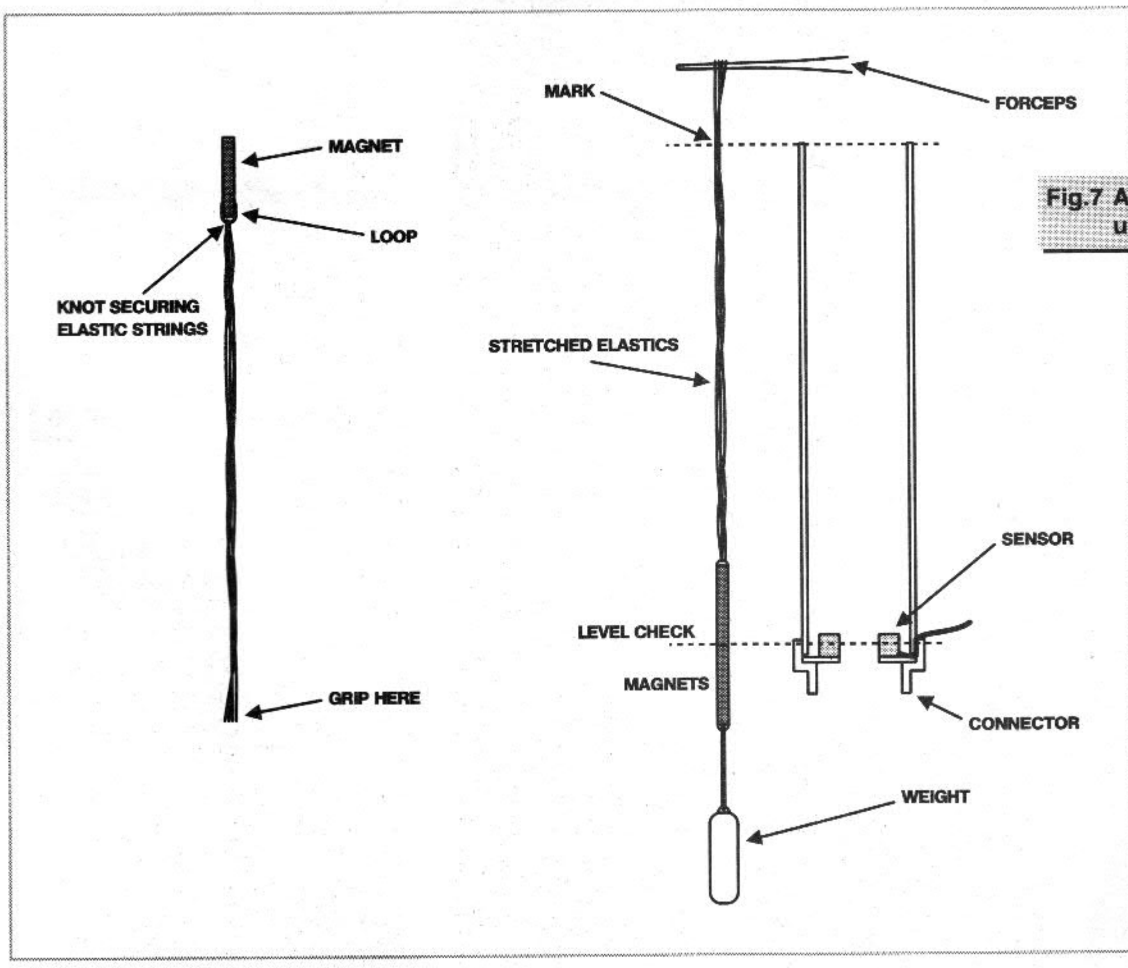


Fig.7 Alignment of upper section

sockets for these. In fact insert these sockets first as these give a guide for the other components, then solder these and the terminal pins in. Do not plug in the amplifier chips until you have tested the power supply and completed the other board construction. The two high-stability regulators have only two of the three pins of their TO92 case used so the third may be left unsoldered. The full pinout is given for orientation of the devices. It may be best to build the power supply and regulator sections initially then test with a temporary connection to the transformer. There should be around 22V across the two reservoir capacitors C1 and C4 remembering that with respect to ground C4 should be positive and C1 negative. At pin 4 of both IC3 and IC4 sockets you should find -15V +/- 5% and at pin 7 of the same IC's +15V +/- %5. If this is correct you are unlikely to blow up the two amplifier chips. With the high stability regulators REG1 and REG2 installed you should find + and - 2.5V across the potentiometer VR1. If these tests are OK then you can precede to final construction. The layout in the case, which must be metal for adequate electrical screening, is not too important providing you keep the signal wires and connectors away from the mains cable and terminals on the transformer. Mounted into the box is the transformer with a 30V centre-tapped output connected to the on-board PSU unit, as shown in Figure 8. The amplifier input uses a small section of the twin core plus screen cable between the connector and the PCB pins, the output to the chart recorder uses the same audio coax. Set switch 4 to the 'on' position on the amplifier to select gain times 20, using R7.

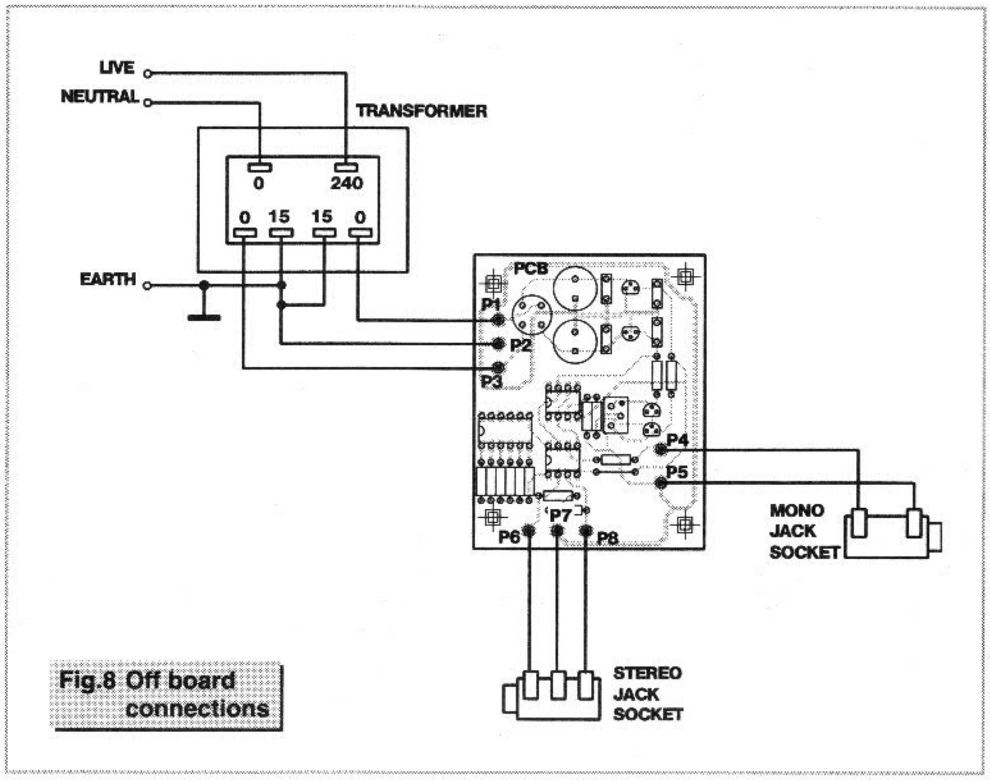


Fig.8 Off board connections

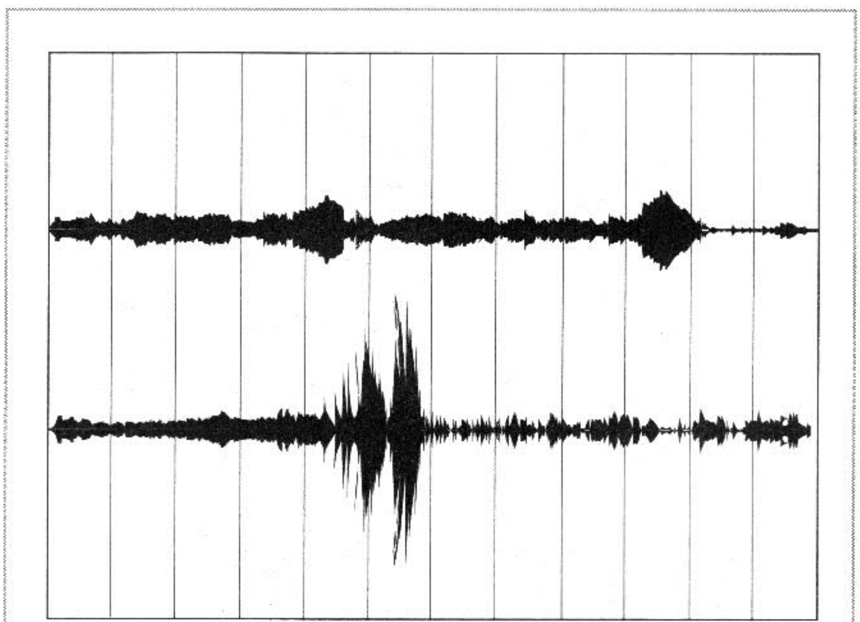


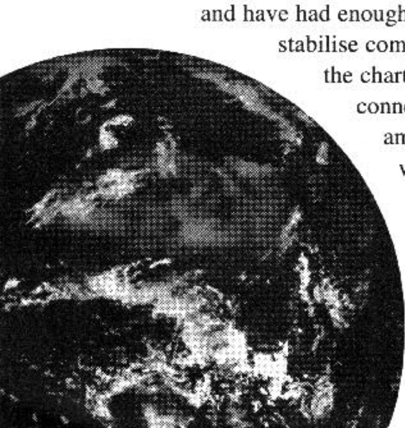
Fig. 9 Typical Chart recording

Table 1

Desired Gain	1% Resistor	Actual Gain	5% Resistor	5%Gain
1	No Connection	1	N/C	1
2	49.9k	2.00	47k	1.94
5	12.4k	5.03	12k	5.16
10	5.60k	9.93	5.6k	9.93
20	2.61k	20.15	2.7k	19.52
50	1.02k	50.02	1.0k	51
100	510R	99.04	510R	99.04

Final Set-up

By now the detector should be set-up and have had enough time to stabilise completely. Set up the chart recorder and connect the amplifier to it, without the sensor connected at the moment. By using the zero controls and shorting out the input to the recorder set up the recorder zero. Remove the short and you can now adjust the amplifier zero using the internal potentiometer. Then plug in the sensor. The pen will begin to dance around, so reduce the sensitivity of the recorder until the pen is only moving about 1 division. With luck you will not have set up in the middle of some seismic activity and when you start to monitor you will see the sort of output



Parts

Resistors

(all 1% metal film)

R1,2	4k7
R3,R11	1k0
R4	100k
R5	49.9k or 47k
R6	12.4k or 12k
R7	5k6
R8	2.61k or 2k7
R9	1.02k or 1k0 as R3
R10	510R
R12, R13	47k
VR1	10k type 64Y 20 turn pot
Resistors on coil	22R by 2

Capacitors

(pin spacing in inches given in brackets)

C1,C4	470uF 25V radial electrolytic (0.2)
C2,C3,C5,C6	100nF ceramic (0.2)

Semiconductors

IC1	79L15
IC2	78L15
IC3	OP77 or OP177 or OP07 must be low drift type
IC4	Burr-Brown INA114 or Analogue Devices AD620
Tr1,Tr2	LM336-2.5 voltage regulators
Br1	W02 Bridge rectifier 100V 1A or better

Additional Items

3 watt rating mains transformer PCB mounting, output 15-0-15V
(Other voltages usable if value of resistor soldered to coil is modified)
Only the 240V coil used for signal pickup. 240V input with 2 by 15V outputs at 3 watt rating chassis mounting transformer
Diecast aluminium box for the amplifier
(Plastic cases not suitable as the circuit must have electrical sheilding).
Stereo jack plug and socket for the amplifier input
Mono jack plug and socket for amplifier output
Two core and screen cable for input connection
Audio coax for output connection
6 way DIL switch
PCB standoffs
1mm PCB pins
There may be difficulties in obtaining the instrumentation amplifier and the high stability operational amplifier as well as the correct gain setting resistors. The author can make these available if enough people are interested. For the output the Lloyd Instruments G450X recorder is to be recommended for its low cost of £650 and the fact that it is made in England.

Hardware Store Parts

68mm PVC drainpipe (this comes in a piece about 8ft long)
2 drainpipe connectors
Small piece of stiff plastic sheet
(2mm thick and at least of a size to cover the drainpipe connectors)
Glue for the drainpipe connectors and plastic sheet-Epoxy Adhesive (Araldite)

Fishing Store Parts

2oz (60gm) Ledger weight, peardrop shape
Small artery forceps
Medium fishing pole elastic about 0.5mm in diameter, which will stretch by approximately 100% with the 2oz weight tied to the end. Author used Autan-Peche Zim No.4

rather like Figure 9. In this the chart paper has been formed into a loop that takes 24 hours to pass through the chart recorder. Thus one long sheet contains many days of recording as each day the pen is moved upwards using the zero control on the recorder. It may be possible to build an amplifier incorporating this time shift operation but this was not done in the prototype. Figure 10 shows an early recording of some activity that occurred at 23.20 hours on Thursday 25th February 1993. Communication with the British Geological Survey is pending at the moment. I am hoping that I may be able to get hold of a listing of seismic activity for the initial period of my tests and compare this with the results that I have obtained. So far I have eliminated domestic effects that may cause detector disturbances, such as doors banging, washing machine and other household appliances. Jumping near the detector gives an output for 20 seconds. Late at night these household effects will disappear anyway. I have found a signal attributable to traffic on the M27 which is about a mile away, but again much less than the seismic disturbances I believe I have recorded. An update will follow when I can fully analyse my results.

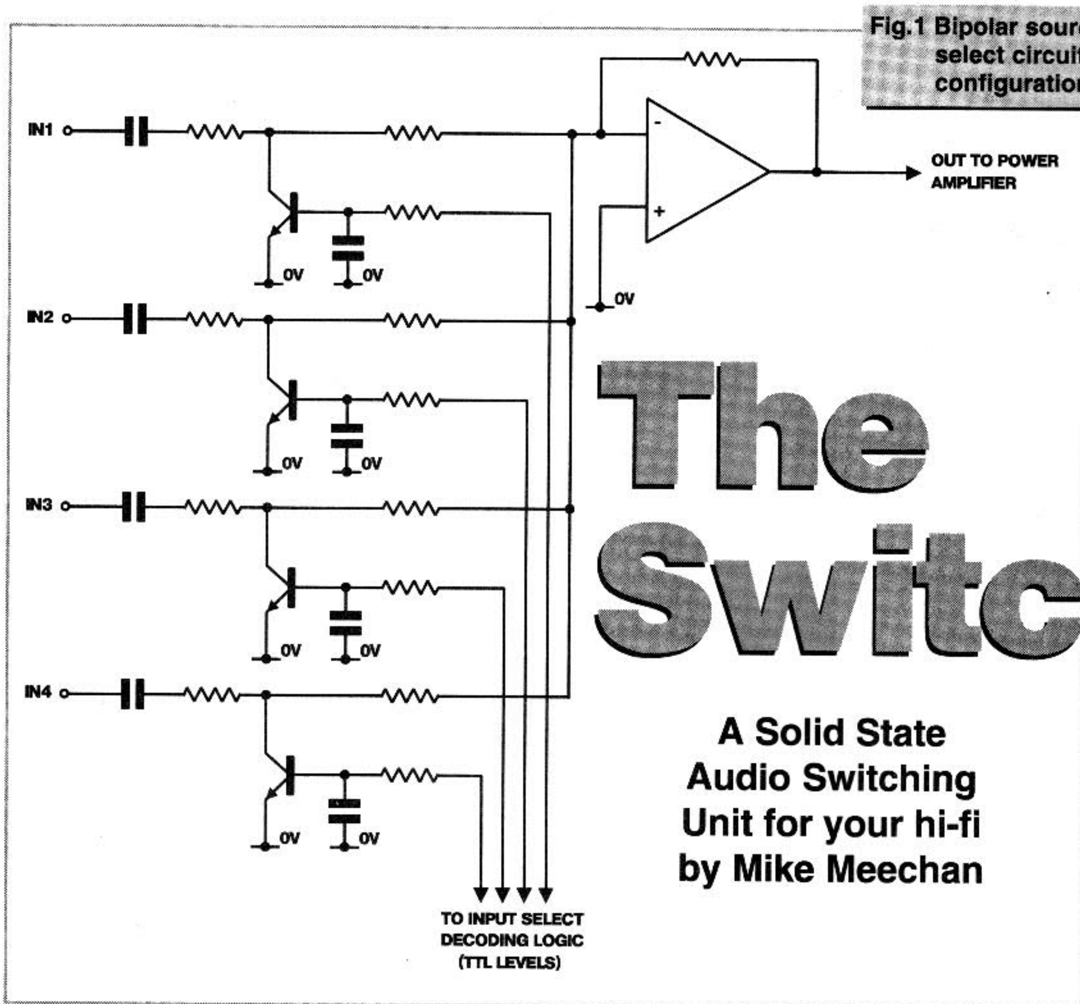


Fig.1 Bipolar source select circuit configuration

The Switcher

A Solid State Audio Switching Unit for your hi-fi

by Mike Meechan

Most of us remember combination preamp/power-amp hi-fis of yesteryear. Simple, uncluttered facias were complemented only by an ON/OFF switch, a TAPE/SOURCE switch, a VOLUME control, and if the maker was feeling particularly generous, BASS, TREBLE and BALANCE, with perhaps a SUBSONIC FILTER thrown in.

Then the eighties came, and so did hi-fi components which you could have in any colour so long as it was black. Next, LED, fluorescent or gas discharge audio power meters were the rage. Then it was to be then the turn of Compact Disc.

Finally, the video industry grabbed its share of the home entertainment market. Although it was only pop videos initially, feature films followed, and just about all films on video, unless they're very old, now come with hi-fi audio, while some of the latest include surround-sound or similar soundtracks. The introduction of NICAM sound to television broadcasts did the same for television as hi-fi did for video. Camcorders with hi-fi audio recording then arrived. As for the future, RDAT and DCC, although not yet widely accepted by the public, and soon likely to be another possible source of audio signal.

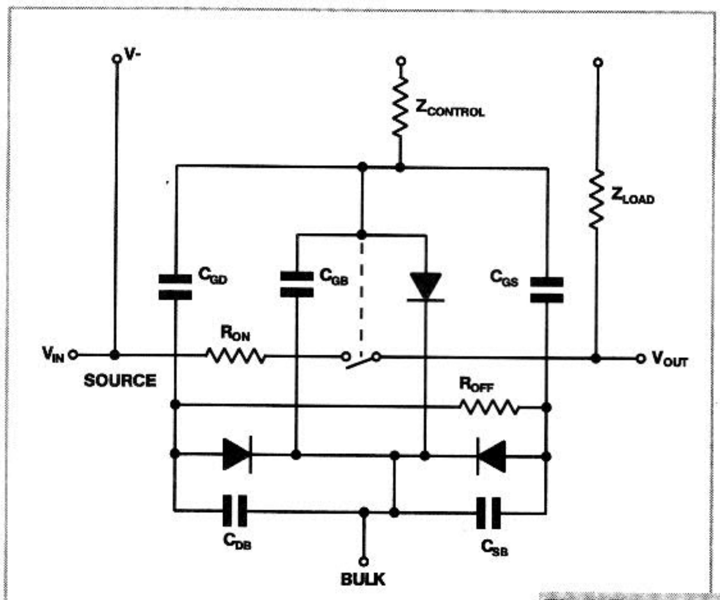


Fig.2 Equivalent circuit of P-channel MOSFET

The Ins and Outs

That there is now a smorgasbord of different impedance, level, audio or related sources all battling for your overloaded amplifier. A technophile's house might contain Disc (Vinyl and Digital), Tuner, Cassette (Analogue and Digital), and Video or Television (which normally controls the switching of other video-related sources like Satellite and Camcorder). There may also be more than one VCR or cassette deck. This makes a total of nine possible audio sources.

What is that I hear? Your amplifier ISN'T overloaded...You've bought one of those flashy, new, multi-source types which can emulate the sound of your

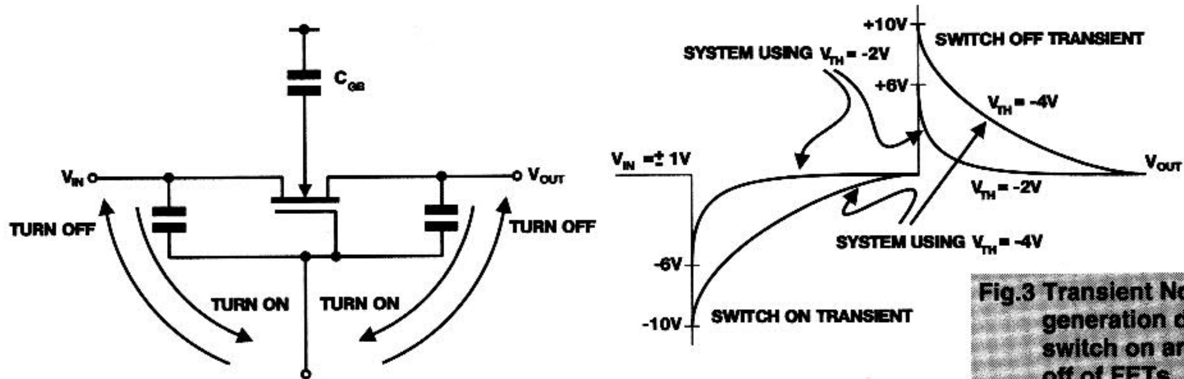


Fig.3 Transient Noise generation during switch on and switch off of FETs

favourite jazz club right down to the condensation streaming down the walls, and a back panel with thirty sets of phono connectors? Shame on you.

If that is the case, this article is most definitely NOT aimed at you. If you've not outlayed outrageous sums of money on the latest pre-amp, must you make do with a homebrew four-in-one-out passive switch box, and relinquish your remote-control, couch-potato status? Not if you build The Switcher.

The circuit has been designed so that it is easy to increase the number of input sources. It can be constructed in its basic state and expanded as required. The Switcher can grow alongside a burgeoning hi-fi system.

There is also the option of adding an infra-red remote control unit and a VCA. This can be used to control the volume setting from the remote handset. I thought of including some optional remotely-operated tone controls, but could find no reasonably priced ICs which had distortion performance in line with the rest of the system, ie better than 0.005%. In the interests of retaining some audio fidelity in the system, this was abandoned.

This month, we'll look at the problems which this type of control system can pose for the unwary, and explore methods of achieving good performance. We'll finish by presenting the switch unit in its basic state - Input/ Output board and PSU. Next month we'll look at the optional add-ons (remote control, VCA) and the component overlays, construction details mechanical/housing possibilities.

The Technology of Audio Switching

Although superficially a trivial technical exercise, the remote or electrical control of audio sources poses many problems. There have been many dissertations about the merits or otherwise of this type of control. These tend to centre more around the "otherwise" than around the merits. Designers fret about the detrimental effect which the switching operation can have on the absolute

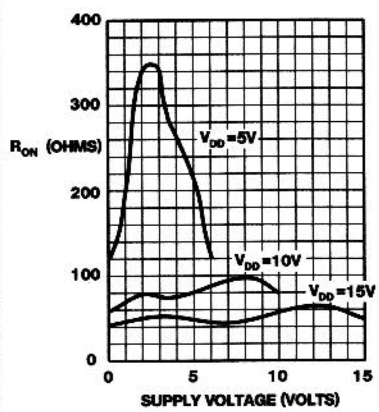


Fig.4 Graph of variation in R_{on} of 4066 channel

fidelity of the source being switched.

Relay Race

Remote routing of audio can be done in a variety of ways. These can be implemented, essentially, in one of two ways - electromechanical or non-electromechanical (solid-state). The electromechanical approach encompasses relays and devices such as Uniselectors (electrically-activated, multi-way, multi-bank rotary switches used, at one time, to route telephone calls). These types have been preferred by the subjective or perfectionist brigade of audiophile designers and listeners. The absence of any solid-state devices in the audio pathway, and the virtually absolute isolation between the in and out pins, means an almost perfect switching action, with no added distortion or noise. Given this, it is the drive circuitry, and basic dependency on the mechanical integrity of the relay, rather than the process which the audio signal undergoes as it is switched, which can cause problems. Good quality relays, (with long term reliability prospects for the electromechanical drive actuation, and for the switch contacts) are expensive, since the package must be sealed to exclude all air, and the contacts must be coated with a noble metal such as silver, gold or electrum. Reducing the size of the package for minimum weight and bulk makes the relay even more expensive.

In addition, purely mechanical considerations for this type of remote switch also encompass the layout and design of the PCB. The fundamentally inductive nature of the relay means that a lot of energy in electro-motive force is expended each time the device is activated or de-activated. This energy can find its way by devious paths into the audio, and cause splats, clicks and other undesirable sonic disturbances. Physically isolating the audio and drive currents lessens these effects - no mutual inductance coupling - as does electrically isolating audio supply/ ground from logic supply/ground. RF design rules, ground planes, hefty earth tracks, and soft start drive circuitry all help to make the relay a completely transparent switch. Despite the cost and complexity of these measures, they are used in many excellent and highly-rated pre-amplifiers, mixing consoles, etc.

Solid-State Switching

There are several ways of implementing a solid state switch. Bipolar transistors can be used, although only as muting switches, where the device merely clamps the input signal to earth. The physical construction of this type of transistor doesn't allow bi-directional signal flow, and the control signal (onto the base terminal) is inadequately-isolated from the main signal path. Nevertheless, with small signal levels which will yield a reasonably low level of distortion from the switch, arrangements such as that shown in Figure 1 have been used with some success in budget audio equipment.

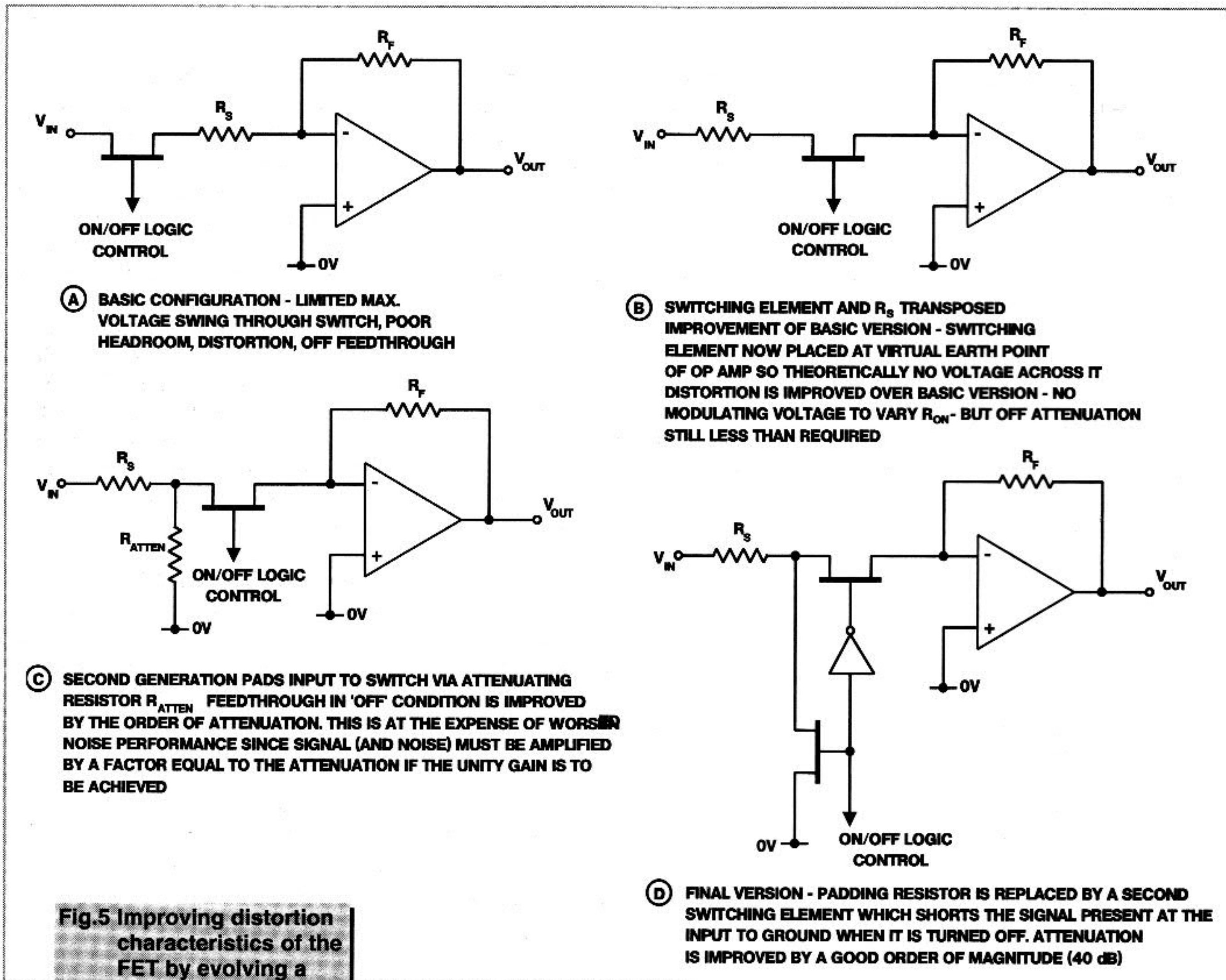


Fig.5 Improving distortion characteristics of the FET by evolving a virtual earth design

Chips with Everything

Most contemporary designs, however, use of the Field Effect Transistor's superior attributes where it matters - good, high, on/off impedance ratio, and a high degree of isolation between the control signal and the audio being passed or blocked by the device.

Back-to-back FETs - or more correctly, MOSFETS - allow bi-directional signal flow and multiplexing or demultiplexing of signals. The 4016, 66, 51, 52 and 53 from the 4000 series of CMOS ICs are fairly representative of the construction of early integrated analogue switch packages. These have been superseded in many respects by newer - albeit slightly more expensive - packages from companies such as Analog Devices, Harris Semiconductor and Siliconix. However, from a hi-fi audio point-of-view, most fail either in distortion, or maximum signal handling capability, or both. Rudimentary, textbook-style switching configurations for the 4000 series CMOS analogue devices achieve quoted distortion figures around 0.04% and a maximum signal handling capability of +18dBu when the devices are powered from 18V rail-to-rail. Measured distortion was found to be an order of magnitude worse - typically 0.4 - 0.1% - which is obviously short of the figure demanded by today's discerning listener. Even the newer switches suffer, since most are intended for video applications where 1V peak-to-peak is the accepted standard. They are also intended to work into low, picture or "video-esque" type impedances which are around the 75R mark, and considerably lower than those commonly encountered in audio work. FETs, whether discrete or integrated, also have the nasty tendency to cause clicks as they change states. This is caused by a phenomenon known as control feedthrough or charge transfer, and is the result of parasitic capacitances inherent in the physical make-up of the FET. See Figure 2. Changing the voltage on the gate - the control port - from one value or polarity to the other, as in Figure 3, causes an undesirable transfer of the charge stored on these capacitances to the output. This is obviously potentially damaging - no pun intended - to any amplifier or loudspeakers connected further down the reproduction chain.

So far, the FET approach hasn't stood up too well to scrutiny. Just what can we do about the distortion, signal handling, and click problems? Distortion in a FET is caused by the absolute value of the audio signal altering the small but finite value of the device's 'o' impedance. Not only is the R_{ON} modulation effect supply voltage-dependent, as shown in Figure 4a, but is also dependent on the magnitude of the analogue signal input voltage. Large signals cause more of this effect - which is, essentially, amplitude modulation - and so worsen distortion performance.

Vanishing Distortion

This gives us a clue to a cure. If we reduce the signal level through the switch, the distortion will also reduce. This can be done by attenuating the input signal, as in Figure 5a. Sadly, however, this is unsatisfactory, as it compromises headroom, and worsens signal-to-noise ratio. Amplifying the signal back up to its original level also amplifies any noise by the same factor. Putting the FET next to the virtual earth point of an op-amp inverter means that, in theory, there is no signal voltage across the FET, and so the modulating effect, and the distortion, are magically reduced. Arranging for another FET, a shunt one this time, to ground the signal when the series FET is switched off raises the attenuation ratio by a good order. Figure 5d shows the ultimate evolution of this simple and cost-effective type of switch. It is one possible arrangement and can provide a low distortion, high headroom switch.

Unfortunately, with most integrated switches, getting rid of the clicks is a virtually impossible task, since we have no outside point to control directly the gate of the signal FETs. The transition time between the change in logic states causes the problem, since the internal architecture of the IC causes a definite threshold between on and off logic states. The switch changes from the on to the off state very quickly, and we have no control over it; this means a theoretically infinite rising or falling edge as the switch change states. Since the magnitude of the click or glitch depends on the difference in voltage levels of the two logic states of the control waveform, and also on the time taken to change from one state to the other, using smaller control voltages, or slowing down the edge of the switching waveform would seem to be a cure. Obviously, using a slowly ramping control waveform isn't applicable to the integrated package analogue switch, but it can be used with discrete designs. Figure 6 shows a typical manifestation of this type of discrete switch. The FET changes state over a period of 20ms or so. Therefore the same charge is transferred at change of state of the switch, but over a sufficiently log period that the charge amplitude is small enough to be lost in the noise floor of the op-amp.

One design which uses this approach, but in an integrated form, is the SSM2142 IC from Analog Devices. Figure 7 shows the internal chip architecture. From the Specification Table, Figure 8, most aspects of its noise and distortion performance are limited only by the quality and fidelity of the input sources, and the characteristics of the op-amp output buffer stage (if fitted). This is The Switcher's IC.

Inside The SSM 2412 Dual Audio Analogue Switch

The IC comprises three major functional blocks, each duplicated in the second channel of the chip. These blocks are:

1 'T' Switch

This consists of two JFET switches, SW1 and SW2 of Figure 7, which are the main SERIES switches, and a third SW3, connected as a shunt device.

2 Ramp Generator

Refering to Figure 9, this part generates a ramp voltage when commanded by the Control Input. A LOW-to-HIGH TTL logic transition at the Control Input initiates a ramp which alters states from a -7V level to a +7V level, and in a time interval of 12ms. A HIGH-to-LOW transition, on the other hand, causes a ramp in the opposite direction, from +7V to -7V, over a period of 4ms. A secondary function of the Ramp Generator is to supply the bipolar +/-3V reference voltages for the Switch Control. Figure 10 shows the relevant timing diagrams for appropriate parts of the circuit.

3 Switch Control

The ramp from the last section is applied to two discrete differential amplifiers comprising Tr5-Tr8 in the switch schematic of Figure 7. These are in the Switch Control section of the IC, with one amplifier referenced to +3V and the other to -3V. There are two Switch Control Outputs: The Main Switch Control drives two 250uA current sources controlling the inverting inputs of each op-amp. When the current sources are ON, they cause a gate-to-source voltage of approximately 2.5V. This is sufficient to turn OFF both SW1 and SW2 JFETs. When the current sources from the Main Switch Control are OFF, each of the op-amps acts as a unity-gain follower ($V_{GS} = 0$) and both of the JFET switches will be ON. The Shunt Switch Control controls the shunt switch of the "T" configuration, SW3.

Switch Operation

As mentioned earlier, the theoretically infinitely-fast change in switch states of analogue switches causes clicks as the switch changes. This is not a problem with the SSM2412 as it is designed to ramp on or off gradually, over a period of milliseconds. This soft transition prevents the popping or clicking often associated with audio switching.

Consider what happens when we wish to turn the switch ON. The Control Input is initially LOW and the Ramp Output is at -7V. This means that the Main Switch Control is HIGH making each current source provide 250uA to the system. These currents, in turn, generate a 2.5V gate-to-source back-bias for each JFET switch (SW1 and SW2), making them turn OFF.

Conversely, the Shunt Switch Control is at a negative voltage level, and so holds the shunt JFET, SW3, in the ON condition. Undesired control feedthrough signals from the two series JFET's are thus shunted to the negative supply rail through SW3.

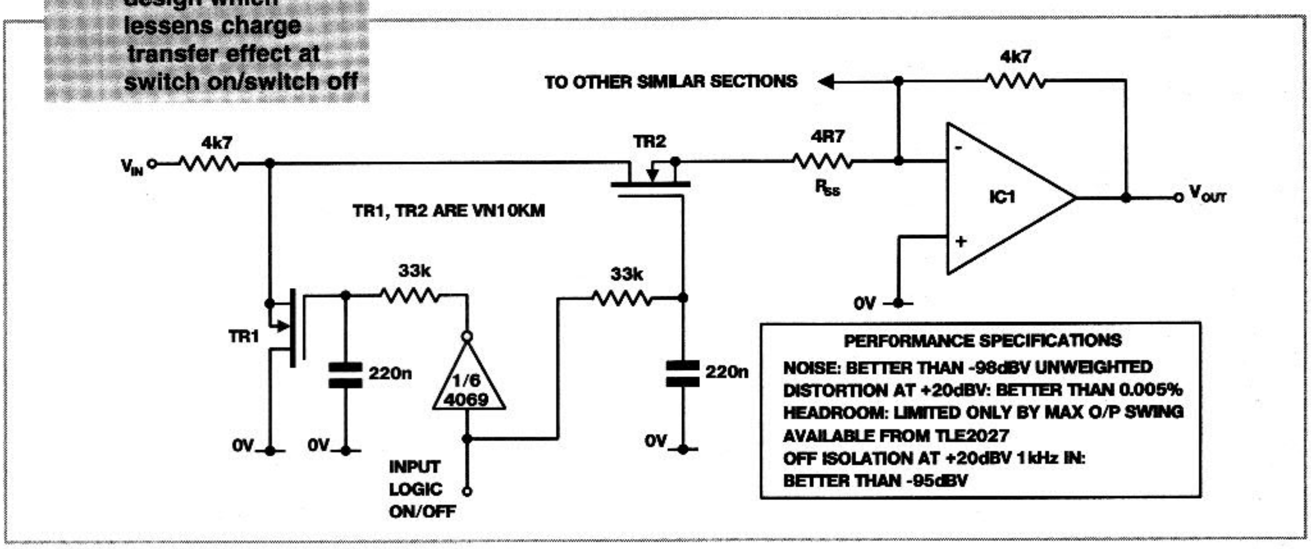
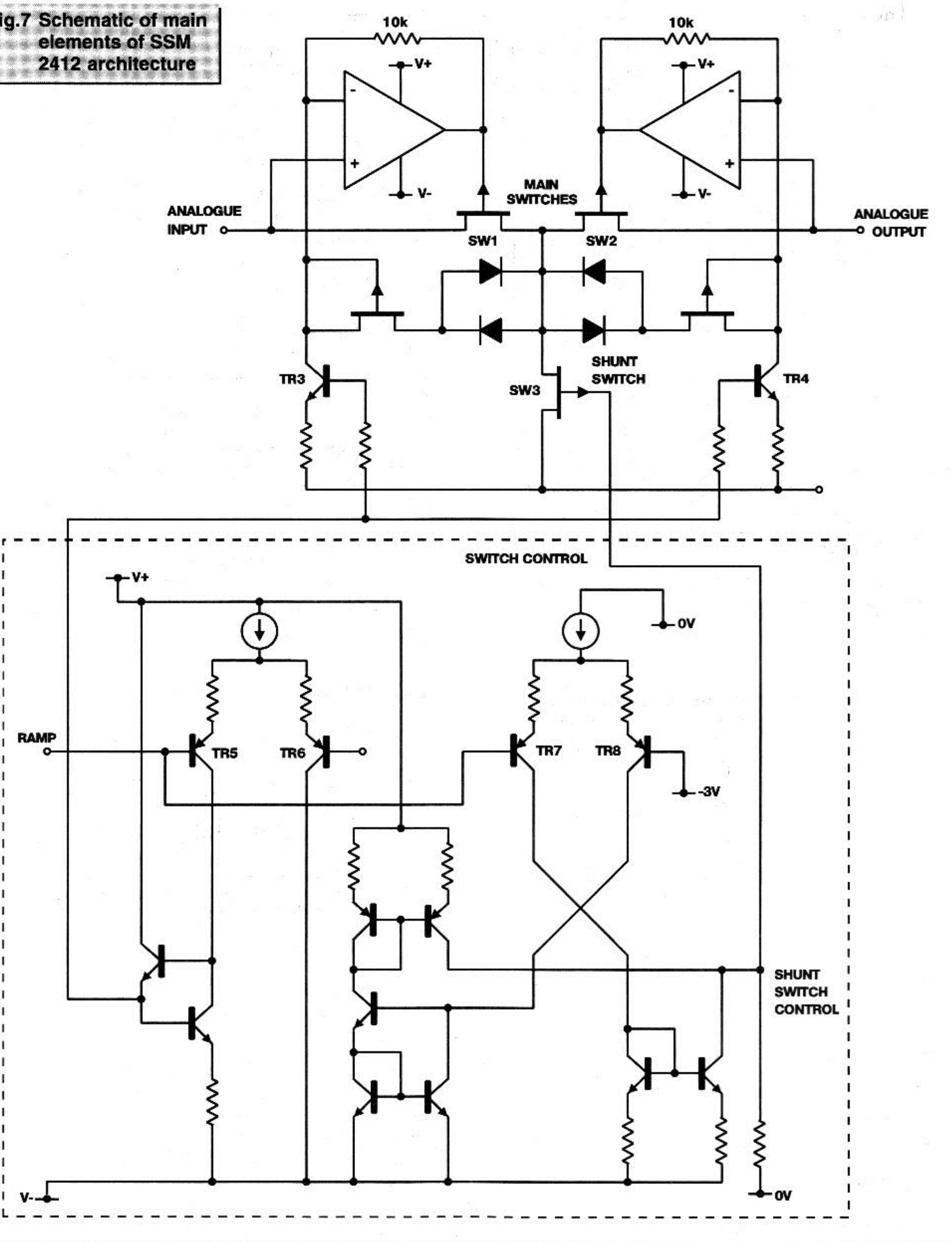


Fig.6 Discretre MOSFET design which lessens charge transfer effect at switch on/switch off

Fig.7 Schematic of main elements of SSM 2412 architecture

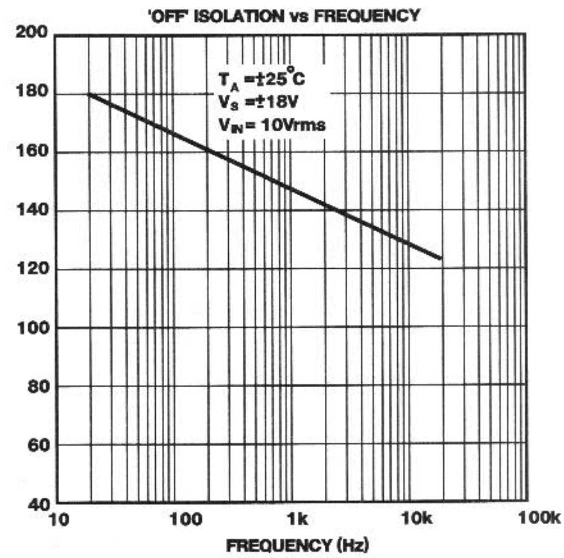


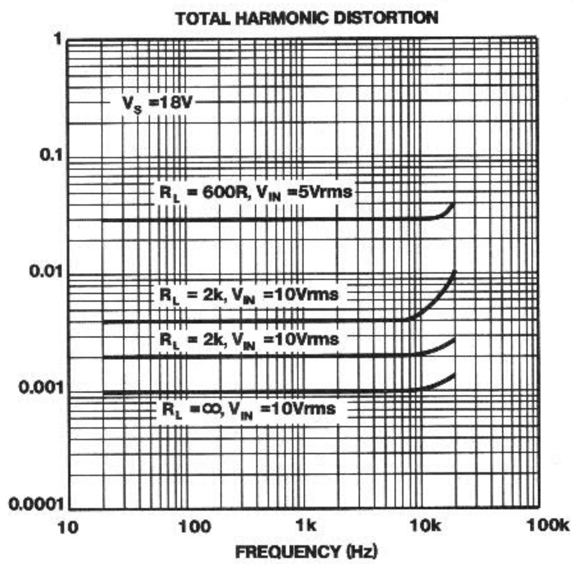
Once the Control Input changes from a LOW to a HIGH state, the Ramp Generator slews towards its positive-most state, as shown in timing diagrams in Figure 10. Beyond the -3V threshold, the Shunt Switch Control is pulled positive by the second differential amplifier (Q7 and Q8). This condition forces shunt switch SW3 OFF, although SW1 and SW2 are still in the OFF state.

Once the ramp output reaches +3V and the drive for the Main Switch Control output is gated OFF by the differential amplifier comprising Tr5 and Tr6, current sources Tr3 and Tr4 go into the OFF state, and the V_{GS} of each of the main switches falls to zero. The high speed op-amp followers provide a gate-to-source voltage which is essentially zero over the full audio signal range. This assures a constant low-impedance over the full audio signal range while the switch is in the ON state. The total time required for this sequence of operations to occur is 3.5ms.

We must now consider what happens when we wish to turn the switch OFF. A Control Input LOW initiates the ON-to-OFF transition. The Ramp Generator integrates down from approximately +7V towards -7V. At the threshold voltage of +3V, the compa-

PARAMETER	VALUE
SWITCH 'ON' RESISTANCE ('R_{ON}')	60R
'R_{ON}' MATCHING	1%
TURN-ON TIME	3.5ms
TURN-OFF TIME	1.5ms
OFF ISOLATION	120dB, 20Hz - 20kHz
CHANNEL-CHANNEL CROSSTALK	96dB
THD	0 - 10Vrms, 0.003%
SPECTRAL NOISE DENSITY	1nV/√Hz
WIDEBAND NOISE DENSITY	200nV pk-pk





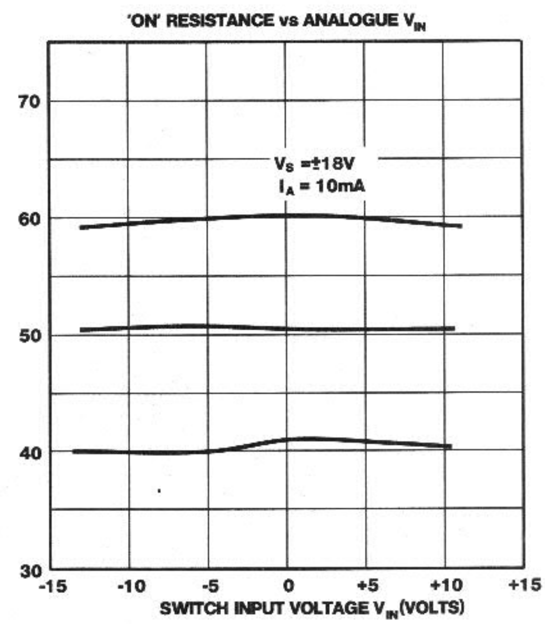


Fig.8 Specifications of SSM 2412

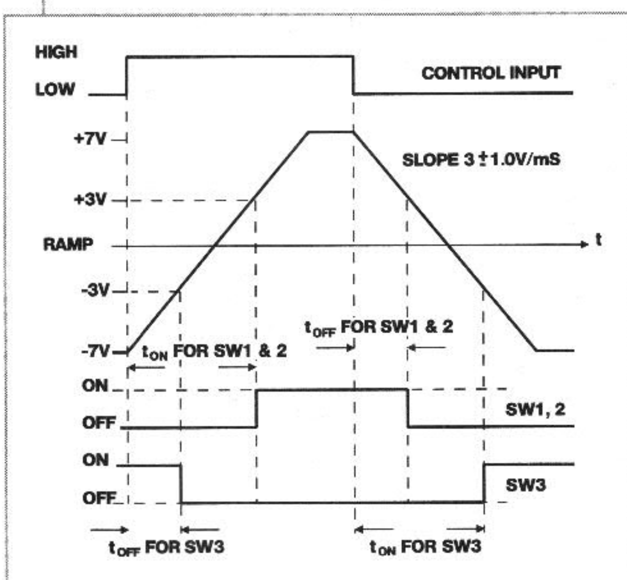


Fig.9 Relative timing diagrams for the various parts of the switch control system

rator controlling the Main Series Switches, SW1 and SW2 flips HIGH, turning on the current sources comprising Tr3 and Tr4, which turn SW1 and SW2 into the OFF state. We now have a condition where both the series switches and the shunt switch of the "T" are OFF. As the ramp integrates further, a second threshold level, this time -3V, is reached. At this point, the Shunt Switch Control changes state and SW3 is turned to the ON condition. The ON-OFF transition is now complete, with SW1 and SW2 both OFF, while SW3, in the ON state, shunts away any undesired breakthrough of the analogue input signal. It is worth noting that the ON to OFF time of the two main switches is just 1.5ms, the time taken for the ramp to fall from +7V to +3V, while its turn-on time is more than twice this.

This break before make characteristic of the switch can be of great significance in systems where there may be hundreds of sources able to access a bus. It is best if there are never, even momentarily, two sources connected simultaneously to the bus.

The "T" attenuator configuration of the FETs provides excellent OFF-isolation, since not only does the input signal have to pass through two open-circuit series elements but it is also shunted after the initial attenuation of the first FET. The distortion is very low because of the way in which the gate-to-source voltage of the two series FETs is held to zero.

Next month, we'll look at the optional VCA and infra-red remote control handset and receiver, and finalise the construction, setting up, and operation. Finally, if you're baulking at the cost of an 8-input unit with the SSM 2412 switch ICs, we'll provide a board layout which uses relays rather than ICs.

References

Meechan, Mike, Solid State Switching, Electronics World and Wireless World, July 1993 (published by Reed Publishing)

Analog Devices Data Sheet

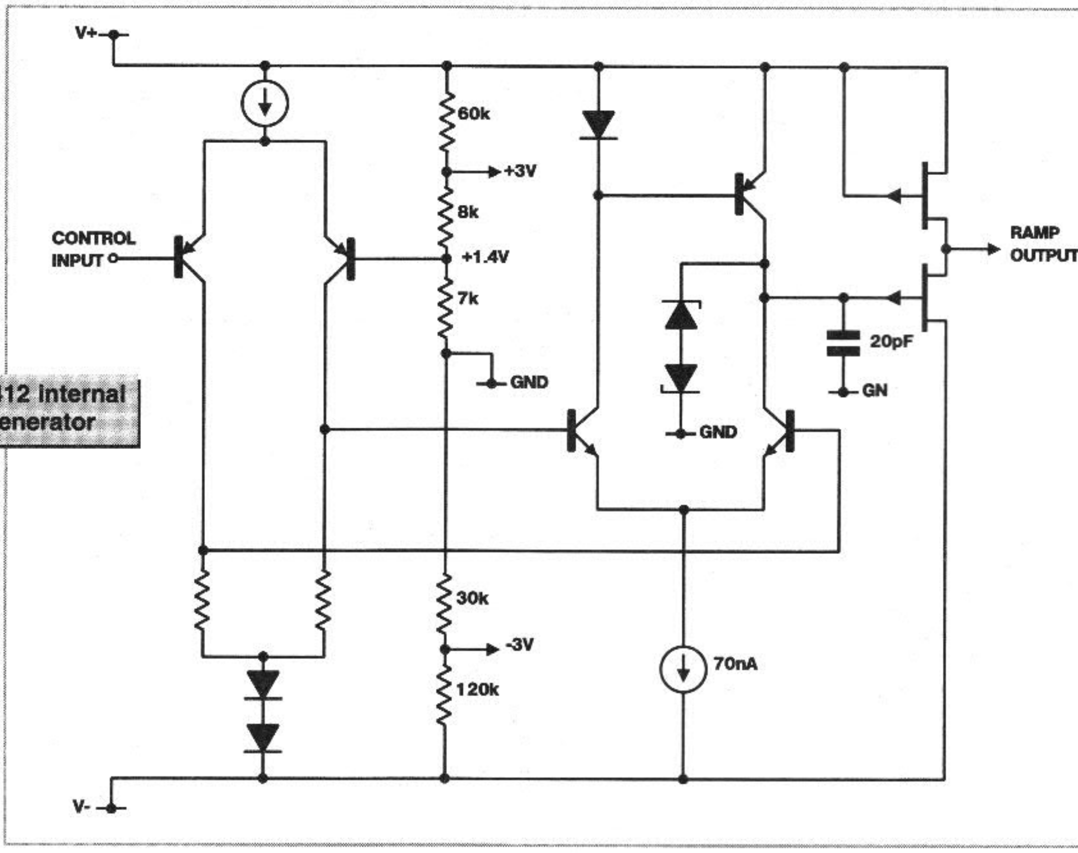


Fig.10 SSM 2412 internal ramp generator

The Works

The clever part of the circuitry (the SSM 2412) - has already been described in detail. The remaining parts concern the power supply rails for the IC's, and for generating control signals from a front-panel switch pad (or the optional Remote Control), and then decoding them so interfacing with the control input pins of the switches. Inputs are via PCB-mounted phono sockets SK1 to SK8. These could be replaced with other connectors n the rear panel but insted wired (using screeened lead) to Veropins soldered in the appropriate positions on the PCB. C9, R8 (and the relevant components for sockets other than SK1) remove any DC from the signal and reference it to ground. This allows the op-amp output stage to swing symmetrically about ground before clipping is encountered. It also prevents clicks on the output as the switches change state. The pinout for the SSM2412 (given in component catalogues) shows pins 3, 5, 8 and 10 to be unconnected. The data sheets show these to be "guard" pins to be earthed if good left/right crosstalk and off isolation performance isn't to be unduly compromised.

That concludes the input and analogue switch section. Dealing with the front panel switch array, SW1 to SW8 are all DPDT non-latching pushbutton switches The two halves of the switch are paralleled together to form a high-reliability, SPDT switch. As there are TWO sets of contacts in tandem the risk of simultaneous failure is very low. Each switch is arranged so that there is a "supply lockout" daisy-chain connection between the switches. So power for other switches down the chain is passed through all the preceeding switches. Pressing SW4 removes the supply from SW5 to SW8, which, in turn, stops any ambiguity in the decoding process if and when two keys are pressed simultaneously. It is one simple way of assigning priority to a switch in a large switchbank. We now need to decode which switch has been depressed.

There are one or two expensive keyboard encoder IC's around but some of their better attributes aren't really required for a simple application here. Discrete logic was used to generate the codes instead.

Each switch output is applied to the corresponding input of the 8-input priority encoder (IC1). A priority encoder IC generates a binary output code dependent upon which, if any, of the input pins are asserted at a particular time. Each input pin is given an "importance weighting", or priority, with input 6 having a higher priority than, say, input 2, but a lower priority than input 8. Because of the switch lockout arrangement, this part of the IC's operation is unimportant. This IC decodes the switch inputs. The lockout arrangement means we can also detect whenever any switch has been pressed. The normally-closed contact on each switch is at logic one. As power comes via the contacts of its succeeding and neighbouring switch, pressing any one removes the power and the logic level falls to zero. This is detected by the falling-edge pulse detector circuitry around IC4. It triggers the latch on the main board. The priority encoder address is therefore latched into the 4-bit latch of IC9 on the main board. Although this method might seem a little nefarious, it saves us having to use another IC - an 8-input OR gate - on a board already heavily populated by trackwork.

This stored address is decoded by IC10 and converted to a one-of-eight output. Of these eight outputs, we are able to select, via jumper links, LK1a, b, LK2a, b etc which of

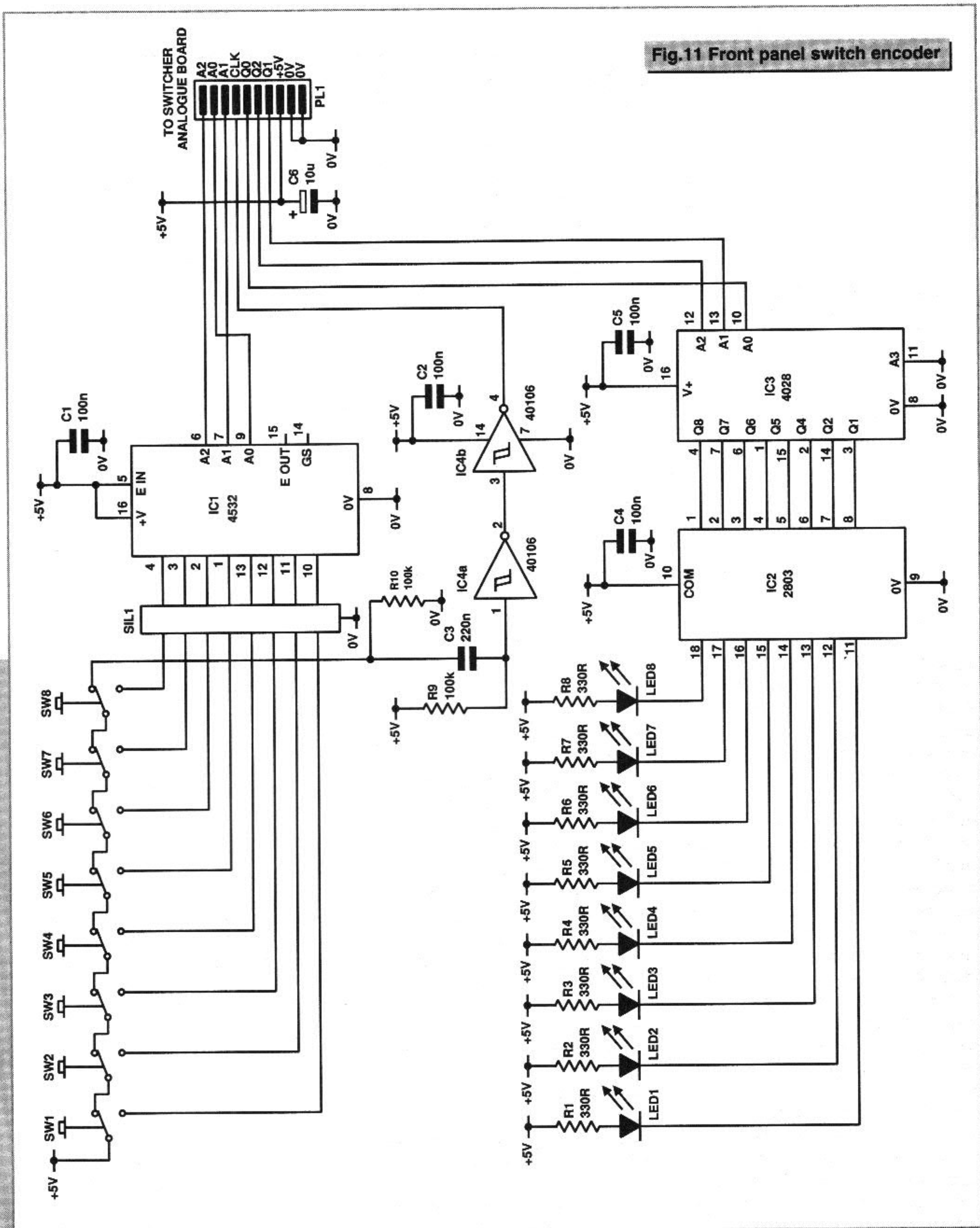


Fig.11 Front panel switch encoder

the upper or lower four of the eight are used to turn on or off, the relevant analogue switches. The circuit diagram shows the links in position "a", ie the lower four of the eight.

This is important since the analogue board only holds four switches. So two piggy-backed, cascaded boards are required to control the full complement of eight possible inputs. A 4 way plug is used to transfer the control logic from the four upper decoded outputs of IC10 to the second switch board. Left and Right signals from the secondary board are then applied to the main switch board via wire links between the points marked X and Y on each of the two boards. This aspect is dealt with more fully in the Construction section next month.

The latched BCD code from IC9 is sent back to the front panel PCB, applied to IC3 on this board and is then used to decode the switch address. This provides a visual

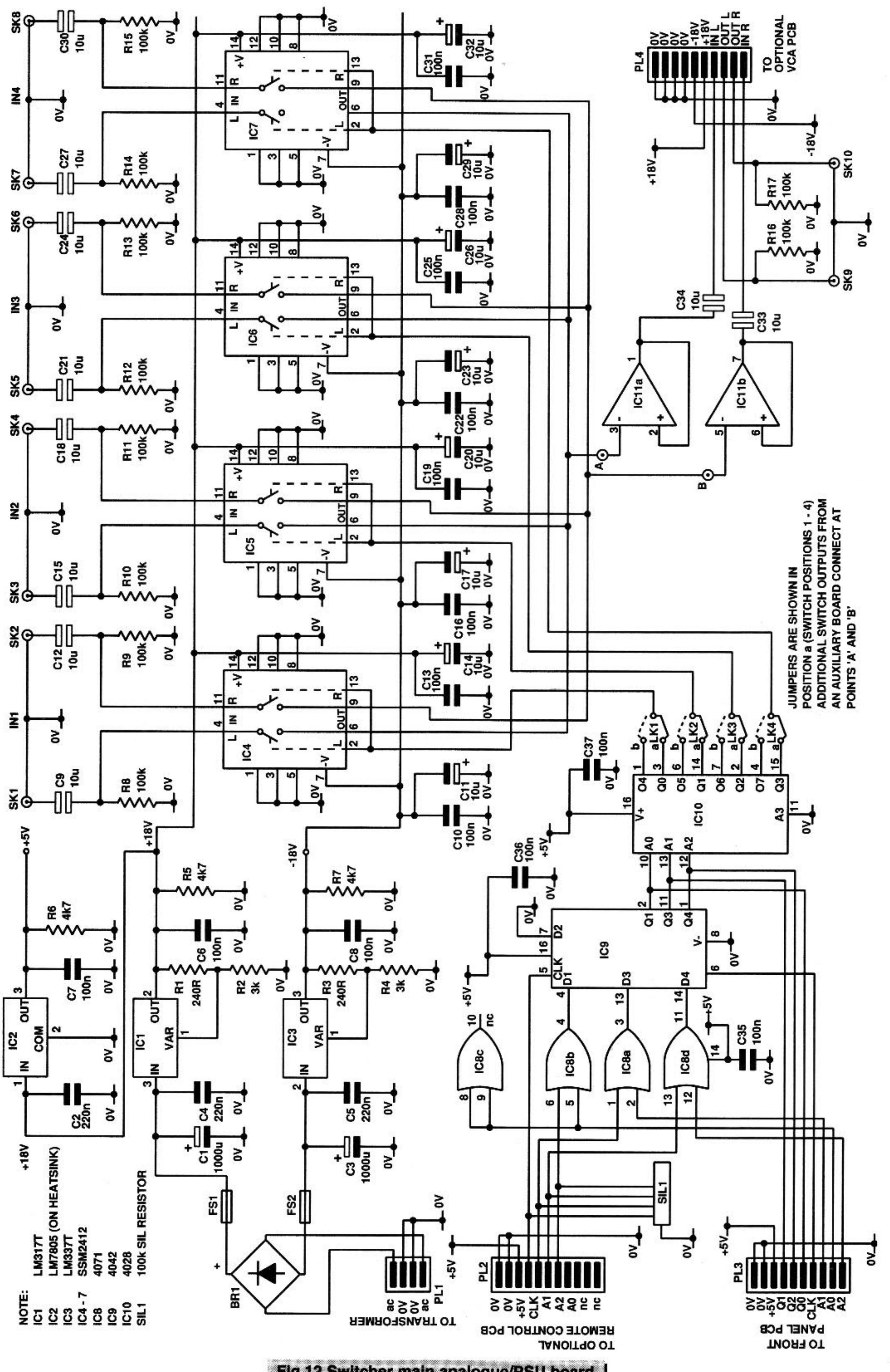


Fig.12 Switcher main analogue/PSU board

indication, via the LEDs and IC2 of the input selected at a given moment. IC8 on the main board allows ORing of the output from the remote control output, if this is fitted. Any incoming data from the remote unit overwrites the front panel information stored in IC9. It latches the switch address output from the remote control section of the logic system.

Three 3 pin monolithic regulators generate the bipolar 18V supply and the +5V for all of the logic circuitry. The input for the 5V regulator, IC2 comes from the output of IC1. This lessens the power dissipation of IC2 by a small margin. Nevertheless, as the voltage differential between the In and Out terminals of IC2 is large, the device is heatsinked. Furthermore, the use of CMOS logic throughout, as well as lessening any switching transisents, reduces power consumption. The bipolar 18V power supply rails provide good headroom and transient-handling performance.

The logic and analogue grounds are joined at the star earth point only on the main PCB. This minimises audible clicks caused when the logic circuitry changes state. This is the reason for using CMOS IC's throughout, since switching transients are much smaller with this logic family because the currents involved at the logic transistion intervals are smaller by an order of magnitude when compared to TTL. A large, ground plane-type layout has been adopted here since high impedance supplies or earth tracks can cause problems in this area. There is also copious decoupling around the IC's. Non-polarised electrolytic capacitors have been used throughout as DC blocks, since these have much superior sonic characteristics at the frequencies involved. (Normal electrolytics tend to distort audio, since the polarising voltage isn't constant and the capacitor can partially rectify any signal across it).

PL4 provides both audio signals and power to the optional VCA board (which we'll look at next month). If this isn't to be fitted, this plug should be omitted and the Left In, Left Out and Right In, Right Out signal points joined using short wire links. The buffer outputs (IC11a and IC11b) are applied DIRECTLY to the output sockets, SK9 and SK10.

Parts

MAIN ANALOGUE/PSU BOARD

Resistors

R1,3	240R
R2,4	3K
R5,6,7	4k7
R8-17	100k

Capacitors

C1,3	1000u 40V radial electrolytic
C2,4,5	220n polyester
C6-8,10,13, 16,19,22,25, 28 31 33-37	100n polyester layer
C9,12,15,18 21,24,27 30,33,34	10u 50V non-polarised radial electrolytic
SIL1	100k Single In Line 8-way resistor array

Semiconductors

IC1	7805
IC2	LM317T
IC3	LM337T
IC4-7	SSM2412
IC8	4071
IC9	4042
IC10	4028
IC11	LM833
BR1	S005 2A, 50V Bridge Rectifier

Additional Items

SK1-10	PCB mounting phono sockets
PL1	4way Minicon latch plug
PL2-4	10 way Minicon latch socket
FS1,2	5 x 20 PCB mounting fuseholder, 500mA A/S fuses to suit

PCB
DIL IC sockets to suit
18-0-18-0 15VA Toroidal Transformer
TO220 vaned heatsink
case front panel
IEC fused mains inlet

FRONT PANEL SWITCH PCB

Resistors

R1-8	330R
R9,10	100k
SIL1	100k Single-in-Line 8 way Resistor Array

Capacitors

C1-4	1O0n Miniature Polyester Layer
C5	220n Miniature Polyester Layer
C6	10u 25V Miniature Radial Electrotytic

Semiconductors

IC1	4532
IC2	ULN2803
IC3	4028
IC4	40106
LED1-8	0.2" Red LED

Additional Items

SW1-8	DPDT Non-Latching Pushbutton Switch (ALPS)

Buttons to suit
DIL IC sockets to suit
PCB
10 way right-angled Minicon-style 0.1" PCB plug

The Power behind the MOSFET

Andrew Armstrong reveals the mysteries of these often talked about but least understood devices

Power MOSFETs are widely used in industrial designs, but are less used in amateur projects. I hope to remedy this by illustrating the relative merits of bipolar and field effect devices, and by showing a number of applications in which one or other device is a clear favourite.

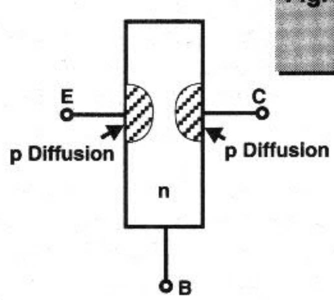
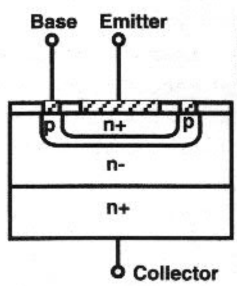


Fig.1 A bipolar transistor structure

Believe it or not, the field effect transistor was invented before the bipolar transistor. The patent on the FET was taken out by Dr. Julius Lilienfield in 1930. He did not make any at that time because semiconductors were insufficiently advanced for this to be practical.

When Shockley, Bardeen, and Brittain discovered the junction transistor, they were trying to make a field effect transistor. After this team had developed their Nobel prize winning bipolar transistor, Shockley went on to develop the FET.

The first useful transistors were bipolar types. Figure 1 shows the structure of the early germanium variety. Figure 2 shows, for comparison, the structure of a silicon planar transistor.



Silicon planar transistor
Note the similarity to the V-MOS structure

Fig.2 Silicon planar structure

In all bipolar transistors, amplification occurs when a current injected into the base permits a multiple of that current to flow in through the collector. To explain why this is so, consider the simplified bipolar transistor structure shown in Figure 3. At the collector/base junction, the electric field is trying to draw electrons from the base region, where the charge carriers are holes, into the collector, where the charge carriers are electrons. The effect of this is to widen the depleted region, in which there are no charge carriers, either holes or electrons.

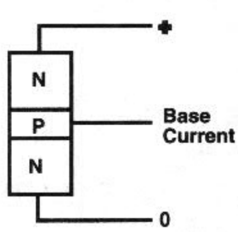
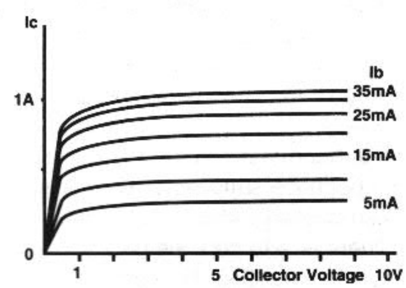


Fig.3 Simplified transistor structure

When a current is injected into the base (remember that conventional current flows in the reverse direction from the electrons), electrons are drawn from emitter to base. In the base region, they encounter the electric field from the collector, and the majority leave the region via the collector rather than via the base wire.

Thus, bipolar transistors are considered current-operated devices in which a collector current of h_{fe} x base current flows. This effect is not linear, because h_{fe} depends on collector voltage to some extent, (to a great extent at low collector voltages), and can also depend on collector current. This is illustrated in the typical transistor characteristics shown in Figure 4.

Fig.4 Transistor characteristics



It is also possible to regard a transistor as a voltage-controlled device, because the current flowing from emitter to base depends upon the base voltage. The current in the base is then regarded as an imperfection in the device. However, the characteristic of a transistor regarded in this way follows the conventional silicon diode curve, which is far from linear. In most types of circuit, this view of the transistor is not very helpful.

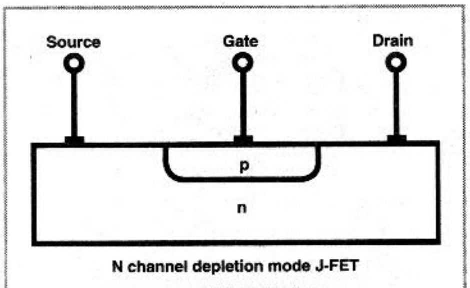
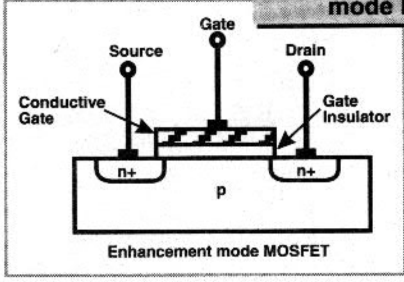


Fig.5 An N-channel junction FET

Field effect transistors

The first widely-used type of field effect transistor was the depletion-mode junction FET. In this type of device, charge carriers are normally present in the N-type material which forms a channel between drain and source. An N-channel junction FET is illustrated in Figure 5.

Fig.6 Enhancement mode FET



There is a small depletion region at the P-N junction, as in a normal junction diode if the gate and source voltages are the same. Most of the channel is unaffected, and current can flow from drain to source, with the channel exhibiting an approximately resistive characteristic at moderate current and voltage levels.

When applying a positive voltage to the gate, it will exhibit the normal forward conduction characteristic of a diode, and will not greatly affect the drain to source current. If, on the other hand, a negative gate voltage is applied, then the depletion region will get wider, so reducing the current from drain to source. There is a point where the depletion region fills the whole channel and only the leakage current of the device flows. The gate voltage at which this occurs is normally referred to as the pinch-off voltage.

Figure 6 illustrates the principle of the enhancement mode FET. Most power MOSFETs operate in this way and in Figure 6, there is no conduction path between drain and source if the gate voltage is zero. It is an NPN structure, but with a very wide base region, and with a reverse biased collector/base junction.

Application of a positive gate voltage will, after a certain threshold limit, induce a layer of N-type semiconductor directly under its insulator. This forms a continuous N-type channel between drain and source, so that current can flow. The higher the gate voltage, the deeper the channel, so more current flows.

These two FET structures are by their nature low-power. There is a problem with simple planar FETs and it is this: the depletion region caused by the body-drain diode extends farther into the channel if the voltage across the device is increased. In order to avoid punch through breakdown, as it is called, the channel must be made longer. Unfortunately that problem reduces the current capability and hence the total power handling.

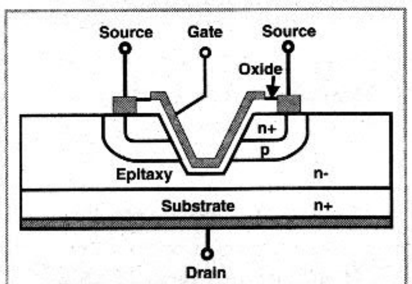


Fig.7 V-MOS FET structure

However, one might expect to achieve high power by paralleling several high voltage devices. This does not work using separate devices, because the operating characteristics of different devices even from the same batch show a wide variance.

In the early 1970s, something called double diffused MOS technology was developed and is now used in modern power MOSFETs. Figure 7 shows a V-MOS FET structure, showing the N+ layer diffused into the P layer. The channel is now formed parallel to the gate metalisation, through the P layer.

The hexFET structure shown in Figure 8 shows how the diffused shape can be changed to flatten the surface of the device. The hexFET is a more recent design, and it can be made with a very wide parallel operating area. Instead of a metalised gate, it has a silicon gate, which is positioned by a standard photolithographic operation, and is therefore more accurate then normal metalisation.

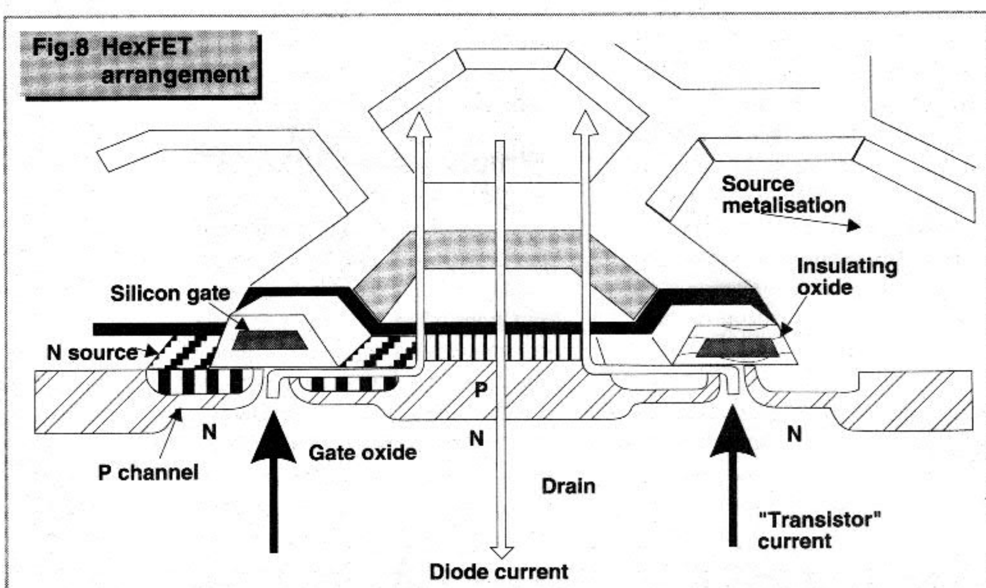
Both of these double diffused FET structures include a bulk diode able to conduct in the reverse direction to the normal FET operation. Some FETs now have these diodes characterised for fast recovery. This can be useful in some fast switching applications such as synchronous rectification.

Power MOSFET operating characteristics

A number of items stand out distinguishing the operation of power MOSFETs from other devices. A common fallacy is that power mosfets can be paralleled in all sorts of applications because of their positive temperature coefficient. This is only partly true.

For switching purposes, where linear operation is not envisaged at all, similar FETs may be paralleled with acceptable current-sharing. This is

Fig.8 HexFET arrangement



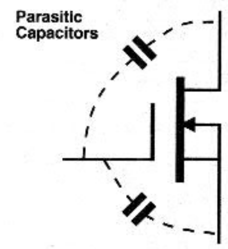


Fig.9 Equivalent circuit showing parasitic capacitances

because the on-resistance of the channel increases with temperature, so the hotter FET will tend to reduce its current. In linear operation, however, current may not be shared at all. Power MOSFETs usually have a very high gain, and can have a large tolerance on the threshold voltage. So one FET can be fully switched on at a certain gate voltage that say another one of the same type is not conducting at all. Even if you have matched devices with the same threshold voltages, the threshold voltage reduces with increasing temperature, so that the hotter FET will conduct more heavily and become still hotter.

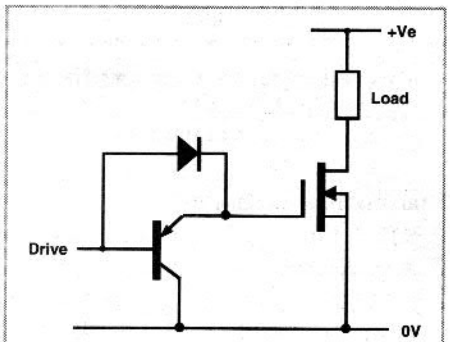


Fig.10 Rapid switching circuit

Another outstanding characteristic of power FETs concerns their switching time. It is primarily determined by how quickly the gate to source and gate to drain capacitance can be charged and discharged by the drive circuit. If the current capacity of the drive circuit is not a limiting factor, then the ohmic resistance of the gate will limit switching speed. Many power MOSFETs can switch in the range of 30 to 100 nanoseconds, if driven hard enough. The ultimate limitation is the resistance and inductance of the gate itself.

To achieve this fast-switching performance, a very high current gate drive is required, with peak currents of hundreds of milliamps. It would appear at first that the gate to source capacitance may give the greatest trouble, but in many circuits it is the gate to drain capacitance which dominates. To see why this is so, consider the equivalent circuit of Figure 9, showing the parasitic capacitances. To switch the FET hard on, the gate to source capacitance has to charge from, say, 0 to 12 volts. The gate to drain capacitance, however, is charged to 24 volts in one direction, and will charge to 12 volts in the other direction when the FET is switched on. Thus, for the same capacitance value,

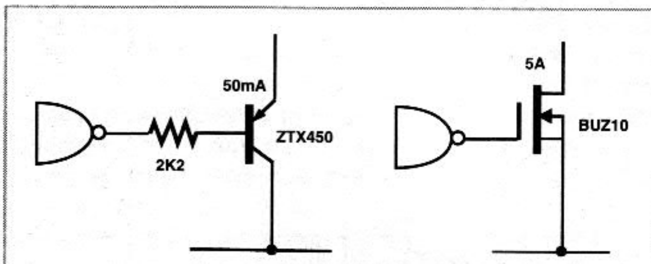


Fig.11 Switching a high current load

three times as much charge must be fed to the gate/drain capacitance as to the gate/source capacitance. This problem gets correspondingly worse when controlling higher voltages.

Most devices driving MOSFETs tend to source current better than they sink it, so that where rapid switching is required, a circuit such as that shown in Figure 10 is often used. Here, a positive voltage is applied to the input and the PNP transistor driving the gate is switched off because its base is held one diode-drop higher than its source voltage. When the input voltage is pulled down, the current-sinking capability of the control device is amplified by the PNP transistor. This can be especially important in some switched-mode power applications, where most of the power dissipation in the FET occurs while it is switching, and therefore passing current while there is a significant voltage across it.

Simple power MOSFET applications

The most obvious application for a power MOSFET in preference to an ordinary bipolar transistor is in situations where a CMOS gate must control a high load current. Figure 11 shows two alternative circuits to switch a high-current load on a CMOS gate. The first one, using a good quality bipolar transistor, can switch perhaps 50mA while the transistor remains in saturation. Higher currents than this will cause the voltage drop across the transistor to increase, and therefore its dissipation to increase. This is because the current gain of the transistor declined markedly when its collector voltage is very low.

The equivalent circuit using a power MOSFET can sink approximately 5A with a low voltage drop. This may seem an unreasonable comparison, because the BUZ10 is a TO220 device, and of a higher power rating than the ZTX 450. However, no advantage can be gained by replacing the ZTX 450 with a more powerful transistor. The base drive current and current gain are the limiting factors.

Another application in which the power MOSFET is clearly superior to the junction transistor is shown in Figure 12. This circuit is an accurate current sink, in which all the current flowing in the source resistor also flows in the drain.

If a bipolar transistor used this configuration, then some of the emitter current would flow in the base, so limiting the current sink accuracy.

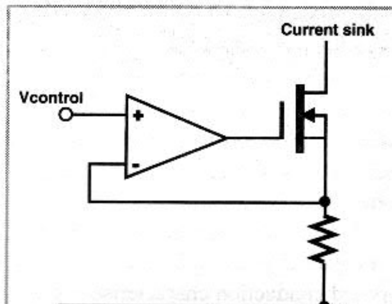


Fig.12 A Power MOSFET is an accurate current sink

Power MOSFETs are almost always an advantage in circuits where low power consumption is required, and in which the switching frequency is not very high. Once a FET is switched on, no power is required to keep it switched on, as we will see in the application circuits next month.

This month we have covered the major points of FET technology. In the second part we will look at a whole bunch of application circuits. The applications will mostly apply to FETs, but one or two will utilise bipolar transistors to demonstrate applications in which bipolar transistors are more appropriate.

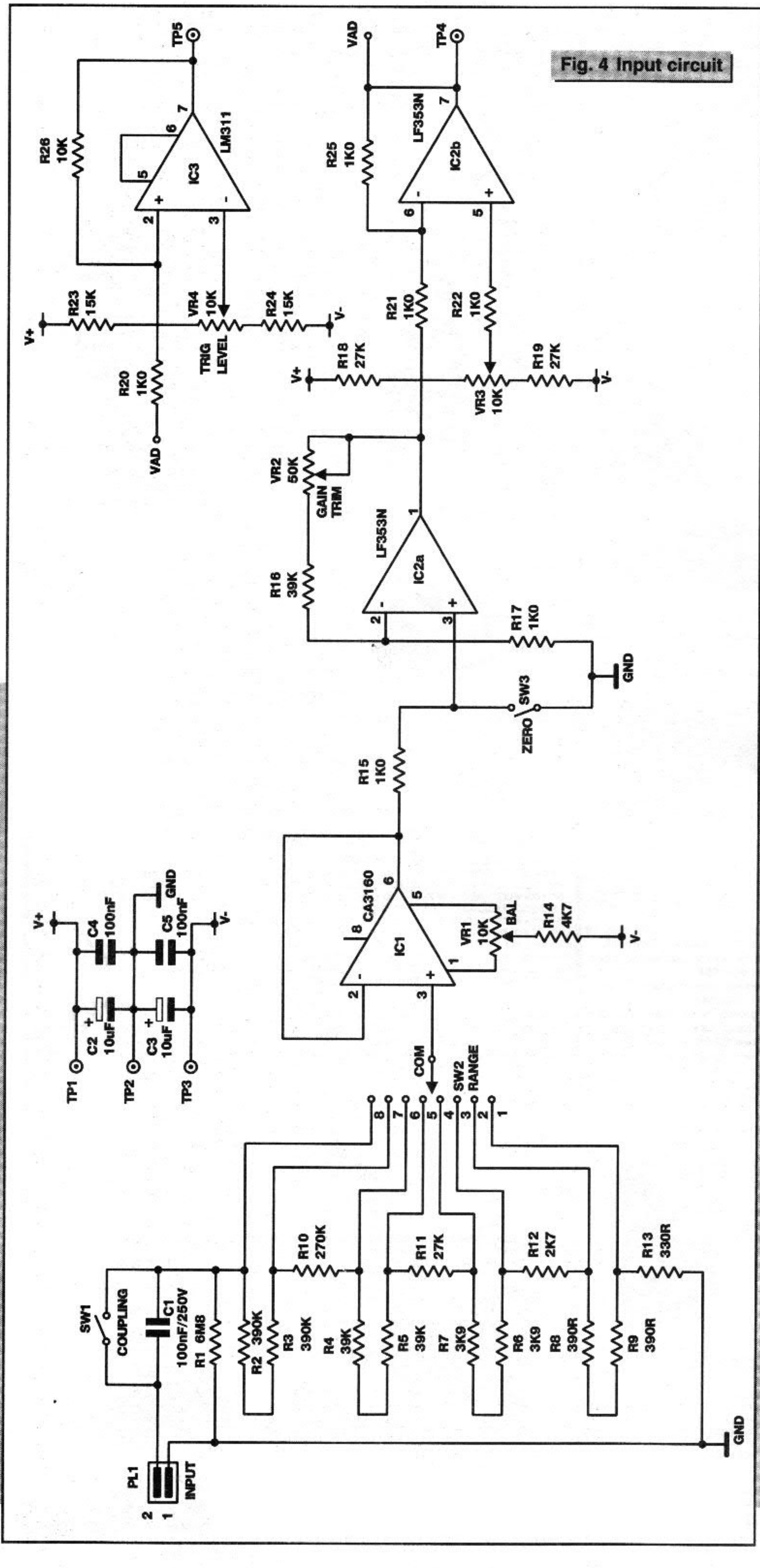


Fig. 4 Input circuit

The

Paul Stenning brings you the concluding episode of his economical 'scope

The majority of the circuit requires a supply of 5V at about 0.5A. In addition the input PCB and the A-D require +/- 12V at a few milliamps.

The output of transformer T1 is full wave rectified by D1 and D2, and smoothed by C12, producing about 8.5V DC which is fed to the 5V regulator IC19.

In addition, one output from the transformer is half wave rectified and voltage doubled by D7, D9, C9 and C14, producing about 16V to drive the +12V regulator IC22. A similar

The Works

Input Circuit

This is contained on a separate PCB to enable screening if necessary.

The input first passes to the switched attenuator, the input impedance of which is approximately 1M0. The output of the attenuator will be 80mV pk-pk for full scale (10mV/div).

This passes to IC1 which is configured as a unity gain buffer with very high input impedance. An offset null control is provided to ensure that the output is exactly zero volts with the input shorted.

The signal then passes to IC2, the gain of which is set to about 62 and is trimmable by VR2. This amplifies the 80mV pk-pk to 5V pk-pk, which is the full range of the A-D. SW3 shorts the input of this amplifier to ground for base line adjustment. The circuit around the second part of IC2 allows for base line position adjustment. This stage also inverts the signal, for the reason mentioned previously.

IC3 is a comparator which is used to generate the sync pulses. The trigger level is set by VR4, and positive feedback via R26 gives some hysteresis which prevents false triggering on noise.

Tele-scope

PART TWO

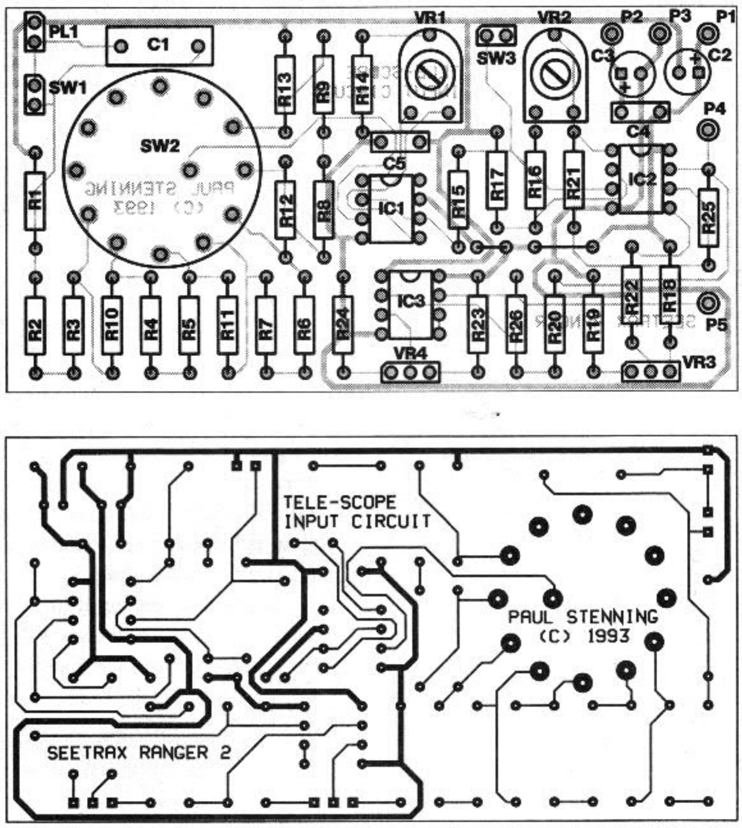
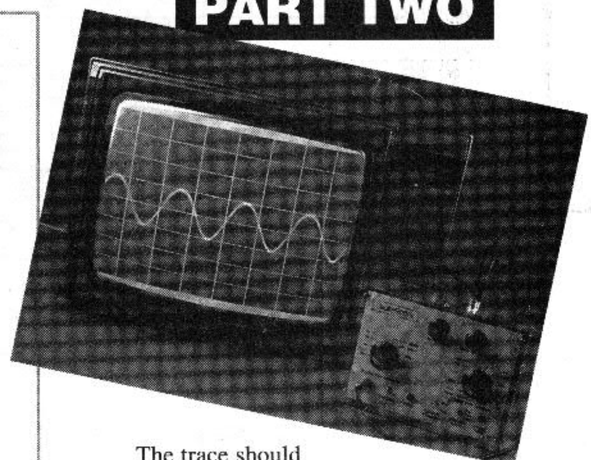


Fig.5 Component positioning on Input board and Foil below



arrangement is used to produce the -12V.

Thus the three voltages are derived from one standard transformer. This should be rated at 12VA or greater, since a lower rated unit may not have good adequate regulation for this arrangement to work.

No mains switch or fuse were fitted on the prototype for simplicity; a 3A fuse was fitted in the mains plug.

Testing

Do not fit any socketed ICs at this stage. Temporarily cover the mains connections with insulation tape if they are not already adequately insulated. Connect to the mains and switch on.

Set your test meter to a suitable DC voltage range, connect the negative probe to TP4 and the positive probe to the pin of IC19 (7805) nearest the modulator. The meter should read 5V DC (+/- 0.25V). Now measure the +12V and -12V supplies on TP3 and TP5, these should both be within +/- 0.5V.

Switch off and insert all the ICs. Set all three presets and both pots to the central positions. Set input coupling to AC, input range to 3V/div, trigger polarity to +ve, trigger mode to normal and timebase to 8ms/div.

Link the centre pin of the input connector to one of the outer transformer pins on the main PCB, and connect the unit to a TV. Switch on.

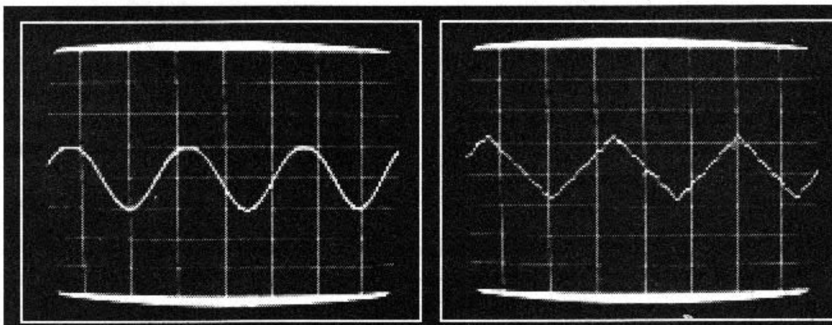
Turn the volume on the TV right down, and tune a spare channel selector to channel 36. If all is well (fingers crossed) the graticle and some sort of trace should appear.

The trace should be about 3-4 cycles of an approximate sine wave, but with the top and/or bottom slightly flattened. If the Zero button is pressed it should become a straight line, adjust the position control to place this near the centre line of the graticle if necessary.

Adjust RV1 on the main PCB. The effect obtained will depend upon the make of RAM chip fitted. With RV1 fully anti-clockwise the trace may freeze (this can be confirmed by pushing the Zero button) whilst with the preset fully clockwise, some of the trace dots will be in the wrong positions (this may appear as random dots or more than one trace). Set the preset to a position between these two extremes, which gives a proper trace. Best results were obtained on the prototype using RAM chips made by HMS and Hitachi, although all the devices tried gave acceptable results.

Set the Trigger Mode switch to Hold, and the display should freeze. Now set it to Free Run, and the trace should appear to roll sideways, since the sync is disabled. Return the switch to the Normal position.

Adjust the Trigger Level control,



Two traces showing sine and triangular waveforms

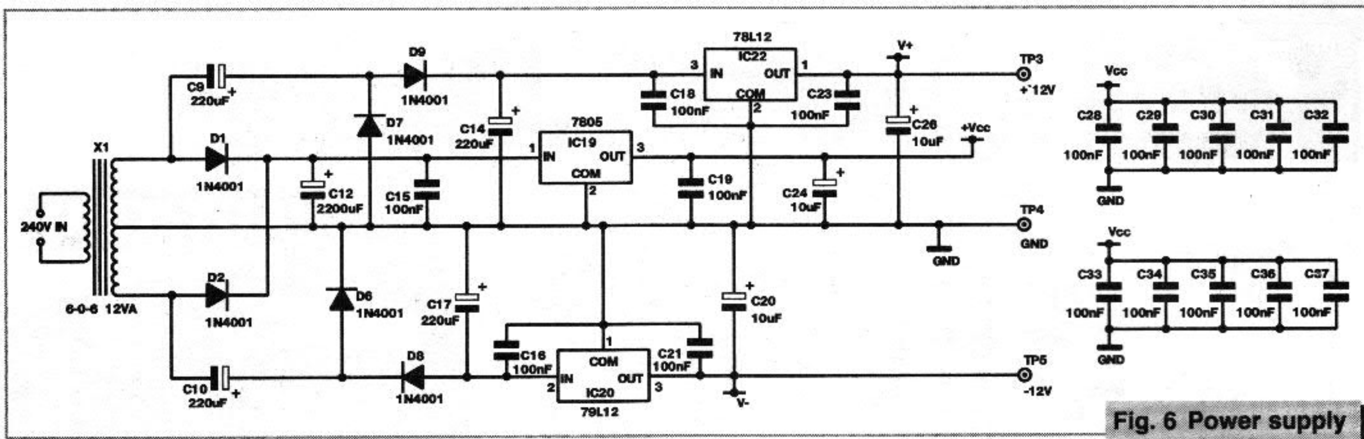


Fig. 6 Power supply circuitry

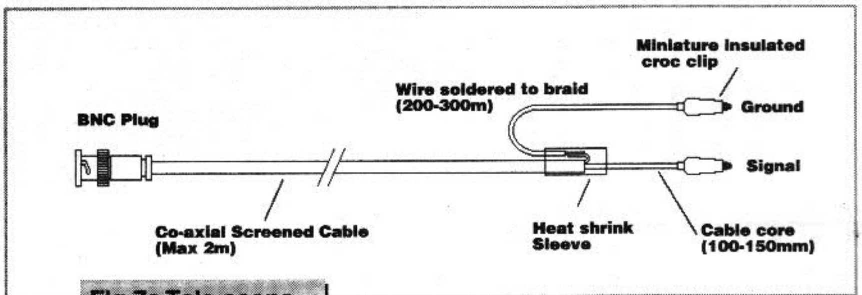


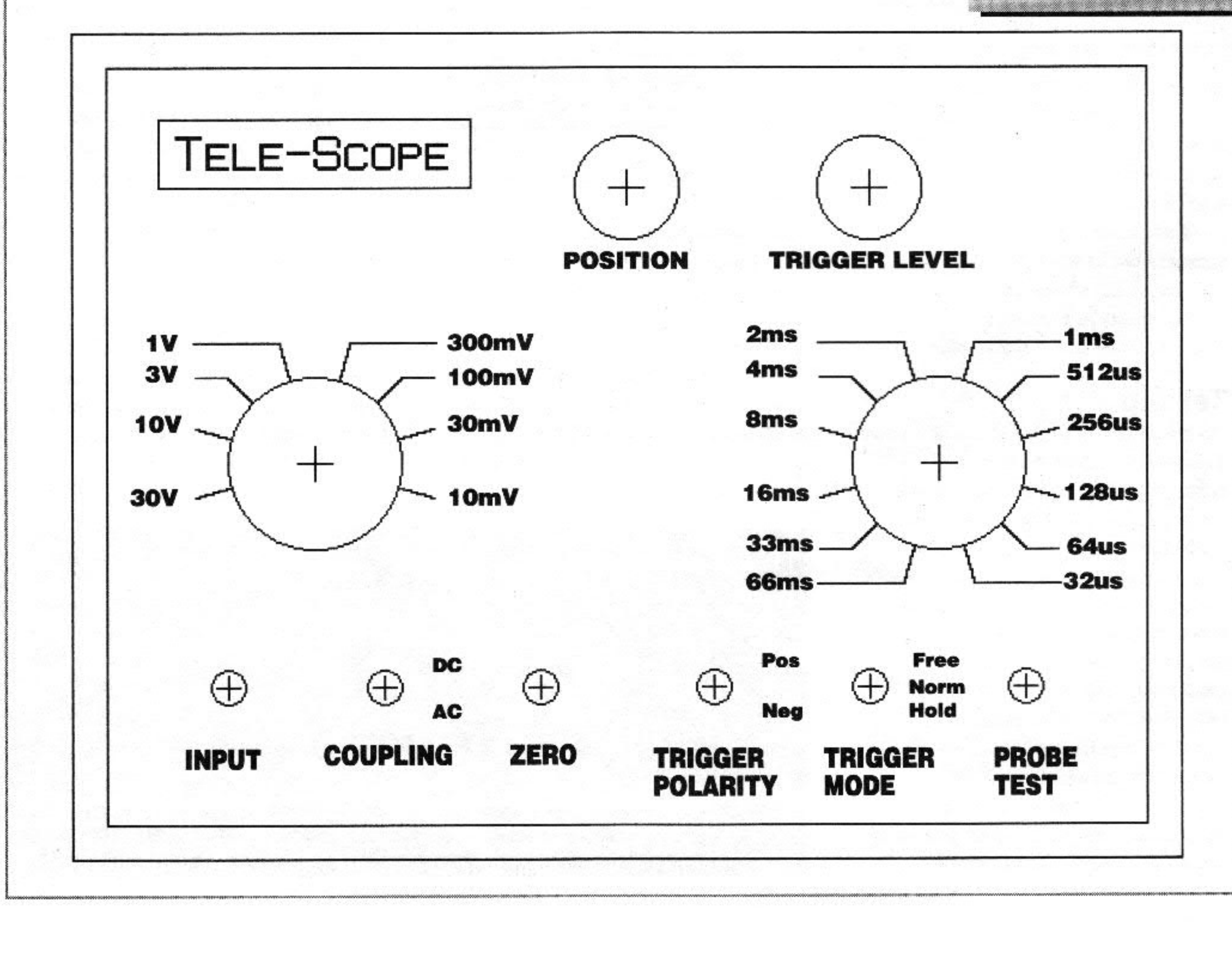
Fig.7a Tele-scope probe details

the trace should appear to move sideways as the circuit triggers to different points on the waveform. As the control nears the ends of its range the trace will roll due to the sync being lost. Return the control to a point where the unit is triggered and set the trigger polarity to -ve. The trace should appear to invert as the trigger circuit is now operating on the falling edge of the waveform.

Check the operation of the Input Range and Timebase switches by operation them two or three positions either way. Do not set the Input Range to the 10mV/div setting as the input signal is large enough to damage the amplifier on this setting.

Disconnect the input from the transformer, and short circuit the input. Press the Zero button and adjust the

Fig.7b Template for front panel shown at 75% full size



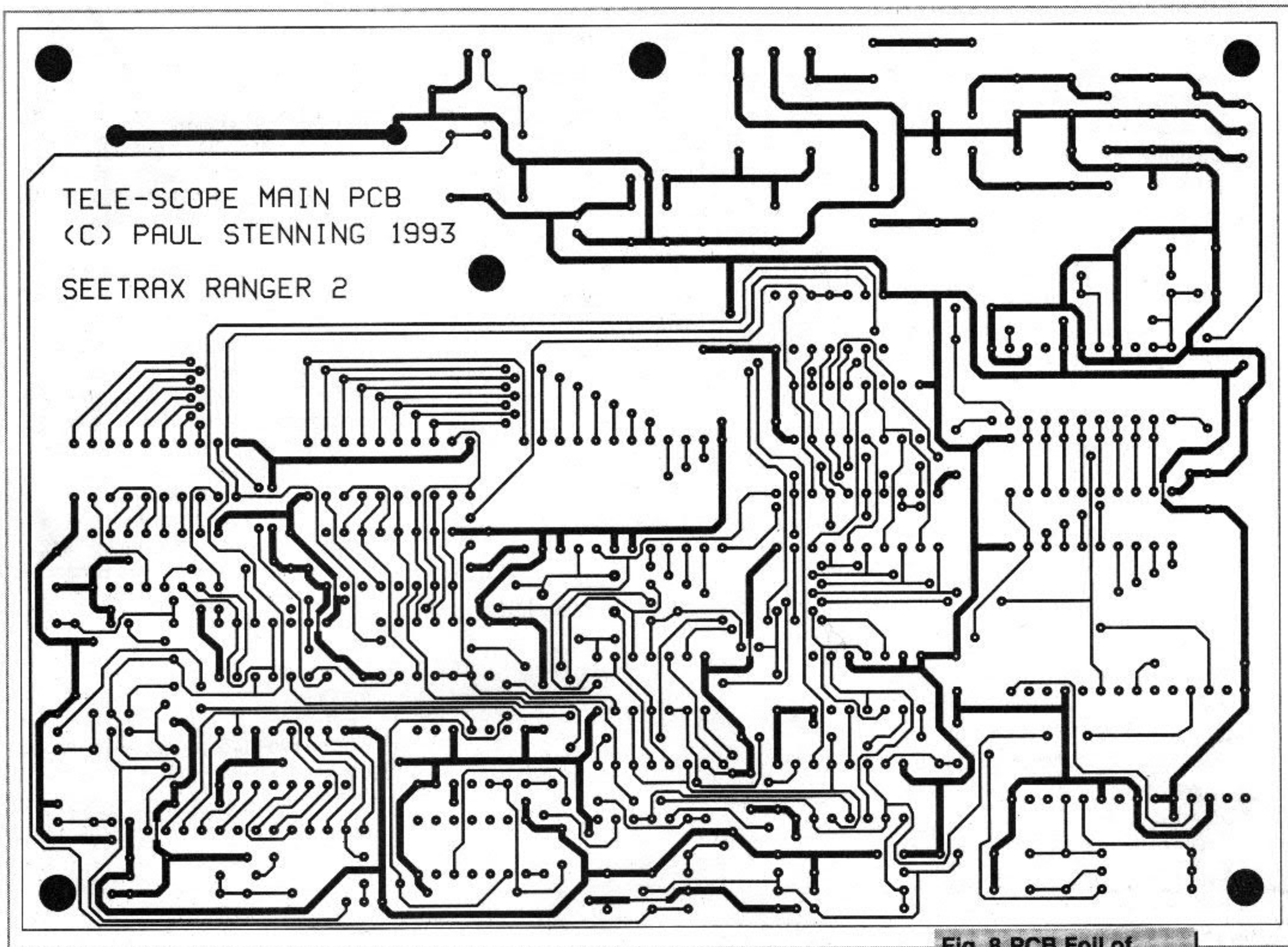


Fig. 8 PCB Foil of main Tele-scope board

Position control to place the line exactly on the centre line of the graticle. Release the Zero button and adjust preset VR1 on the input PCB to bring the trace back onto the centre line. Continue to trim VR1 until the trace does not move when the Zero button is operated.

The best way to adjust the input gain preset (VR2 on input PCB) is by comparison with another oscilloscope, however the following information assumes you do not have this luxury. Set the Input Range to 3V/div, input coupling to DC, and connect the input to TP3 on the main PCB (+12V). Press the Zero button and position the line on the second graticle line up from the bottom. Release the button and adjust VR2 to position the line exactly 4 divisions up from its previous position. If you have a reasonably accurate meter, measure the +12V and set VR2 accordingly. Disconnect the input.

Finally set the Timebase to 256us/div and the Input Range to 300mV/div. Connect the input to the probe test output, the display should show about 2 cycles of a square wave, 1 Volt (3.3 divisions) high, above 0V. Switch the input coupling to AC and the trace will drop down the screen about 1.6 divisions.

If you have access to an audio signal generator you can now try the unit on all Timebase and Input Range settings. Take care not to apply more than +/- 10V on the 10mV/div range.

If you've got through all this successfully, the unit is working and set up correctly. In addition you will hopefully have begun to get the feel of using the equipment!

Operation TV 'scope

This is not the place for a full description of the use of an oscilloscope. If the equipment is new to you, a number of books are available, as well as recent magazine articles.

Much of the use of this unit has been covered in the previous sections, however the following information should be borne in mind.

The maximum frequency signal that can be successfully displayed is 20KHz.

The input is not fully protected against overload. On the 10mV/div range the input signal is applied directly to the op-amp, and therefore must not exceed +/- 10V. On other ranges the attenuator will give some protection, unless the input is excessive. It is generally safest to start on a high voltage range and switch down until a suitable display is obtained.

The ground of the unit is connected to mains earth. Therefore the input must not be connected directly to the mains or to mains powered equipment, unless an isolating transformer is used on the equipment being tested.

AC input coupling is generally used to display a signal which has a DC offset. A good example of this is viewing the ripple on a power supply's output - this may be only a few millivolts but offset by 5 volts or more. Note that the AC coupling capacitor is rated at 250V DC and this must never be exceeded.

The Trigger Mode switch would generally be left in the Normal position, since this will cause the display to free run if it cannot trigger. If measuring static or slow moving DC voltages it may be better to switch to Free Run, to eliminate jitter as the voltage passes the trigger point.

Switching the Trigger Mode to Hold freezes the display, so the probe may be removed. This can be useful if you cannot see the screen and the probe position at the same time. It may also be useful for catching transients and edges, but this relies on you operating the switch at the right moment.

The TV set used may not show the full width of the display. This is not generally a problem, although the set's width control could be adjusted to suit, if one exists. Alternatively it may be possible to move the display from side to side slightly with one of the hold controls, in which case adjust it so the left edge can be seen. These adjustments should only be carried out using external controls if they exist, do not dismantle a TV set unless you are absolutely sure you know what you are doing.

For most purposes an adequate probe can be made using a length of reasonable quality co-axial screened cable about 1.5 metres long with a BNC plug on one end and two small crocodile clips on the other. The clip on the core of the cable could be replaced with a purchased or home made probe of some description if preferred.

The probe test output is used for adjusting X10 and X100 attenuator probes. The probe tip is connected to the output and the adjustment screw on the probe or connector body is adjusted for the best square wave. The leaflet supplied with the probe will give more information.

The Timebase switch offers the following times per division:- 65.536ms, 32.768ms, 16.384ms, 8.192ms, 4.096ms, 2.048ms, 1.024ms, 512us, 256us, 128us, 64us and 32us. These are rounded to slightly more tidy numbers on the front panel overlay.

The Input Range offers the following voltages per division:- 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV.

Final Note

The author is currently looking for a good home for his prototype Tele-Scope. He would prefer to donate it to a charity, voluntary group or educational establishment. The unit will be supplied working but no further support will be available. Any interested parties should write to the author via Electronics in Action.

Parts

Input Circuit

Resistors

(0.25W, 5% or better).
1% recommended for R1-13.

R1	6M8
R2,3	390K
R4,5	39K
R6,7	3K9
R8,9	390R
R10	270K
R11,18,19	27K
R12	2K7
R13	330R
R14	4K7
R15,17	1K0
R20-22,25	1K0
R16	56K
R23,24	15K
R26	10K
VR1,2	10K Horizontal Preset
VR3,4	10K Lin Rotary Pot

Capacitors

C1	100n 250V (0.4" lead pitch)
C2,3	10u 25V Radial
C4,5	100n
IC1	CA3140 or CA3160
IC2	LF353N
IC3	LM311
PL1	BNC Socket
SW1	SPST Min Toggle
SW2	1 Pole 12 Way Rotary Make Before Break (S)
SW3	Push To Make Switch

Additional Items

XT1	5.000 MHz, HC18U case
PL1	BNC Socket
TP6	1mm Socket
SPST	Centre Off Toggle
SW2	SPST Toggle
SW3	1 Pole 12 Way Rotary Break Before Make (NS)
MD1	UM1233 UHF Modulator
X1	Transformer 6-0-6V, 12VA or greater

Veropins and/or SIL header strip
IC sockets if desired 3 x 8 way, 9 x 14 way, 4 x 16 way
4 x 20 way, 1 x 22 way 0.4", 2 x 24 way
Thin tinned copper wire
Case
Heatsink or bracket for IC19
5 Knobs
3 Amp 3 core mains flex
13A mains plug with 3A fuse
Cable clamp or grommet
Oscilloscope probe or parts
Phono to Aerial UHF lead
Wire
PCB and transformer mounting hardware

Shoppers' Notes

The majority of the components should be readily available from your usual supplier. In case of difficulty, all items are listed in the current Maplin catalogue.

All the non-polarised capacitors except the 100n 250V, should have a 0.2" (5mm) lead pitch. Other types may fit if the leads are formed to suit.

The 74 series logic ICs may be either 74LS or 74HCT, if you are ordering specify the 74HCT. The 4040 and 4024 however must be the 74HCT types, as standard 4000 series devices are not fast enough.

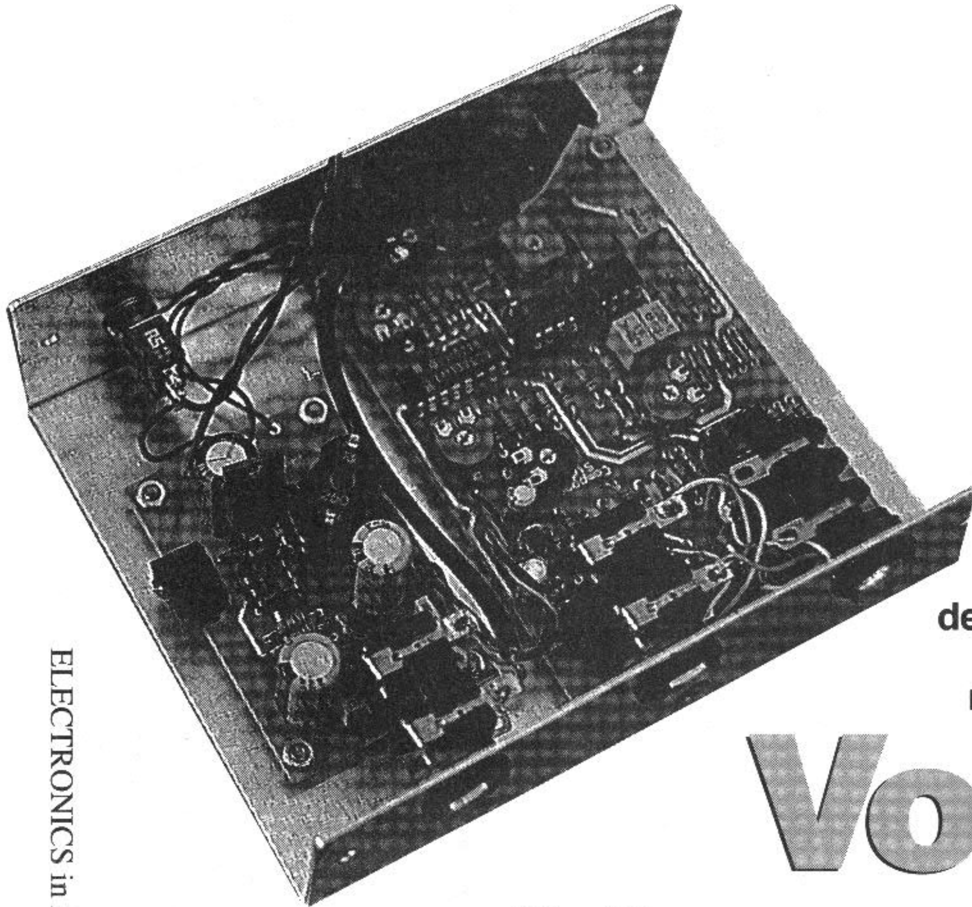
The 78L12 and 79L12 regulators may be replaced with standard 7812 and 7912 types, if these are to hand.

The two rotary switches are identical in appearance. For identification, the Make Before Break is marked "S" on the base, whereas the Break Before Make is marked "NS".

The two PCBs are available from the Electronics in Action PCB service.

Next Month

Paul Stenning provides us with a project for budding film makers - create a professional finish with his Video effects unit



Andrew Armstrong has designed a multi-purpose, bi-polar power supply for last months Anti-Howler project

Voltage Versatility

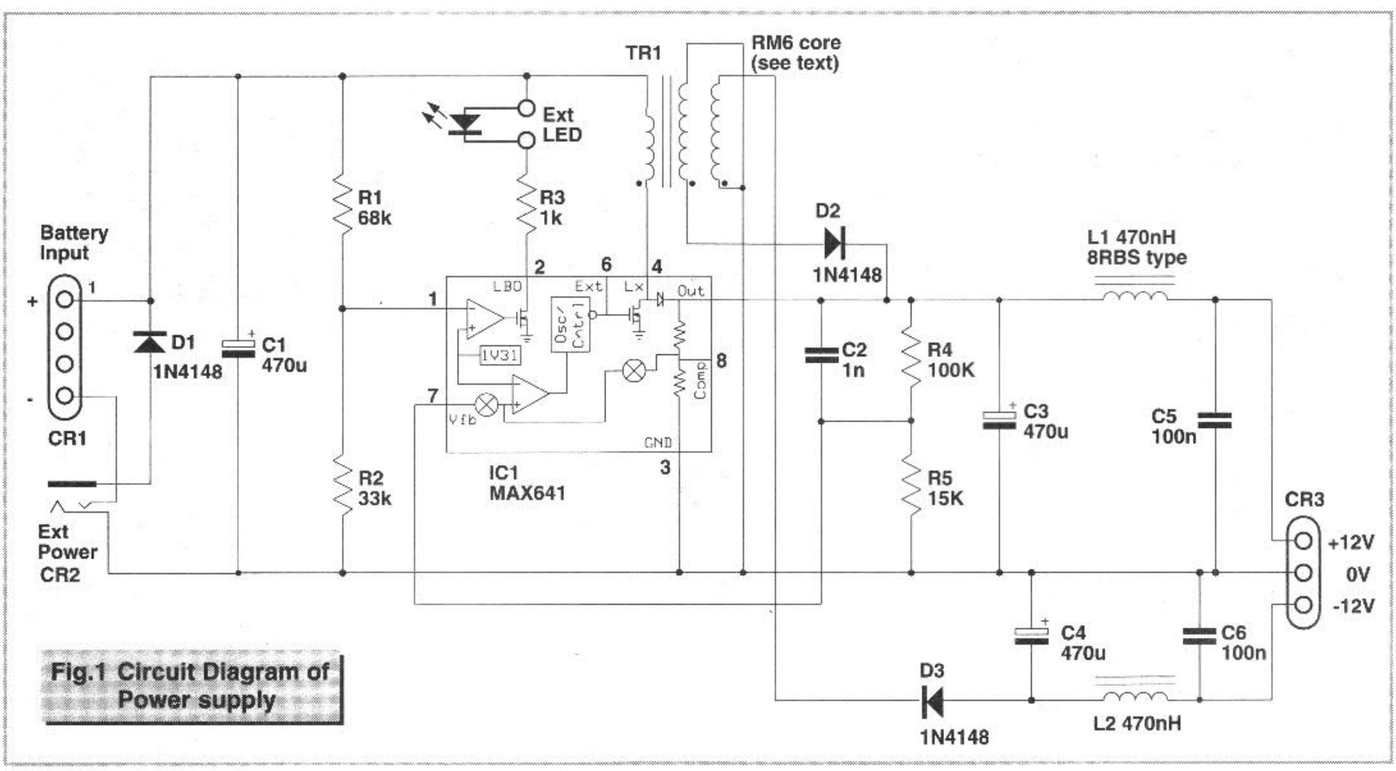


Fig.1 Circuit Diagram of Power supply

The Anti-Howler project last month requires a +/- 10 to 15 volt power supply to operate properly. It will at a pinch run on a couple of PP3s, but its performance deteriorates before the battery voltage has declined to what is normally considered the end of its life.

I don't like throwing batteries away before they're fully used, and neither do I like the cost of PP3s in pounds per Watt-hour. I decided instead to design a power-converter to run on four economical cylindrical cells (for the Anti-Howler, AA-size batteries are the right size). Because I so strongly dislike waste, one aim of the project is to run down the batteries past the normal end-

The Works

The circuit diagram is shown in Figure 1. Starting at the input, power may be fed in via CR1 from a battery pack, or via CR2 from an external mains supply. If the power is fed in via CR2, the battery pack is disconnected by the switch in the socket, and the power supply is protected from reverse polarity by D1. Both CR2 and D1 can be left out if the supply is never intended to be used from a mains adapter. If a mains adapter is to be used, it is recommended that DC voltages in the range 4-9V are used. Local decoupling to cope with the high-current switching pulses is provided by C1.

Low battery detection employs a comparator built into the MAX 641, which compares the internal 1.31 volt reference (also used as the power supply reference), with a potted-down battery voltage. With the resistor-values shown, the low battery detection lamp will switch on at 4 volts. This gives plenty of warning of failure, because the supply delivers enough power to run the Anti-Howler down to below 3 volts' input if the optional extra fet is fitted. The terminal voltage of the prototype unit when its output started to sag was measured at 2.67 volts. The low battery indicator output is current-limited by R3 to give adequate brightness to use with a low-current led. Using a high-current LED would to some extent defeat the purpose of the low-battery warning, because the battery would run down faster. However, if you cannot easily get a low-current LED, the value of R3 may be reduced until adequate brightness is obtained.

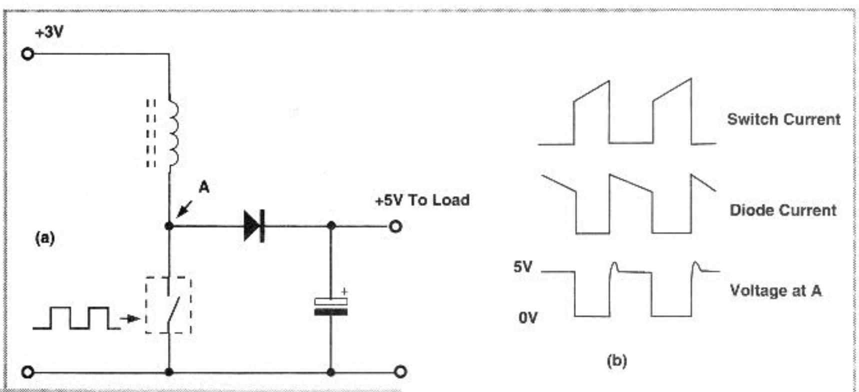


Fig.2 Waveform and circuit showing flyback principle. Ringing at A is due to internal inductance of the capacitor

of-life voltage until they were flatter than the proverbial pancake. Of course, when a battery is run down to this voltage, its final failure is very rapid, so the project has to include a low-battery warning light which operates at around the normal end-of-life voltage to avoid sudden unexpected failure of the equipment while in use. The power supply can be used with other projects which need +/- power supplies, as well as the Anti-Howler.

As it turns out, the MAX 641 switched-mode converter chip made by Maxim is designed for this sort of job. It is available from Electro-Mail (RS Components' sister company) so that amateur constructors can get hold of it.

Converter Topology

The positive and negative supplies (approximately 10 volts in this design) are generated by a transformer-coupled flyback converter. A flyback converter relies on the principle that when a current is flowing in an inductor, if the path through which the current was flowing is interrupted, then the terminal voltage will rise until the current can flow in another path. This is illustrated in Figure 2. Here a low-voltage supply is increased in voltage by charging the inductor via a transistor and then discharging it into the load via a diode.

...one aim of the project is to run down the batteries past the normal end-of-life voltage until they were flatter than the proverbial pancake

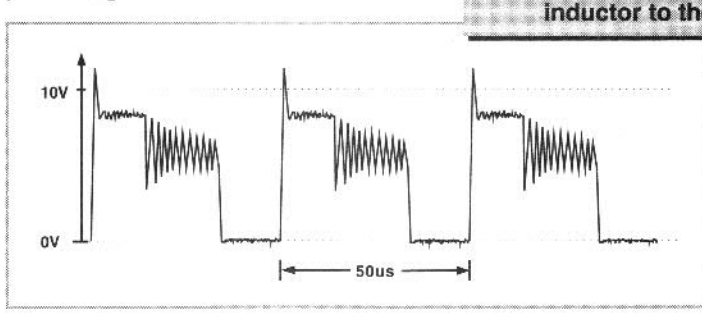
It is possible to feed in energy through one winding of a transformer, and extract it via another winding. This is how the design in Figure 1 works. Unfortunately, there is never perfect coupling between the windings, so that some energy must be taken from the primary winding. Many transformer-coupled switched mode power supplies waste this energy in a snubber network. This is largely unavoidable in the case of mains operated power supplies which must provide isolation. There has to be a significant thickness of insulation between primary and secondary windings, so that some part of the magnetic field around the primary does not enclose the secondary. The energy contained in this part of the field must be dealt with in some way or it is liable to destroy the switching device.

Because the outputs of this design do not need to be isolated, this otherwise unloved and unwanted energy is not wasted - it is fed to the output. Partly for this reason, this design is highly efficient. Most of the power fed into the transformer comes out of the secondaries in the normal way, but the energy stored in the leakage reactance of the primary winding is fed to the positive output via the internal catch diode in the chip. This is illustrated by the waveform shown in Figure 3.

Voltage Regulation

The MAX 641 has two feedback points. If pin 7 is left unconnected, the internal analogue switches automatically take the feedback signal from the internal feedback network. This sets the output to +5 volts. If a feedback voltage is

Fig.3 Waveform on IC1 Pin 4 with a 5V input, 30mA load. Note the ringing in between cycles, due to insufficient energy in the inductor to the load



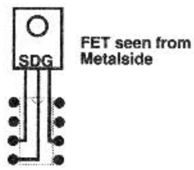


Fig.4 Extra FET connections (FET seen from metal side)

applied to pin 7, then this takes over control of the chip and the output can be set to a higher or lower voltage. With the values of R4 and R5 as shown, the output voltage is approximately 10 volts. Feedback compensation, to keep the whole thing stable, is supplied by C2.

The positive output is directly regulated, and the negative output closely tracks it. The two secondary windings are bifilar wound to ensure very close coupling, so it is possible to draw widely-differing currents from the two outputs without seriously upsetting the balance between them. The only proviso is that there must be at least some load on the positive output if the negative output is to supply a current. The outputs are decoupled by C3 and C4, and additional high-frequency filtering is provided by L1 and C5, and L2 and C6.

Extra Efficiency

The internal fet of the MAX 641 has a high-enough on-resistance to reduce the overall efficiency if more than about 200 milliwatts total load is what's required. As it turns out, the Anti-Howler draws approximately 300 milliwatts from each supply. Under these conditions, the efficiency goes

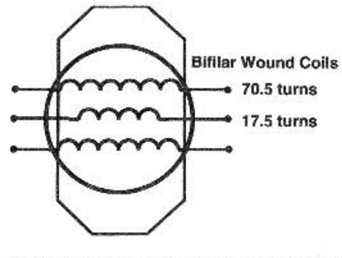


Fig.5 Transformer winding

down rapidly as the battery voltage falls, and the voltage drop across the internal FET becomes a significant fraction of the supply voltage. Using only the internal switching FET, the outputs fell below a reasonable operating range, with an input voltage of 3.6 volts.

To raise the efficiency in this rather high-load application, an external switching FET was fitted using the external drive signal provided for this purpose from the chip. As this extra FET is an optional later addition, it was simply soldered to the pins of the IC, as shown in the photograph. Using the external FET, the peak voltage drop was measured at 100mV, which adds a loss of approximately 3.5% of the input power, at the lowest workable battery voltage, and approximately 1.5% at six volts.

When using the external FET, it was found that increased switching noise was falsely switching the low-battery comparator. To remove this problem, a 100nF capacitor was fitted underneath the PCB between pin 5 of the chip and the adjacent earth track - on the prototype, a surface-mount capacitor in the 1206 case style that was used, but any small ceramic or polyester capacitor that will fit in the space can be used.

Construction

Apart from winding the transformer, construction is largely a matter of soldering the components to the PCB. Do remember to top solder all component pins to which there is a top track, though! Several minor options are available:

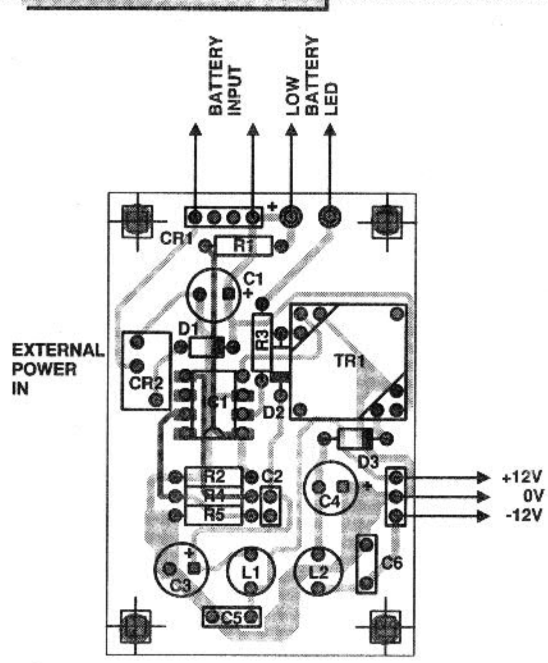
Input and output connections have been laid out to accept 0.1" Molex connectors as shown in the parts list. However, depending on how the power supply is to be used, wires may be directly soldered to the pcb as shown in the photograph.

If the power supply is to be used with the anti-howler project, then I strongly suggest that you add the optional power FET (which can be a BUZ10, BUZ11, BUZ71 or almost any low voltage TO220 N-channel mosfet). Figure 4 illustrates the connections required.

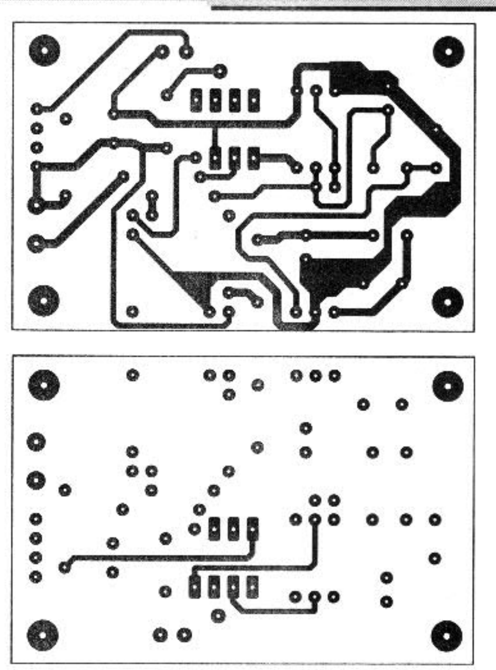
If you fit the extra FET, you MUST fit an extra 100n capacitor (C7) under the PCB between IC1 pin 5 and the adjacent 0V track.

The transformer is wound with

Fig.6 Component layout



Foils:
Solder side - top
Component side - bottom



17.5 turns on the primary, and 70.5 turns on each secondary. The relative phase of the primary and secondaries must be preserved, so choose a direction to wind (either way) and wind all windings the same way, starting from the same end. The primary connects to the middle pins at each end of the former and the secondaries to the outer pins, as shown in Figure 5.

The secondaries are bifilar wound, to make the regulation between positive and negative outputs accurate. The way to make a good bifilar winding is to twist two strands of wire together, and wind with the twisted pair of wires. Obviously, it will be necessary to use a circuit tracer to identify which ends form one coil - and they must not be crossed over if the unit is to work.

To test the unit, connect a 330R load resistor from each output to 0V, apply 6V to the input, and check the output voltages. You should measure approximately +/- 10V. Then connect the LED to the low battery warning output, and reduce the input voltage to check that the low battery warning switches at about 4V, and that the supply gives at least +/- 9V to significantly below this voltage (to under 3V if the extra FET and capacitor are fitted).

About the only likely faults to stop the unit working would be a missing top-soldered joint, an incorrectly wound transformer, or an incorrectly fitted extra FET. If built correctly the unit should work perfectly and be very reliable.

Parts

Resistors

(All 1% 1/4W)

R1 68k
R2 33k
R3 1k
R4 100k
R5 15k

Capacitors

C1,3,4 470i 16V (pref. 3.5mm pin spacing)
C2 1n ceramic 0.1" pin spacing
C5,6 100n polyester or ceram, 0.2" pin spacing
C7 100n smd or small ceram (optional extra)

Semiconductors

D1,2,3 1N4148
IC1 MAX641 (Electromail 655-420)
Q1 BUZ10 or similar (Optional extra)
LED1 Low current LED eg Maplin UK48C (Off PCB)
(Note this should already be present on the Anti-Howler)

Miscellaneous

CR1 4 pin 0.1" Molex plug
CR2 2.1mm power socket maplin RK375
CR3 3 pin 0.1" Molex plug
L1,2 470iH 8RBS chokes
Part No 262LYF-0100K (Cirkit 34-62100)
TR1 RM6-250 for winding details see text.
Suitable battery holder for 4 off AA (or other chosen size) cells.
4 pin Molex shell
3 pin Molex shell
Molex crimp contacts.
PCB, wire, solder etc.

Clang

Owing to the gremlins from using new software in the page make-up last month, a number of 1s and other digits seem to have inexplicably disappeared from the circuit diagram on page 34.

In the bottom left hand corner the upper capacitor connected to CR8 is C12 220n, and C15 is 100p. The first resistor is R31 47K. R32 and 34 (connected to ground) are 10K and R33,35 100K. In the top right, the resistor is R36 10K and C13,14 10uF. In the middle right R28,29 10K and far right R38 is 1K and C16 1uF (input to pin 16 IC4). These items are verified in the component listing.

At last, a fully functional upgradeable PCB CAD system to suit any budget. Substantial trade-in discounts are available against other "professional" PCB design packages ...

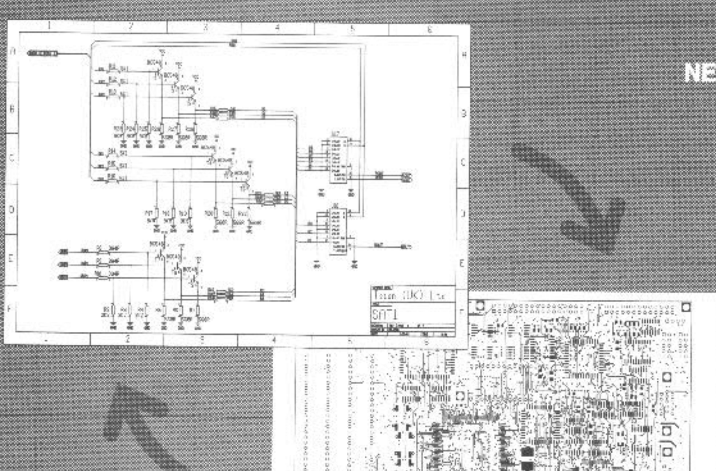
... call now for details.

BoardCapture

Schematic Capture Design Tool

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single-sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)

- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2



BoardMaker

BoardMaker1 - Entry level

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level

- All the features of BoardMaker1 +
- Full netlist support - BoardCapture, OrCad, Schema, Tango, CadStar and others
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator - Database ASCII, BOM
- NEW Thermal power plane support with full DRC

BoardRouter

Gridless re-entrant autorouter

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)

Call, write or fax for more information
or a full evaluation kit

Tsien (UK) Limited
Aylesby House
Wenny Road, Chatteris
Cambridge
PE16 6UT
Tel (0354) 695959
Fax (0354) 695957

tsien

Instrumentati

No ordinary op-amp will do for detecting very small measurements as David Silvester shows.

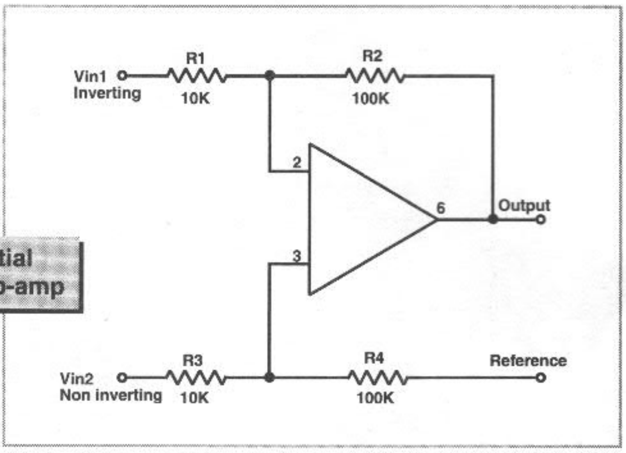


Fig.1 Differential mode op-amp

Instrumentation amplifiers are a specialised type of amplifier that must not be confused with operational amplifiers even though some manufacturers will call their op-amps instrumentation amplifiers. Elsewhere in this issue is a simple seismograph that has to have a very stable fixed gain differential amplifier to work. Since the amplifier output is sent to a 1mV full scale recorder on which it is possible to see 0.01mV changes you can begin to see just how stable the instrumentation amplifier has to be long term.

I intend to look at instrumentation amplifiers here and their differences from operational amplifiers. Whilst a simple low cost op-amp like the LF351 or LM308 is priced at about 40 to 50 pence, the precision high stability op-amps (OP77 etc.) cost from £1.50 to £5 whilst the instrumentation amplifier contains three such precision op-amps and costs from £3.50 to £10 depending on the facilities it offers. Instrumentation amplifiers are easy to use, easier than op-amps in fact and for their capabilities offer very good value for money.

What is it?

An instrumentation amplifier is a closed loop gain block which has differential inputs and an output which is single ended with respect to a reference terminal. The operational amplifier is an open loop gain block that must be controlled by the use of external feedback resistors. The input impedance to either input of an instrumentation amplifier (in-amp for short) is identical and very high, typically 10^9 to 10^{12} ohms whilst those of the op-amp in a differential circuit will be vastly different as I shall show later. This is because the gain setting resistors of the op-amp are part of the input circuit whilst the in-amp has gain setting components isolated from the input. As such the instrumentation amplifier may be of a variety of types which can have its gain preset internally, set externally with by selecting various pin connections, digitally programmed, or user selected with a single gain setting resistor across a pair of IC pins.

Common mode rejection is the ability of an amplifier to measure the difference signal that appears across its input terminals whilst ignoring signals that are common to both inputs. The original requirement for in-amps was in such applications as electrocardiographs where millivolt signals derived from the patient's heart were to be amplified whilst the volts of 50Hz mains pickup were to be ignored. Even the low cost Burr-Brown INA114 has a common mode rejection of 100dB, a 10V common mode input signal will give the same output as a 0.1mV differential signal. Other properties required of the instrumentation amplifier are low noise,

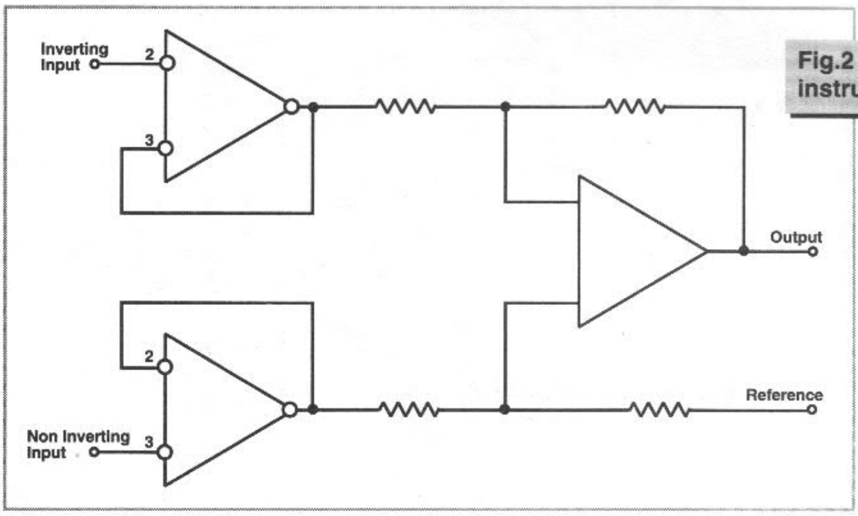
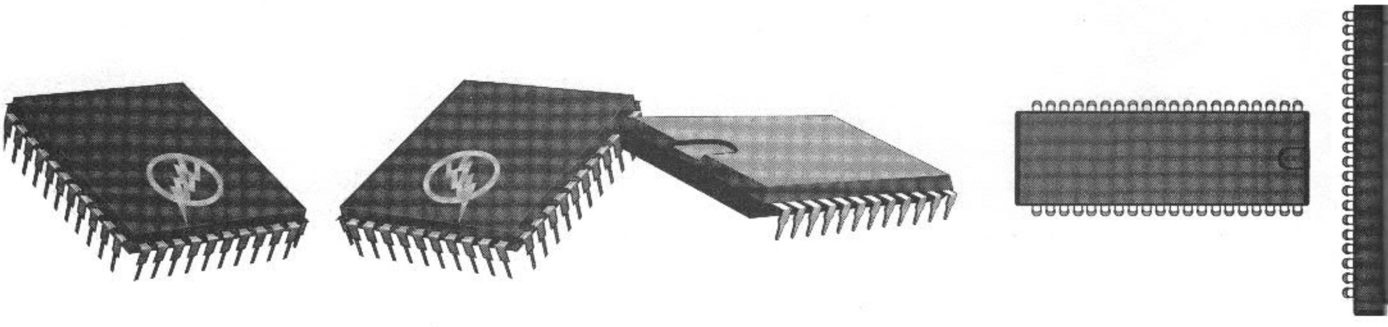


Fig.2 Three op-amp instrumentation amplifier



on Amplifiers

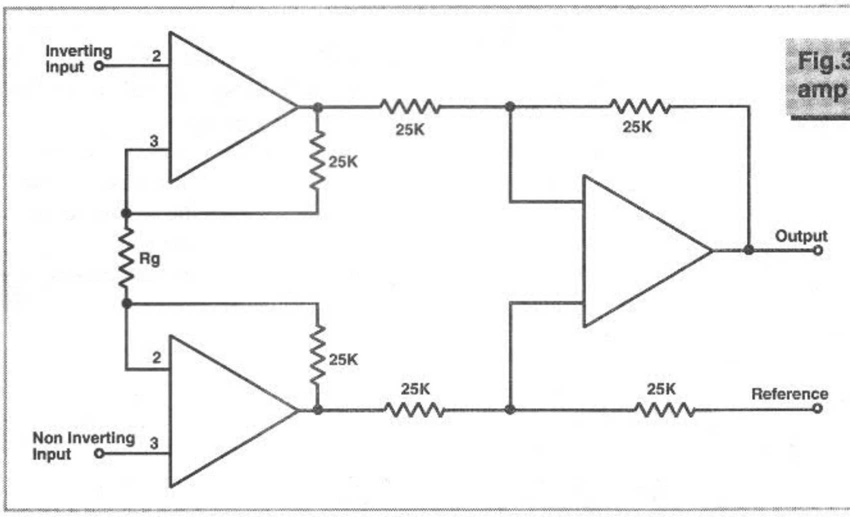


Fig.3 Commercial instrumentation amp configuration

low offset and drift and low bias currents. Frequently added to this is the in-amp's capability of not being damaged by very high input voltages since they contain their own protection circuitry. As such instrumentation amplifiers come in as bipolar or FET types. Bipolar in-amps have lower noise but higher input bias currents than the FET devices, just as in op-amps.

In-amp applications

Regrettably instrumentation amplifiers are rather ignored except in specialist areas, whilst they would offer advantages for many applications were they better known. For all forms of data acquisition where you are working from the low output signals of say thermocouple temperature sensors, load cell weighing systems or any Wheatstone bridge sensor working in high noise environments, the instrumentation amplifier excels. Medical instrumentation has been mentioned for ECG and EEG monitors and for audio systems their high common mode rejection makes them excellent for microphone amplifiers. As more users come to know of them so the list of applications will increase.

Inside the instrumentation amplifier

Let us go back for the moment to the use of the operational amplifier in the differential mode that is the simplest form of in-amp type circuit. Consider Figure 1, with the point marked as reference connected to ground, although providing the reference is connected to a low impedance point the voltage is not too important if the op-amp is working in its linear region. The op- amp is running from +/- 15V supplies. The circuit is of a ten times amplifier and if R1 = R3 and R2 = R4 then:

$Vout = (Vin_2 - Vin_1)(R2/R1)$

There are of course serious limitations to this circuit, look at the input impedances. The inverting input of the op-amp is a virtual earth so the input impedance seen by Vin_1 is 10K whilst Vin_2 sees 110K as the non-inverting input is a virtual open circuit. Also the circuit is dependent on accurate matching of the resistors, a 0.1% mismatch drops the common mode rejection to 66dB and we normally buy 5% or 1% tolerance resistors!

Although there is a two op-amp instrumentation amplifier they are little used in practical in-amp chips. The next

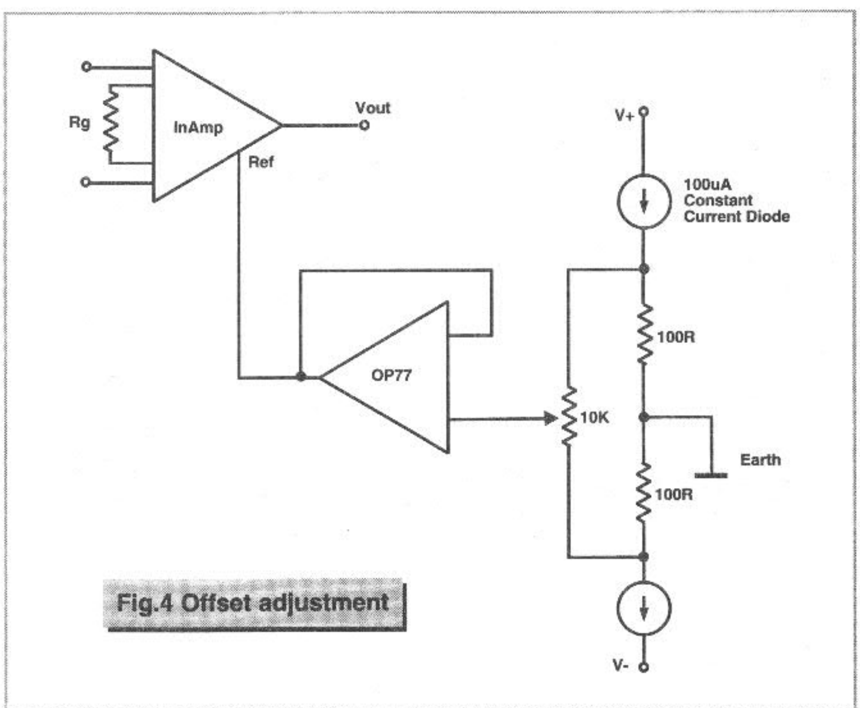
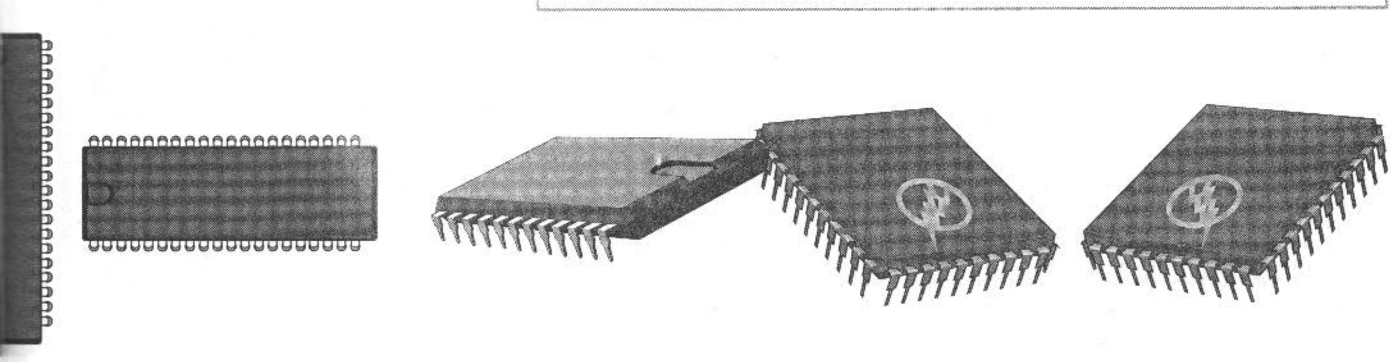


Fig.4 Offset adjustment



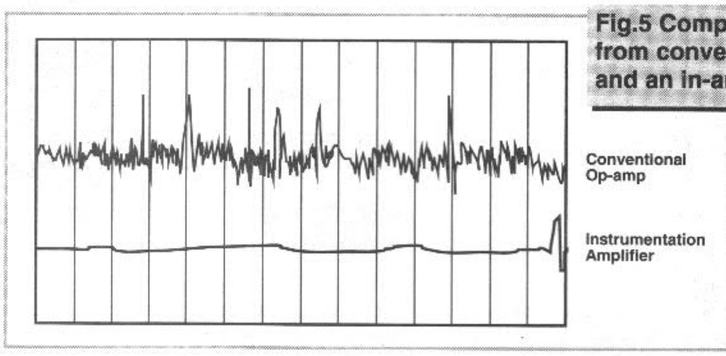
possible improvement is the three op-amp type shown in Figure 2. Here we add two buffer op-amps and since these can be in one pack to reduce drift problems it is a much better proposition. The inputs now both see a high input impedance but to get variable gain we need to change two resistors not one and again the tolerance for them must be very high. The alternative is to give the input stages the gain as shown in Figure 3, and it is this type of circuit that is used in the instrumentation amplifiers that you can buy off the shelf. It is the actual internal circuit of the Burr-Brown INA114. Since all of the resistors are made at the same time on one piece of silicon they are accurately matched at all times, which gives the high drift stability of the instrumentation amplifier. The gain is set by a single resistor Rg and uses the simple formula:

Gain = 1 + (50K/Rg)

In the Burr-Brown INA114 or the very similar Analogue Devices AD620 (they appear to be pin compatible but check your data books) this resistor is supplied by the user. With Rg open circuit (ie. Rg is infinite) then the gain is 1. At the other end of the range as the value decreases with increasing gain then factors such as internal wire resistance or the absolute gain of the internal amplifier stages control the external resistors effect. Normally though the circuit designer will want one of a fairly standard set of gains, say 10 times and the manufacturer recommends values selected from the 1% resistor range that give accurate results for normally required gains. Since it is the input stages that now give the gain whilst the third amplifier is a times 1 buffer/adder circuit, differential signals receive the gain of the input stage whilst common mode signals are only amplified by 1. The seismograph amplifier itself is a high stability, accurate, switched gain differential amplifier that can be built in its own right to fulfil any amplifying application, not just that given.

Neither the INA114 or AD620 in-amps has an offset adjustment pin as such and it is normal to use the circuit of Figure 4 to give this offset. Note the abbreviated schematic symbol for the instrumentation amplifier. The OP77 op-amp provides the low impedance that is needed at the reference terminal if the in-amp is not to have its common mode rejection ratio degraded, and it must of course have a very low drift, no 741Cs here.

Fig.5 Comparitive readings from conventional op-amp and an in-amp



Whilst building the seismograph I had originally built an instrumentation amplifier based on the internal layout of the INA114 and with the offset circuit similar to that of Figure 4, but using a TL074 as the op-amp. The results are shown in Figure 5; the wavy line is the TL074 built amplifier at 10mV full scale, the straight line comes from the INA114 device at 1mV full scale.

The INA111 is a FET input equivalent to the INA114 with much lower input bias but higher noise, drift and offset but even these figures put most op-amps to shame. The PGA204 and 205 are digitally programmable types with gains of 1, 10, 100 and 1000 for the PGA204 and gains of 1, 2, 4 and 8 for the PGA205. The INA120 costs £8.02 and has pin selectable gains of 1, 10, 100 and 1000 since it contains the gain resistor selection internally, and incidentally its drift figures are lower as the gain setting resistor is thermally connected to the other resistors, being on the chip itself. Both the PGA and the INA120 have offset adjustment pins for one of the first stage amplifiers but it is only with gains of 100 and 1000 that most of the offset comes from the first stage. At lower gain the reference pin offset circuit shown earlier is recommended by the manufacturers.

Conclusions

My experience with instrumentation amplifiers has been very good. They are simple to use, stable and have characteristics that are unmatched in op-amps. Although you can build an instrumentation amplifier from separate components at a lower cost its capabilities will be less than those of the bought-in in-amp chip. If you use special op-amps and low tolerance resistors to match performance then the cost exceeds the cost of the bought item anyway. Having discovered them I am sure you can find many applications or projects where their special attributes will be of use.

Free Smart Book Demo Disk Offer

Print in **BLOCK CAPITALS** Allow 28 days for delivery

Name ....

Address ....

.... Postcode ....

Send in the completed coupon with 2 x 20p coins stuck to a card for postage and packing to: **Frax Demo Disk Offer, Electronics in Action,**
PO Box 600, Berkhamsted, Herts. HP4 1NL

Terms and Conditions
Only correct applications will be considered, ie those filling in their name and address in block capitals and sending in 2 x 20p coins to cover postage and packing.
The offer is subject to availability and closes on 5th November 1993
The offer is open to those resident in the UK only.
No responsibility can be accepted for applications lost, damaged or delayed in the post. Proof of posting is not proof of receipt.
Allow 28 days for delivery. This offer is not intended to create a legally binding contract.

Did you miss the offer in the first issue of this magazine?

The Frax Demo disk authoring system is still available for a limited time. Just fill in the coupon here and send to us today at Quantum House Publications Ltd.

You may photocopy this coupon if you do not want to cut the magazine.

Tomorrows World presenter Judith Hann at the launch of the project. This took place at the RNIB headquarters, London in March of this year

The RNIB Electronic Newspaper is a new and exciting way for blind and partially sighted people to gain independent access to a daily newspaper

An event that took place earlier this year could provide the start of a revolution in the newspaper industry in the next decade.

For centuries, newspapers, news sheets and magazines have been brought to your door printed on paper and up until recent times (1980s) the method of producing a newspaper had hardly ever changed. Although still on paper, the industry took a giant leap into the world of Desk Top Publishing where skills in traditional typsetting techniques were replaced with arranging page layouts on computer screens.

This year, one national daily newspaper took another experimental step into possibly troubled waters, to radically alter the way our newspapers are delivered. In one swoop it is now technologically possible to cut out the printer, the distributor, the wholesaler, the retailer and the newspaper boy by electronically delivering the news straight to your home. The implications of this will inevitably alter distribution

The Electronic Newspape


In the broadsheet section

Bosnia FC The team that came out of the camps – to Dewsbury Back page

• Home Lockerbie: the latest twist of a tangled tale
• Economics Will Hutton on the left's lack of a creed
• Sport The US wins the Ryder Cup; Prost is world champion
• Comment Paul Foot's column

45p Monday September 27 1993 Published in London and Manchester

Guardian 2 tabloid with Media and 16 pages of jobs

Gerald Grosvenor The billionaire who says he is not interested in material things

• Media Birtism hits Radio One; boring broadsheet agony
• Arts Madonna: The Girlie show comes to Wembley
Robbie Coltrane: how I came to play a clinical psychologist
• Profile: Ben Elton

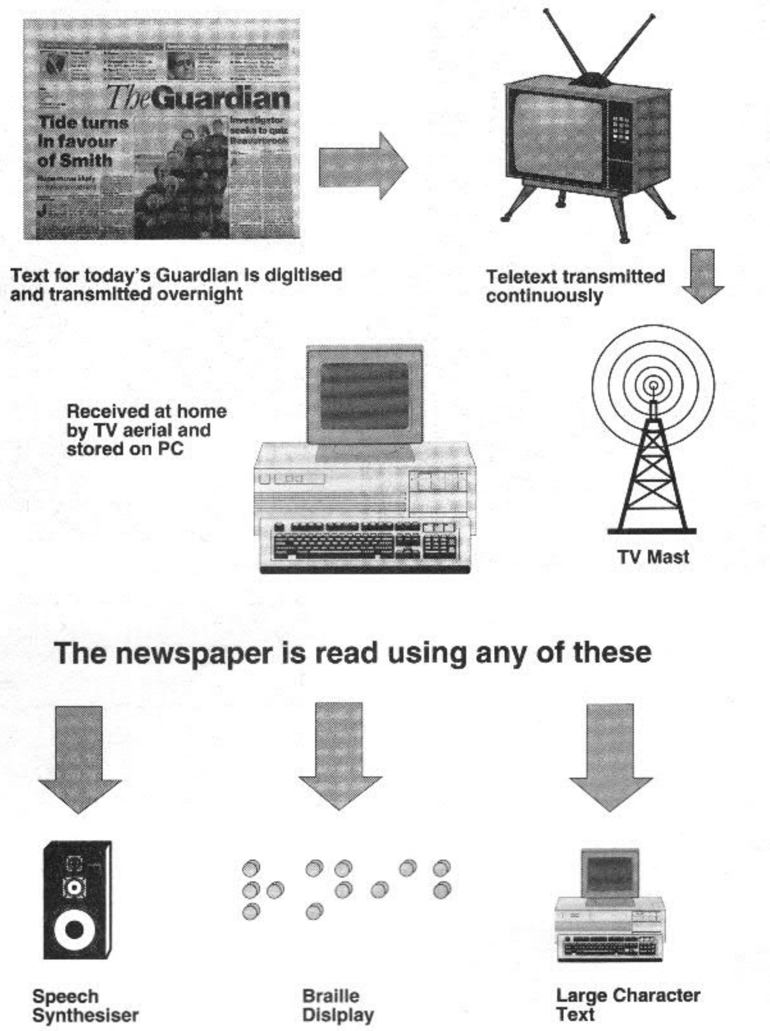
The Guardian

Tide turns in favour of Smith

Nupe move likely
o sway waverers

Investigator seeks to quiz Beaverbrook

How the electronic newspaper works



r Boy

methods in the future.

The Guardian has been the first national newspaper to make itself publically available over the airwaves. It has been carried out as an experiment in association with the Royal National Instititute for the Blind.

The RNIB Electronic Newspaper, as it is known, is a way for blind and partially sighted people to gain independent access to a daily newspaper.

Using a TV aerial, personal computer and speech synthesiser or braille display, a visually impaired person can read their own copy of The Guardian at the same time the print version is delivered to their sighted neighbour.

It also provides a greater independence for people who are deaf and blind because the electronic newspaper can be accessed by a braille display.

The electronic newspaper also gives full access to BBC and ITV teletext services and TV sound.

In Operation

The evening before publication, The Guardian pages are processed to remove photographs, graphics and tables which are difficult to convey with synthesised speech. The pages are then compressed and coded for transmission using an encryption technique which ensures that only ETNA uses, the transmission organisers, can receive and decode files.

The 'reader' plugs a TV aerial into the ETNA decoder board fitted to his/her personal computer and overnight, The Guardian files are received via teletext transmissions and stored on the computer's hard disk. When required, they are decompressed and processed ready for reading. By 6am on the day of publication (before many sighted people get the print version), The Guardian can be read using a speech synthesiser, braille display or large character display. Teletext and TV sound are also available at any time.

Readers can read the full text of The Guardian cover to cover if they wish. However, the newspaper is presented in sections, following the layout of the print version, with the same categories: Home News, Foreign News, City, Sport, Education, European News, Features, and the special Guardian Tabloid section. Readers are invited to choose the category which interests them, and then browse through the headlines until they find an article they would like to read. Once selected, the complete article can be read in one go, or a paragraph at a time, a line at a time, or word by word. Unfamiliar or foreign words can be spelled out.

The newspaper reading software allows the user to find and read articles and teletext pages with a series of simple menus. The majority of operations can be completed using a handful of keystrokes, making the system suitable for people who have never used a computer before.

The menus allow the reader to search for articles of special interest, and the number of back copies which can be saved for future reading is limited only by the hard disk capacity of the computer. For more experienced users, there are a range of facilities which include setting and returning to bookmarks, searching within articles and teletext pages, and importing documents in the ETNA format from floppy disk.

Electronic newspaper benefits

Access to a daily newspaper in this way could provide the visually impaired with a lot of employment opportunities, something that has been denied them in the past. This would apply to anyone who needs to know what is going on in the world; they can now access information electronically given the appropriate equipment.

Anyone can now find articles on specific subjects using a search mechanism. A businessman or woman for example may wish to search for details about a particular competitor within the City pages. A Search facility enables the user to key in the name of a company, the electronic newspaper will present all the articles which feature that name.

Education

The newspaper opens up access to information on a variety of topics, particularly to students of Politics, Economics, English and Current Affairs.

A teacher can save articles for conversion to braille hard copy at a later point. This will allow visually impaired pupils to all have a copy of an article for use during a lesson.

Libraries

Some libraries already offer specialist equipment for visually impaired people to use. An electronic newspaper terminal would allow libraries to expand their services not only for visually impaired people but also for everyone else who might want quick-access research and cannot afford to buy the equipment.

Electronic newspaper archiving facilities allow librarians to keep and catalogue back copies of The Guardian for everone including visually impaired readers to refer to. There are future plans to offer local newspapers on disk.

Home

The electronic talking newspaper provides an obvious solution for blind and partially sighted people with news, analysis, current affairs and features every day, but it also opens up the world of news for deaf-blind people. They are denied access to radio, TV news, and print but the electronic newspaper with its active braille output, provides information for the first time about the outside world.

The simple menu driven software makes the newspaper system suitable for all ages. The newspaper is divided into categories and enables readers to select the area they are interested in, such as sport, arts, or foreign affairs.

The Equipment

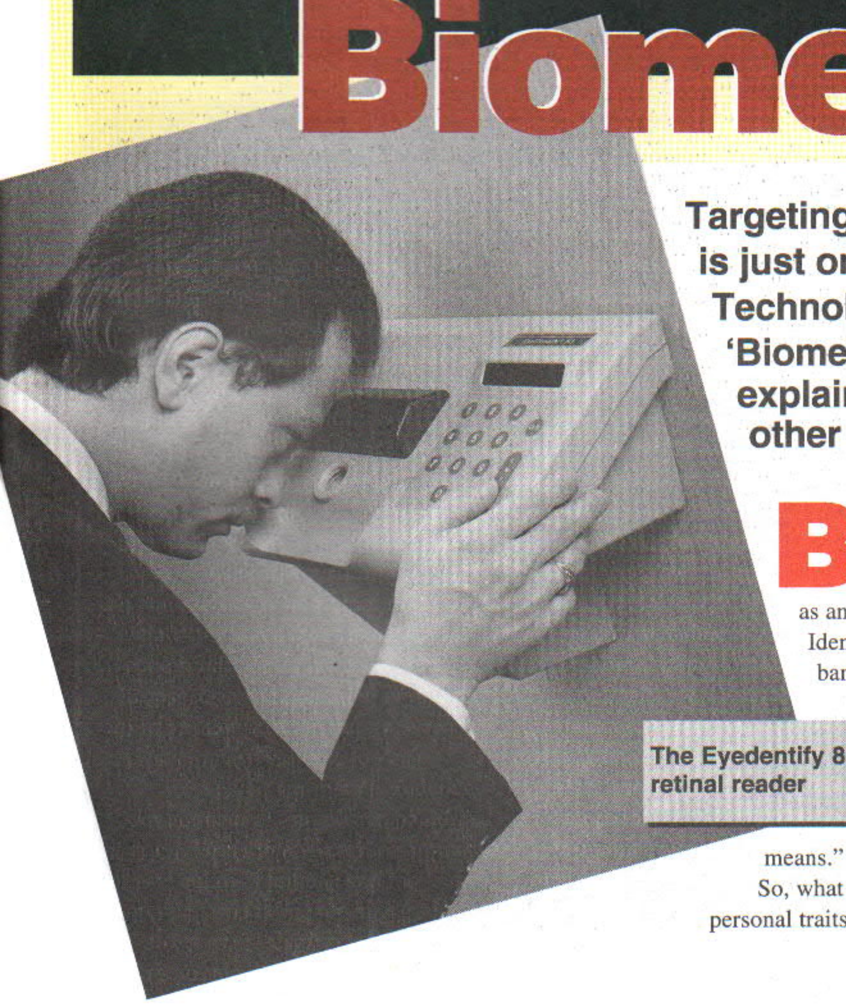
The system requires an IBM PC compatible personal computer with an ETNA decoder card. A professionally installed TV aerial is also recommended to ensure complete, error free reception. The electronic newspaper system supports a range of speech synthesisers, such as Apollo and Infovox, and transitory braille displays such as Alva. ETNA can supply and install a complete newspaper system, or just the component parts required by individuals.

The Future

It is planned to extend the range of information available to blind and partially sighted subscribers. Books, magazines and local newspapers could be made available in the ETNA format, delivered to the user on floppy disk. Developments within Europe will hopefully result in the availability of European books and magazines, all accessed by the simple ETNA software.

For further information about this scheme contact:
RNIB
Telephone 071 388 1266
ETNA Ltd.
Telephone 0661 860

Biometrics



The Eyedentify 8.5 retinal reader

Targeting the end of credit card fraud is just one possibility of Biometric Technolgy. Emma Newham, Editor of 'Biometric Technology Today', explains this and the multitude of other uses

Biometrics is the highest tier of three often quoted security system levels. The lowest in this structure is something which you might already have such as an ID badge or card. The second is a Personal Identification Number (PIN) or password for credit and bank cards. Biometrics form the third tier in a security structure because it is something which involves us and is defined as, "a measurable physical characteristic or personal trait used to recognise the identity, or verify the claimed identity, of a person, through automated means."

So, what exactly are these physical characteristics and personal traits referred to in this definition? The more commonly

The HandkeyID3D from Recognition Systems Inc. uses the hand's geometry to verify users.

referred to are fingerprints, hand geometry, retina blood vessel patterns, facial and vocal characteristics and signature and keystroke dynamics. Although anything which is unique to each person can be adopted with differing ease of use and convenience. All biometric verification systems work in the same way and are affected by the same factors. In order for a person to be verified, they first have to be enrolled on the system. This is done by letting the biometric device 'see' the person's individual characteristic, either once or a number of times depending on the system. A template is then made from the aggregate that is the fingerprint being read by an optical scanner or a phrase being repeated for a voice system. This process can take up to five minutes. The template is then stored in the device's memory, on a central database or on a plastic card which the person carries with them. If stored in memory or on a central database, each template is usually linked to the specific person by a PIN. When used for physical or logical access control, the system can be programmed at the enrolment stage with details of when and which doors or computer files the person is allowed access to. When the person needs to gain access to a biometrically secured area or be verified as the authorised cardholder at the point-of-sale, they simply enter their PIN or card and give a new sample of their characteristic. This new sample is then compared by the device to the template. If they are similar enough, the system will allow the person to make a transaction or to access the area. The system does not, however, give a definitive yes you are that person or no you are not - it gives a score, usually in the form of a percentage. The closer the score to 100%, the better the similarity between the template and the newly given sample. Unfortunately, because of the difference between positioning of a finger each time or changes in a signature, a 100% score cannot be achieved. As a result of this, it is possible for a system to falsely accept or reject someone.

Fingerprinting - The Oldest Method

One of the oldest forms of identification is the fingerprint, with the history of its use going back to Ancient China. In 1684 Nehemiah Gruw of the Royal Society in London noticed that the tips of everyone's finger was different and could be catalogued according to a number of main patterns including loops, whorls and arches. The quality of fingerprint varies between race, gender, occupation and age with the worst prints being from a young, female, Asian or mine worker. As a person gets older, their skin hardens and the fingerprint

Rolls-Royce Dynamic Signature Verification System

becomes more pronounced. Orientals tend to have much finer print details, as do women, while dirt, grease and sweat all obscure the details as well.
The main users of fingerprinting as most of us know are the police who started fingerprinting offenders in the mid 1880s. The prints were collected using special ink and deposited on a card split into ten sections. The prints are classified according to the major patterns as well as branches and terminations of the ridges called minutiae. In the late 1960s, the FBI started automating the process of crosschecking fingerprints found at the scene of a crime with those already on record.

The automated systems used by police forces are the Automatic Fingerprint Identification Systems (AFIS).

The other automated fingerprint systems are for verification. These work in the same way as most biometric systems with the user being enrolled and a template stored, possibly with a PIN, for later comparisons. These devices check that the finger being offered is 'live', so that a severed finger cannot be used. Fingerprint verification differs from AFIS as the new fingerprint is compared against only one stored sample, the alleged user's, rather than a multitude. A person is verified as being the person they allege to be with a straight 'yes' or 'no' rather than giving a list of possible owners of a specific fingerprint.

To use a fingerprint verification system, a finger is placed on a reader which scans and captures the print details. In most cases, an actual image of the fingerprint is not stored in

When a fingerprint is gained from the scene of a crime, it is scanned into the AFIS and compared with every fingerprint of known criminals stored on the database. A list of the most likely owners of the fingerprint is then produced. The use of these systems is by no means universal, with many searches still having to be carried out manually. The number of characteristics matched between a fingerprint found at the scene of a crime and one held on record needed for a positive identification of a criminal varies from country to country, with 16 being required in the UK.

memory, but rather details of the minutiae points in a digitised form. The scanning process is done using an optical scanner or ultrasonics which can look below the finger's surface, thus eliminating the problem caused by young, female, Asian or mine workers. Another form of verification using the tip of the finger looks at the unique positioning of the sweat pores. Contact sensitive micro switches read the ridges on the fingerprint, and can tell where the sweat pores occur, as they are holes in the ridge. The system also locates the ridge endings and a template is made from the sweat pore to the ridge ending distance. What makes this particularly interesting is that the scanner is only 13mm square and 20 microns thick, and could easily be incorporated onto a standard bank card, even under the hologram, with the template being stored on the magnetic stripe.

As people often associate fingerprinting with the police, a large publicity campaign might have to take place before any mass commercial use could be implemented. As the fingerprint image is not captured for verification systems, it cannot be used for police purposes, even if it were legal to do so. If the template is stored on a plastic card, the cardholder always has the template with him or her and there is no need for a central database at all.

Hand Geometry

The lengths and shapes of fingers can also be used to identify people. Hand geometry works on the principle that the dimensions of the bones stay the same after childhood, with the possible exception of arthritic change. Either a two or three dimensional picture of the hand or fingers is captured by a digital camera. The reading can be affected by a large ring being worn or by an injury. One device currently being developed looks at the pattern of veins on the back of the hand to produce a bar code like template. An infrared scan detects the size and position of the blood vessels. Other systems in this category look at creases on the back of finger joints or scan the palm print. The hand size geometry template is smaller than for other biometrics, being only 9 bytes and it can be stored as a machine readable code on a card or printed in a passport as is being done in an automated passport control system written about later. The biometric system offers the best security from imposters but is not, unfortunately, the most convenient to use.

Eye Dentification

It has been known since 1935 that the pattern of blood veins on the retina of the eye is unique to each person, even identical twins. Only a few, rare diseases affect this pattern, and because of its proximity to the brain, the eye is one of the first parts of the body to decay after death! To scan the retina, the user must look into a lens on the device and focus on a visual alignment target to make sure that the same part of the retina is scanned each time. A low intensity infra-red camera is used to take a picture of the retina. Although the

system has received 'health certificates' from numerous countries, it is still difficult to persuade some users that it will not damage their eyes. As this system requires more user involvement than others, retinal scanning devices will not find their way into the point-of-sale environment. Because of the high cost, security level and user involvement most of these devices are being used in high security areas such as military bases and NASA's Kennedy Space Centre.
Another part of the eye being used for verification is the iris, the texture of which is unique from person to person and eye to eye.

Face ID

The oldest way of identifying individual people is by their face. It is something which we all do every day and think nothing of, but try describing exactly what a friend looks like to someone who hasn't met them and you can see the problems in trying to teach a computer. The facial recognition systems of today use neural networks as the identification processors. These systems can verify a person, either by a photograph or live via a camera. The commercial system currently available requires a person to be standing front on to the camera for verification. A lot of work is being carried out in this area by the Massachusettes Institute of Technology (MIT). A laboratory system can recognise a person with their head at different rotations. MIT is also working on systems which recognise facial expressions and can track a person through a simple scene. Ultimately, these combined technologies could monitor crowds of people and watch known trouble makers or detect a nervous person walking through customs control at an airport.

It's All In the Voice

Work has been on-going in the field of voice verification and recognition for over 20 years, with the first breakthroughs being made in the early 1970s. Voice verification systems cannot be compromised by mimics as they analyze the vocal characteristics that make the speech rather than the speech itself. The vocal characteristics are dependent on speech processing mechanisms of the body such as vocal tract, nasal cavities and the mouth itself. There are two different types of systems available in the voice verification field.

Voicekey voice verification system from International

One is designed for identifying people over the telephone lines for things like accessing bank account details held on a central computer, while the other type is for access control to buildings or computer networks/PCs. The cost of a stand-alone system is dependent on the amount of doors or access points to be secured. Systems using telephone lines tend to be expensive, owing to the high cost of software required on the central computer and not the access telephone point. These systems tend to have more problems than the stand alone types, as they are affected by noisy telephone lines. There is a further distinction between voice systems: text dependent or text independent. Text dependent systems require the user to repeat the same word or phrase that was said at enrolment, while anything can be said when using a text independent system. Voice systems do not tend to run into problems if the person's voice changes owing to a cold, because the voice template is updated each time it is used. They do however run into problems with background noise, a problem which many companies are trying to overcome with noise cancellation techniques and positioning of the microphone. One area where voice verification is being used is home confinement of criminals. Each person is telephoned at a random time every day and their voice verified to check that the person who should be in the house is still there.

Tablets of Stone

As people are used to signing their name for financial transactions, it is hardly surprising that signature verification devices are mainly being designed for the point-of-sale environment. Where these systems differ from non-automatic ones is that they do not check the shape of the signature but the way it is written. Accelerated movements, time taken to sign, the speed of angular movements and when the pen is lifted off the paper ('i's dotted and 't's crossed) are all characteristics taken into consideration.

To capture these dynamics, the signature must either be written on a special tablet or with a special pen. Another signature verification device uses acoustic emission - the sound a pen makes when in contact with paper. Some of these systems also capture an image of the signature which can be printed at a later date.

Ultimately it may be possible for retailers to do away with paper records of transactions and agreements and keep computer records of the captured signature. This cannot currently be done as a paper record needs to be kept for legal reasons. Keystroke dynamics works on the principle that frequent users of computer keyboards develop an individual, verifiable rhythm. This technology runs into problems because a person's typing speed changes substantially when they become tired.

These systems work best when confined to passwords being typed at the log on stage.That is the technology and what it can do, but apart from being arrested and having your fingerprints taken, where else are biometric devices actually being used?

Smart Fingerprints

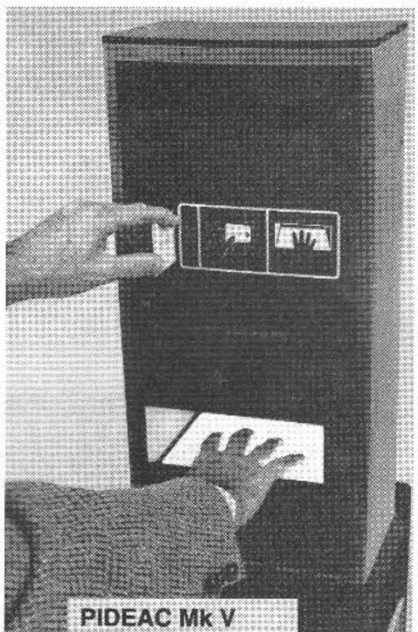
Some 420,000 visitors to Expo '92 in Spain were able to gain access to the exhibition area by having their fingerprint scanned. Season ticket holders and members of staff were all issued with a smart card: a plastic card with a chip embedded in it. The cardholder's fingerprint template was then stored in the smart card's memory. To gain access to the site, the smart card was inserted into a reader on the turnstile and the fingerprint scanned. The newly acquired fingerprint characteristics were then compared to the template and access granted or denied.

The organisers decided to use smart cards and biometrics as a symbol of what technology is capable of doing now and for the 21st century - one of the themes of Expo '92. The advantage of using biometrically secured season tickets was that if lost, a card was of no use to anyone else and more likely to find its way back to the owner. Expo has now finished but it showed the world what could be done with the technology and was the largest mass market application to date.

Anyone who has been abroad on an airplane will know of the long queues and questioning to get through passport control, when all you want to do is start your holiday. A system currently in use in America will get you through passport control in around 30 seconds. The scheme, known as INSPASS (Immigration and Naturalisation Service Passenger Accelerated Service System) is using hand geometry scanners to verify people, with their template printed on a piece of card.

This can be done because the template is only 9 bytes in size and can be printed in the machine readable format known as OCR-B. To enrol on the scheme, an application form needs to be filled in and security checks carried out by the US Immigration and Naturalisation Service.

Once the security checks have been satisfactorily completed, the applicant is then interviewed and their biometric template obtained. As this is a still only in trial stage, applicants' fingerprint characteristics are also being stored in case it is decided to move to that technology in the future. When a cardholder arrives at either of New York's JFK or Newark airports they can proceed to the special INSPASS lane and insert their card, key in flight details and have their hand scanned. Depending on their nationality, either a receipt or I-94 departure document is then printed and they are through passport control. Anyone who visits America at least three times a year and does not need a visa to do so can apply for the scheme. A similar system is soon to go ahead at Germany's Frankfurt airport, whilst a different one is working at Amsterdam's Schiphol airport for Dutch nationals. Other countries and airlines who are part of the World Travel and Tourism Committee (WTTC) are watching these



PIDEAC Mk V Personal Identity Verifier

schemes with a view to improving passenger throughput at all airports.In the future we may all have a page in our passport which contains our hand geometry template, or it may be stored on a smart card along with our medical records and emergency contact details.

One day we could have our voice verified by a device in the bathroom which sets the bath water running at a pre-set temperature while setting up our breakfast for the correct time. On leaving the house you say 'hello' to open your car door while the seat and mirrors adjust to your preferred driving position. You stop and fill up with petrol and pay by credit card, having your signature dynamics verified to complete the transaction.

On arrival at the office, the main door opens for you once the camera has scanned your face and you later have your fingerprint read to turn on your computer. At lunchtime you go to the bank to take something from your safety deposit box and have your eye scanned in order to open the box's lock.

You then go to the pub for a quick drink and some food and when you return to your car it can tell from your voice whether you are over the drink/drive limit or not. You get back to the office but because you are being followed by some visitors who are unknown to the computer, the main door won't open until you have programmed them in for the afternoon. You stop at the post office on the way home to collect that week's child support money and have your fingerprint read to make sure you haven't already collected it. Your child's attendance at school is verified by a scanner in the classroom and access to the canteen for pre-paid meals is secured by another biometric device.

You pick up the family, after saying 'hello' to open the front door, and all go to the airport to start your holiday. Various biometric checks verify which flight you are booked on, notify your destination airport that you are on the flight who in turn notifies a hire car company to have a car ready for you at your arrival time.

Your expressions and gestures are watched as you go through the airport and board the flight as well as at the destination airport. You are off the airplane and through passport control in what seems like no time at all. The hire car is waiting for you already programmed with your voice template for the length of the hire period, while the hotel room requires your hand print before the door will open. All this may seem a bit extreme, but it is just one possibility of what life in the next century may be like using today's new technologies.

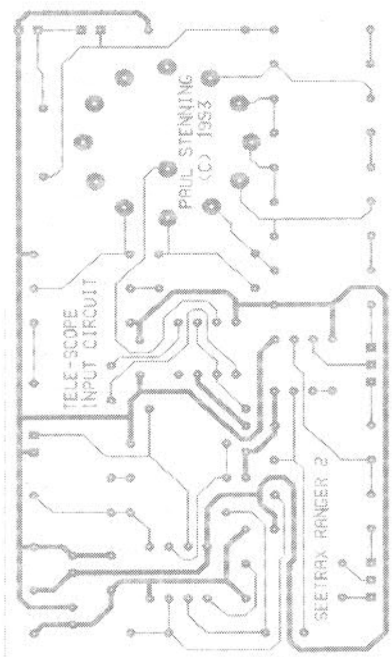
During the last century, you would have been laughed at for talking about 'moving pictures' or for suggesting that man would go to the moon in the 20th century.

Emma Newham is Editor of Biometric Technology Today.
Tel: 0458 223261
Association for Biometrics at the National Physical Laboratory on 081 943 7002.

At Your Service

In order to build some of the creations appearing in this magazine, you may wish to fabricate them on a printed circuit board. It just so happens that Electronics in Action can provide these at very reasonable cost if the need arises. Just simply fill in your details in the box, send in your payment and we'll do the rest. You may photocopy the form if you wish as we know some of you do not like destroying the mag.

Payment must be received with order, either postal-order or cheque made payable to:
Quantum House Publications Ltd.



Please print your name and address in **BLOCK CAPITALS**

Name ....

Address ....

.... Postcode ....

Send the completed coupon (include 80p for postage and packing) to:
At Your Service, Electronics in Action
PO Box 600, Berkhamsted, Herts. HP4 1NL

Please enter amount required in appropriate box

- [ ] QH1193-1 Power Supply (double sided) .. £6.00
- [ ] QH1193-2 Telescope Input board £5.50
- [ ] QH1193-3 Drainpipe Seismometer £5.50

Boards from the October issue

- [ ] QH10931 Telescope Main Board £12.00
- [ ] QH10932 Hi-fi Preamp £4.50
- [ ] QH10933 Laser Zone £5.00
- [ ] QH10934 Anti-howler (double sided)....... £5.50
- [ ] QH10935 Sig Gen board £4.50
- [ ] QH10936 Crossover unit £3.00

Total remittance including P&P £ [.]

Allow 28 days for delivery

Corrections October '93

Crossover Conundrum
Fig.6 showed IC1 as TL072, it should be TL074 as in the parts. C3 should be 100nF in both diagram and parts. Fig.11, the polarity signs were missed off the summing junctions. The foil shows the top side.

Anti Howler
Gremlins in new software caused a number of 1s and other digits to inexplicably disappear from the circuit diagram on p.34. In the bottom left hand corner, the upper capacitor connected to CR8 is C12 220n, C15 100p. The first resistor is R31 47K and R32,34 connected to ground, are 10K and R33,35 100K. In the top right, the resistor is R36 10K and C13,14 10uF. In the middle right R28,29 10K and far right R38 1K and C16 1uF (input to pin 6 IC4). These parts are verified in the listing at the end of the article.

Audiophile Pre-amp
Fig.7 the wire across C6,7,8, and 106, 107, 108 should be removed. PL2 connections should read from top to bottom +V,0,-V

ADVERTISERS' INDEX

Subscribe

to this magazine for 12 months and get 25% off our news-stand price

We will deliver to your door post paid for only

£20.25

Dont miss out - subscribe today by sending your cheque or postal order (made payable to: Electronics in Action) to: Subscriptions Dept, QH Publications PO Box 600, Berkhamsted, Herts HP4 1NL

ELECTRONICS in ACTION

This offer applies to UK Residents only

Baylin Publications

24 River Gardens, Purley, Reading. RG8 8BX. England.
Tel/Fax 0734-414468
Mobile 0836-582785
Pay by: UK£ cheque, Access, Mastercard, Visa, C.O.D.

ALL ITEMS EX-STOCK.

Ku Band Satellite TV, Theory, Installation & Repair 4th Edition. Footprints, dish theory, cables, site survey, polar mount adjustment. ***£25.***

European Scrambling Systems, Circuits, Tactics & Techniques. By John McCormac, digital sound, smart cards, pirate decoders, for hackers. ***£32.***

World Satellite TV & Scrambling Methods. 2nd Edition, by Baylin, Madox & McCormac for the service engineer. ***£29.***

Home Satellite TV Installation Videotape. Forty minutes VHS Pal. See how 3 metre dishes are installed. ***£27.***

Satellite Installation Guide. 3rd Edition. By John Breeds. ***£13.***

The Satellite Book. 2nd Edition. A complete guide to satellite TV . Theory and practice by John Breeds. ***£31.***

World Satellite Almanac. 3rd Edition by Mark Long. 300 Footprints, Frequencies, Transponder Loading, Orbital Assignments. ***£69.***

World Satellite Annual. Update by Mark Long. ***£39.***

TVRO System Analysis and Aiming Software. 5.25 or 3.5 disk, (DOS 3.2). Calculates dish size and lists coordinates of all satellites in view. ***£39.***

Satellite Toolbox Software, for IBM Comp. Hard Disk– 5.25 or 3.5. ***£59.***

Wireless, Cable & SMATV, Microwave broadcasting & cable TV. ***£35.***

World Satellite Yearly by Dr. Baylin, Loading and 200 Footprints. ***£38.***

PRICES INCLUDE P. & P. UK. Airmail Europe add 10%. Outside Europe +20%.

SYSTEM 200 DEVICE PROGRAMMER

SYSTEM: Programs 24,28,32 pin EPROMs, EEPROMs, FLASH Memories and EPROM Emulators as standard, quickly, reliably and at low cost Expandable to cover virtually any programmable part including serial EEPROMs, PALs, GALs, EPLDs and microcontrollers, in many different packages.

DESIGN: Not a plug-in card but connecting to the PC serial or parallel port; it comes complete with powerful yet easy to use software, cable and manual.

SUPPORT: UK design, manufacture and support. Same day dispatch, 12 month warranty. 10 day money back guarantee.

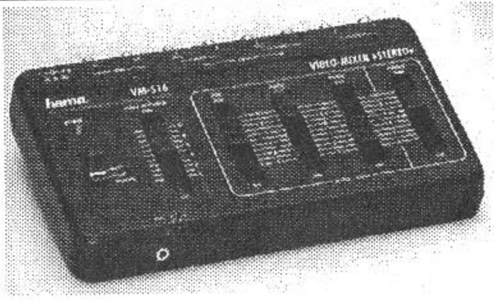
mqp

ASK FOR FREE INFORMATION PACK

MQP ELECTRONICS Ltd
Park Road Centre
Malmesbury, Wiltshire SN16 0BX. UK
Tel: 0666 825146 Fax: 0666 825141

GERMANY 089/4602071
NORWAY 071-17890
ITALY 02 92 10 35 54
FRANCE 1 69 30 13 79
Also from VEROSPEED UK

SOME GREAT AUDIO/VIDEO EQUIPMENT AT *hama* ZINGLY LOW PRICES



VM516 Stereo Video Mixer

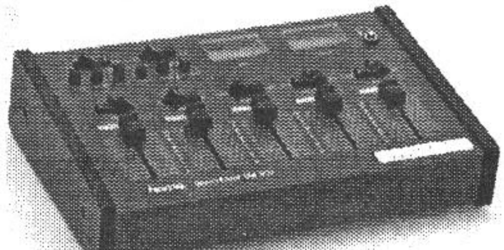
Desk type video sound mixer with enhancer. Allows seperate smooth adjustment and mixing of original video sound with 3 external sources (mic, cassette etc). Master output control. Also continuously adjustable slider corrects video signal when copying. Supplied with 12V mains adaptor

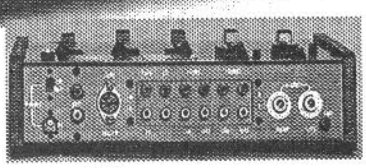
***Our Special Low Price:* £39.95**

SM502 Stereo Mixer

4 Channel audio mixer with inputs for mic, mag/cer phono and tape/tuner. Outputs for headphones and to amplifier. Freq Res 20-20000Hz, S/N ratio >55dB. Supplied with 9V mains adaptor

***Our Special Low Price:* £44.95**





SM507 Stereo Mixer

Big brother of SM502 - this one has all the facilities of the above mixer + twin VU meters and an additional record/replay DIN socket. As can be seen from the inset pic, the socketry on the rear is excellent.

***Our Special Low Price:* £69.95**

***hama** - one of the largest manufacturers of video and camcorder accessories, providing the amateur and semi-professional with high quality state-of-the-art technology. Full details (4 pages) of new products in our 1994 Catalogue - items listed here are only available until stocks are exhausted. Order soon!*

JUST ARRIVED

Large qty of software on 3.5" disks - as 'given away' on covers of computer mags - mainly for PC's and Amigas. Most disks ONLY £1

1994 CATALOGUE

172 Pages of Regular Lines + 24 Bargain List Pages

OUT NOW!!

Many New Lines including Casio Audio Products; Hama Video mixers, lenses and accessories; Scanners & accessories; Books from Butterworths, McGraw-Hill, MacMillan and Haynes; CD's; Big selection of CD ROM's; Single Board Computer; + our usual enormous range of electronic components and equipment.

All for just £2.00!!

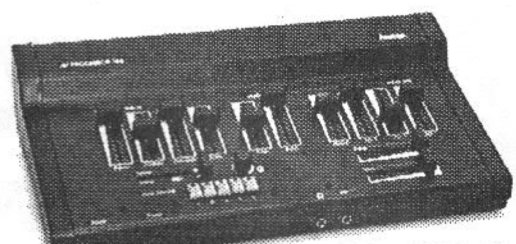
Why not become a Subscriber? For just £6 a year, we'll send you a monthly newsletter with details of all our latest Special Offers, exclusive deals, competitions, gifts and extra discounts

List Price £179.99

AV140 Audio/Video Processor

Corrects video colour signals during copying. Variable colour intensity and contrast. 2 Scart in/outputs; 3rd Scart mon/VCR skt; Aux audio in and mic input, too. Makes & corrects two copies simultaneously!

***Our Special Low Price:* £79.95**



List Price £459.99

AV144 Audio/Video Processor

The ultimate processor - excellent spec, will handle S-VHS & Hi-8. Fitted with a variety of sockets. 5 video, 3 audio inputs; 5 mixed outputs + headphone monitoring. Contrast, Colour sat, Contour controls, 7.7Mhz video bandwidth, resolution >430 lines; 30-25,000Hz audio freq res. Auto noise suppression. 12V PSU supplied.

***Our Special Low Price:* £199.95**

HAN101 Graphic Writer

Produces tables, bar & linear graphs, pie charts - 18 fonts in 9 type sizes (8-75 char. per line). Prints on paper or clear film. Ideal for producing OHP transparencies in up to 4 colours! Compact - 320x260x60mm. Uses 4xD cells, or mains adaptor (supplied) FREE OHP set - 10 sheets + 2 x 4 colour pen sets

List Price £299

***Our Special Low Price:* £99**

MasterCard VISA

All prices in this ad include VAT, **P&P £3.00 per order** (£9.50 next day) Min Credit Card £12. Official orders from Education welcome; min invoice charge £15. Payment is accepted by cheque, PO, cash (inc foreign currency banknotes), book tokens, Access, Visa, Connect. Our stores have enormous stocks - we are open from 9-5.30 Mon-Sat. Come and see us!

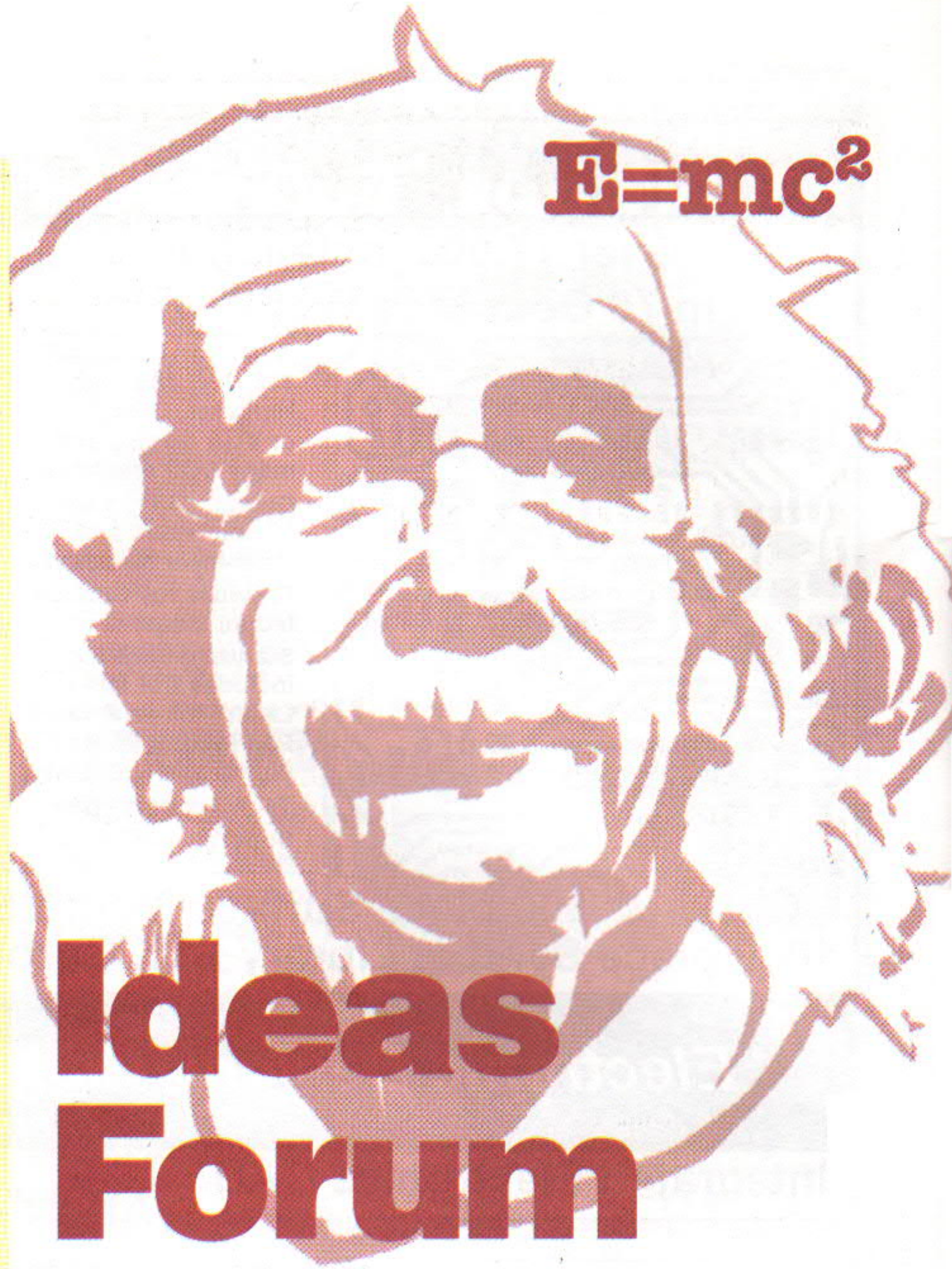
GREENWELD ELECTRONIC COMPONENTS

27C PARK ROAD, SOUTHAMPTON, SO1 3TB

Due to a massive increase in business, we've now installed some extra facilities on new numbers:

SALES & GENERAL ENQUIRIES: 0703 236363
TECHNICAL QUERIES: 0703 325999; ACCOUNTS: 0703 231003; FAX (ALL DEPTS) 0703 236307

FaxOnDemand - A new service from Greenweld to replace our BBS. Masses of information, details of latest offers, all faxed to you automatically. By using the touch tone keys on your fax machine, you will be guided through a menu and be able to select the information you want - or you can leave a voice message. The number for this service is **0703 236315**



Ideas Forum

Time once again to expand these ideas and put some thoughts to paper. This is Electronics in Actions' monthly brainstorm column.

Ever wondered what to do with your spare time? Why not examine the ideas to the left and see if they can provide a spark of an idea that you can develop into something worthwhile. It could be that you are at home, school, college or university and have to make an electronic or allied project for your coursework and you are wondering what to do.

This is an ideas page and is intended to be a regular feature. As soon as you think or know the idea can be achieved by yourself, and it might be a variation on these themes, get a working prototype together. If you think others might like to see your efforts in print, send it in with the details to us and we will seriously consider publishing it. You will of-course be rewarded for your efforts in print. The ideas seen here may even be a cause to write in to our letters page to discuss the ideas you have.

Some of them may well have been designed and built at high commercial level and high cost but it may be you have thought of a quick and easy route to achieving the same end and at much lower cost. The exercise here could also lead to other less costly innovative ideas.

The ideas do not appear in any particular order so keep a look out every month. Very soon Electronics in Action could be printing lists of 'Centres of Excellence' where it would be the place to be for an informal chat and to openly discuss these and other ideas in a sort of brainstorming session.

November

Metal discriminator
Is it possible to sense different types of metal by electronic means? A sensitive density detector for instance, or by measuring its velocity of sound.

Earth ground waves
Measuring the velocity of ground waves or maybe sending digital messages through the ground. What is the best method of getting signals into the ground?

Electrical activity in plants
A device for measuring resistance across a leaf and down the stem.

Osmotic flow
Measuring osmotic flow through plants and electro-osmosis experiments.

IR and UV absorbtion
Recording Infra-red and Ultra violet absorbtion by plant leaves through measurement of reflected radiation from leaves.

Audible sound creation
Sound field investigation using concave spherical reflectors for new loudspeaker system, or by using electrostatic and electrodynamic loudspeakers.

Piezo-electrics
Developing the Piezo-electric loudspeaker for higher power output.

Hearing response of animals
Measuring frequency range of cats and dogs by a resonance technique.

Air pollution monitor
Visual absorbtion using a LASER.

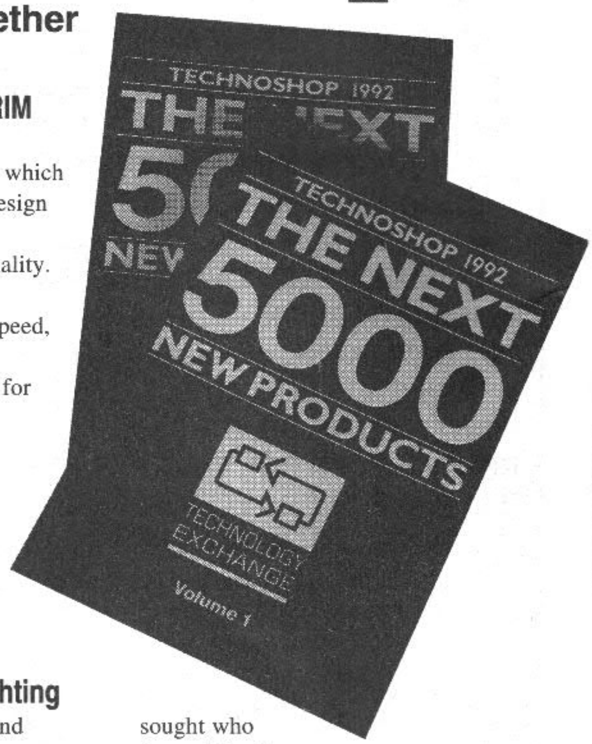
Wind velocity
Sensing the pressure differences ahead of and behind a detector.

Wind direction
Solid state wind direction indicator using a temperature or pressure gradient.

Measuring temperature using sound
Measuring temperature in remote and inaccessible places by sound techniques.

Technoshop

The page that could bring the world closer together



Electronics in Action in co-operation with The Technology Exchange Ltd, the international technology matchmaking service based in the UK, provides you with a selection of technology partnership opportunities every month to which you are invited to respond.

The Technology Exchange, which was formed in 1985 as a not-for-profit technology sourcing service to industry, holds a bi-annual 'Technoshop' Technology Transfer Fair at Heathrow Airport and several 'Techmart' Fairs overseas for the United Nations (UNIDO).

In this issue of Electronics in Action, we continue to present business opportunities from European firms seeking technology partners in the UK indicating on each item whether it is an offer or a request for products or technology.

If you believe that you would qualify to be the partner for any firms described in these profiles, please write to The Technology Exchange quoting the item number and code letters at the head of the entry saying how you wish to respond and enclosing information on your own organisation and its products or services.

The only cost associated with this process is a simple £10 plus VAT introduction fee for each entry to which you respond. For this we will send you the information which we hold on the entry, transmit your response to the source of the entry and invite them to send you more detailed information about themselves and their entry.

The code letters on the entry number indicate the country where the partner is located as follows:-

Code Letters

TO/TR-UK
GOM-Belgium
SOFAD-Spain
GR-Greece
DTO-Denmark
IDA/E-Ireland
PME-Portugal
SG/SGT-Italy
A/ANG/DP-France
B-Bulgaria
ZO/ZL/TVA-Germany

Please respond directly to:
The Technology Exchange Ltd
Wrest Park
Silsoe
Bedford
MK45 4HS
or **Fax:** 0525 860664
Phone: 0525 860333
Please send £10 plus VAT (£11.75) per item with your requests.

Offer DP 35 CAD-CAM Software - STRIM 100

A powerful CAD-CAM system which reduces the effort required to design the product, increases design accuracy and manufacturing quality. Software appreciated for its precision, ease of use, power, speed, compatibility and flexibility. Specific systems also available for the plastics industry and mechanical and design manufacturing. Uniquely, the software incorporates finite element analysis for some plastics and steels. Distributors sought.

Offer DTO TT 6 Halogen/Low-voltage Lighting

Manufacturer of transformers and chokes for halogen / low voltage lighting systems, seeks agents and distributors.

Request DTO 9090 Electronic Equipment

Licences required to manufacture new products in the following fields:-

1 Graphic equipment; sensors, devices and systems for the automatic processing of graphic products.
2 Mobility aids for handicapped people.
3 Electronic lock, security and monitoring systems.

Request DTO 9097 Telecommunications Equipment

A Danish company involved in telecommunications is interested in acquiring new technologies such as systems, equipment, or subjects for new products which may supplement and relate to the company's main line of business. Particularly interested in VSAT technology (Very Small Aperture Terminals). Licence exchanges considered.

Offer/Request GOM ETT 4 Fire & Smoke Detectors

Fire and smoke integrated detection systems which can control air-conditioning, emergency doors, gates, etc. Gas detection units for various gases which can activate emergency telephone dialler. Dealer and installer sought who is capable of obtaining necessary national validation certificates. Company also seeks suitable components for their products.

Offer GOM ETT 9 Informix Online Software Development

Developers of Informix and Unix-based applications and programming tools, seek distributors for their accounting, invoicing, stock control, etc, applications and two specific tools. (1) FGRAB - screen capture system for UNIX. (2) I/MAC - macro precompiles for Informix 4GL.

Offer GOM ETT B 11 Manufacturing software for textiles, fashion, shoe, leather and sports markets

Specialist vertical software solutions for the textile, fashion, shoe, leather and sports goods markets. Each product is designed to monitor the movement of goods between factory, warehouse, distributors and retail outlets. Products available on a wide range of computer platforms.

Offer GOM ETT A 11 Specialist computer terminals

Sales and distribution outlets sought for:- WORKmate-low cost production terminals connecting 250 terminals over RS/232 (water and dust-proof keyboards with barcode, magnetic card, etc); TIMEmate- a stand-alone time and access registration terminal with RS/232 interface; SHOPmate- full stand-alone cash register with barcode, magnetic card, etc; PRINTmate- a thermal label printer for self-adhesive or carton labels.

Offer GOM ETT 22
Point-of-Sale devices for restaurants and hotels

Manufacturer of cash registers, ECR and point-of-sale systems and related software for the hotel and catering industries, seeks European partners capable of selling systems and offering installation and technical support 24hrs a day.

Offer/Request GOM ETT 24
Real-Time systems and software

Belgian company specialising in complex real-time software development, resource monitoring, real-time graphic displays, geographical information systems, software engineering and software development methodologies, on VAX/VMS, HP/UNIX, SGI/UNIX, PC/DOS, Mac/System 7 and Ada, offers joint-ventures on software projects, technology and know-how, and seeks products to distribute in Belgium.

Offer GOM ETT 31
Security access systems

MOVABELL: intercom with remote-control which can be connected to internal or external telephone lines. **JAMES**: access control unit, code and/or card-based system which controls and registers the access to a place or a building. Distributors sought for both products.

Offer GOM 90113
Industrial robotics controls

A Belgian company has developed a new measuring system designed to carry out static and dynamic measurements on industrial robots and manipulators, to ensure the desired accuracy of movement. They now require to appoint exclusive importers/dealers for all European countries except Benelux.

Offer GOM 90120
Data communications products by mail order

A company offering a large range of datacommunication products, which are tele-marketed and sold through an own brand mail order catalogue Blue-Box, is looking for representatives/distributors in several countries. The products are sourced worldwide and pass severe in-house quality tests. The catalogue is currently distributed to some 32,000 named and qualified accounts in 6 countries.

Offer GOM 91104
Microprocessor design and automation equipment

A Belgian company, specialised in microprocessor design, production and marketing of industrial process and automation equipment, intelligent building systems and residential information systems is looking for European software/system houses, system integrators, contractors, equipment manufacturers, etc.

Offer GOM 91106
Electronic control systems for CNC-applications stand-alone controller for automation purposes

The company is looking for representatives of these control systems in all EC countries who will take care of the sales, installation and after sales service of the systems. Preference will be given to smaller firms active in the field of industrial automation, acquainted with the local market of workshops and constructional engineers (machinery designers).

Request GOM 91201
AC motor controls and programmable controls

A Belgian electronic engineering company engaged in the engineering and assembly of control boards wishes to broaden its product range and is looking for the following products. Innovative AC-motor controls such as frequency converters, positioning controls, etc and programmable controls for industrial processes.

Request PME P 34
Electrical and telephone cables

A manufacturer of electrical and telephone cables is looking for technological know-how concerning the manufacture of these products.

Request PME P 51
Electrical industrial installations and illumination

A manufacturer of electrical equipment for domestic and industrial installations and illumination, seeks co-operation in the field on new product development and new manufacturing processes as well as for production and commercial agreements.

Request PME P 52
Repair of fabricated metal products

A manufacturer and repairer of fabricated metal products requests new technology in similar fields.

Offer/Request PME P 56
Telecommunications networks

A company specialising in product development, manufacturing, installation and technical assistance for telephones and telephone central offices, including digital telephone central offices for public networks, seeks partners for distribution as well as co-operation in the field of technology; manufacturing agreements are particularly sought by the company.

Request PME 900034
Transformers and air conditioning

A Portuguese electronics services firm seeks licence or joint venture partner willing to establish and produce transformers, refrigerators, air conditioning or automotive equipment for installation and servicing by the Portuguese partner.

Offer/Request PME P 920070
ADA programming and CIM

IT consultancy developing integrated software systems for use in defence, air traffic control, intelligent buildings, hotel management and environmental control, offer subcontracting in the defence field (in ADA programming) and seek joint venture for know-how transfer in CIM in order to introduce the products to Portugal.

Offer BG 8
Floppy disk drives

Bulgarian state company offers free production capacity for floppy disc drives and is searching for joint venture in the production and marketing of 5.25in., 3.5in. and 2.5in. floppy disc drives. Sub-contracting in the production of aluminium pressure castings and precise tooling could also be considered.

More requests and offers from Technoshop next month

Two Exclusive Reader Offers from Cirkit

DIGITAL CAPACITANCE METER

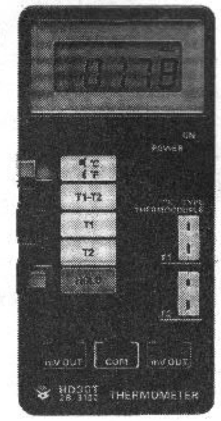
This extremely useful capacitance meter will measure from 1pF to 20,000uF in nine ranges. It is particularly useful for determing values of unmarked components aswell for fault finding and design work. Features include; 0.5 inch 3 1/2 digit LC display, low battery indicator, overange indicator and a zero adjustment control. Power is from a single PP3 battery with approximately 200 hours life from a alkaline type. Supplied complete with full instructions, test leads and one years warranty.

Specifications

ranges	res.	accuracy
200pF	0.1pF	+/- (0.5% + 1 digit + 0.5pF)
2nF	1.0pF	+/- (0.5% + 1 digit)
20nF	10pF	(0.5% + 1 digit)
200nF	100pF	+/- (0.5% + 1 digit)
2uF	1.0nF	(0.5% + 1 digit)
20uF	10nF	+/- (0.5% + 1 digit)
200uF	100nF	+/- (0.5% + 1 digit)
2000uF	1uF	+/- (1.0% + 1 digit)
20,000uF	10uF	+/- (2.0% + 1 digit)
Overload protection:		0.25A 250V fuse
Excitation voltage:		3.2V, all ranges
Dimensions:		x 85 x 38mm
Accessories supplied: Test leads, Battery and manual		

Normal price £39.82
Offer price £33.80

DIGITAL THERMOMETER



An easy to use digital thermometer with ranges to cover -30°C to 1370°C or -20°F to1000°F.
The meter displays temperature from the two sensors either as individual readings or as the difference between them. This dual reading capabiliy has many applications within electronics, such measuring the efficiency of heatsinks by measuring the temperature of the device and heatsink fins. Features include; 4 1/2 digit LC display with polarity and low battery indicators, display hold button and DC output. Operates from a single PP3 battery.
Supplied with full instructions and one years warranty.

Specifications

C range		-20°C to 1343°C
	Accuracy (up to 350°C)	+/-(2°C +2% +2 digits)
	Resolution	0.1°C
F range:		0°F to 1999°F
	Accuracy (up to 662°F)	+/-(2°F + 2.5% + 3 digits)
	Resolution	0.1°F
Dimensions:		145 x 71 x 30mm
Accessories Supplied:		2 Type K sensors, Battery and manual

Normal price £59.91
Offer price £52.50

Capacitance Meter & Digital Thermometer Cirkit Offer

Please send me........7705 Digital Capacitiance meter(s) at the offer price of £33.80. each + £1.40 p&p.
Please send me......HD30 Digital Thermometer(s) at the offer price of £52.50 each + £1.40 p&p
I enclose a cheque for ....made payable to Cirkit Distribution Ltd.
Print your name and address in **BLOCK CAPITALS.** Allow 28 days for delivery

Name ....

Address ....

.... Postcode ....

Please send your coupon and remmitance to :
EIA Reader Offer, Cirkit Distribution Ltd, Park Lane, Broxbourne Herts EN10 7NQ

Terms and Conditions
Only correct applications will be considered. ie those filling in their name and address clearly and enclosing a cheque for the correct amount.
The offer is subject to availability and closes on 18th November 1993
The offer is open to those resident in the UK only.
Allow 28 days for delivery.

Future View

Last month, at Keele University, Professor Colin Humphreys spoke about the science of the very small . Helen Armstrong reports

New materials creep up on us like spiders. They pounce silently. Before we notice anything startling happening, progress has swept on by and we are left with - well, for instance, suddenly we have a newspaper that doesn't turn our clothes black every time we turn a page. But is no longer any good for cleaning car windscreens. Something has happened to the printing ink.

Speaking at the British Association's Science for Life symposium at Keele University last month, Professor Colin Humphreys rounded up (as swiftly as any sheepdog and not at all boringly) a batch of new materials, and herded them neatly into two pens, one for "Health and Wealth" (Fri. 11am), the other (Weds., 10.15 am) exclusively for Nanophysics, the Science of the Very Small.

This is not to say that nanophysics has no bearing on health and wealth. But nanoscience is still at the stage where practising scientists and engineers are seeing a lot more (or less) of it than anyone else.

Take nanowriting. According to Professor Humphreys, in 1959, nobel prizewinner and bongo player Richard Feynman asked: "Why can't we write the entire contents of Encyclopaedia Britannica on a pin head?" This is what happens to scientists. Most bongo drummers, asked to contemplate the head of a pin, would probably see angels dancing on it eventually. Richard Feynman sees an Encyclopaedia.

But now we can do it. Or could, if we really wanted to - engrave all 29 volumes of the Encyclopaedia Britannica on the head of a pin, using an electron beam focussed to 0.5 nanometre diameter (around 2 atoms) as a drill or punch to form tiny dot-matrix letters in materials as hard as sapphire. As a nanometre (one thousand-millionth of a metre) is about one-100,000th as thick as a human hair, it needs somebody with very steady hands. But given that, it could be done.

Nanowriting applications mentioned by Professor Humphreys include filters for molecules and viruses, making very fine wires, and machining structures on a nanometre scale. Tiny nano-robots could be sent to perform cataract operations, repair caried teeth, or chip chloresterol off the inside of blood vessels. I know people who are waiting for this. If the nanomachines become daily rea'ity (and it is on the cards, given time then medical treatment, for one, will be changed out of recognition.

But the over-the-counter price of progress is that you have to keep up. When the Britannica finally appears on the head of a pin, the salesmen will love it, but what about the magnifying glasses? Prof. Humphreys gave the example of Gallium Arsenide lasers used in compact disc players. Until very recently, the standard solid state laser emitted in the infra-red, and needed specialised infra-red optics for focussing. Then very thin Gallium Arsenide, only a few nanometres thick, appeared. If the GaAs laser is made very thin, it can use ordinary glass or plastic lenses, and is cheaper to make.

Rumour says that a British company who made CD players approached a Japanese company for the nanotechnology to make very thin GaAs lasers. Once, this would have worked, but Japan's economy has been having a hard time lately, and the Japanese refused. They recognised a thin competitive edge when they saw one. The company stopped making CD players.

Solid state valves and light emitting Silicon

As for electronics: the valve is back. For 30 years silicon transistors have been steadily elbowing the bulky, delicate glass-chambered valve aside, sweeping everything in their wake until large scale integration began to swallow them up in turn. But the valve is creeping up again. Transistors are still vulnerable in extreme environments (like space), in high-temperature or high-radiation conditions. But now solid-state "nano-valves" are being developed. The difference is in the electron source: instead of a hot tungsten filament, there is a tiny cone of silicon with an apex only a few nanometres across. The effect of only a small voltage on a nearby anode is to "rip" electrons off the cone by field emission. Silicon gives up its electrons more easily than metal cathodes. These nanovalves, said Prof. Humphreys, may be replacing transistors soon in some applications.

Optical computers are another development which has been round the corner for years without appearing on the streets. Now researchers have discovered that silicon will emit light if its structure is only a few nanometres thick. Workers at RSRE Malvern have discovered that porous silicon will also emit light, and so far "rather uncontrolled" experiments have been carried out using this porous silicon. Now Cambridge University has discovered a method of fabricating silicon in columns only 2 nanometres in diameter using - again - nanoscale electron beam lithography (which could, I suppose, be thought of as the Near Letter Quality version of dot-matrix nanowriting). These discoveries in their turn could be used in optical computers, and optical computers will make electrical computers look slow.

Memory materials

But nano-materials have mundane possibilities too. The press has been having a bit of fun with shape-memory metals. Bras that remember their owner's bust shape. Armchairs that remember their owner's bottom! Back to the underwired brassiere? But we can also look forward to self-adjusting orthodontic braces, artificial tooth-roots that don't wobble, postural defect wiring that remains (comparatively) comfortable, perpetual springs, out-of-door litter bins that close themselves if they detect heat, shutting off any litter-conflagration from the outside air. And how? By introducing tiny defects - nano-defects - into metallic structure, they can be made to "remember" their original shape above and below certain transformation temperatures. This is usually heat treatment of some kind (hence the fireproof litter-bin), but, if the popular prints have any truth in them, this could just mean running the stuff through a mixed-coloured wash.

All these are the benefits of thinking small. The alternative - the other corral - is to think different. Or, as Prof. Humphreys describes it, think "new and improved".

Do you stop and wonder what New and Improved actually means this week in the supermarket? It could be a new strain of baked bean, less (or more) artificial flavouring, bigger (or smaller) portions. But increasingly it is going to mean that altered chemistry in the materials used in the product or packaging. And gradually materials that are effectively completely new to us are going to be involved.

How far we will notice this is another matter. "A fundamental reversal in the relationship between human beings and materials is taking place"! said Prof Humphreys' introductory literature. Is this what we always feared - that machines will start to develop humans for their own needs? It hasn't gone that far yet. "Recent advances have made it possible to start with a need and then develop a material to meet it," the precis continues. How many people are aware that this has only started to happen recently?

But now materials can be developed to meet known needs. Of course, luck and serendipity still come into it. In 1989, while working on a polymer transistor, Cambridge workers Richard Friend and Andrew Holmes noticed that the polymer emitted light. By 1992, the efficiency had been increased over 1000 times, and several more colours had been produced by designing new polymers. Better still, the polymers can be spun easily into a flat glass sheet. The British developers have their eye on the multi-million-pound world market for flat-screen television and video displays. Can the jump into production and marketing be made in the UK? That's still under development.

The goodness of carbon fibres

Carbon fibre is a material that has been making an important contribution for years after a shaky start in jet turbine blades, but these are short-fibre materials. Now very long carbon fibres have been developed, and are being used to make ropes.

The strength to weight ratio of carbon fibre ropes compared with steel cables is such that, whereas the maximum span of a steel cable suspension bridge is now 5000 metres, a bridge made from carbon fibre ropes could span 15000 metres - three times as far, and enough to link Africa and Europe across the Straits of Gibraltar.

Much more significantly, huge quantities of steel cabling are used to moor and stabilise deep-water floating oil rigs in depths up to 1500 metres. The weight of the cables is so great that massive buoyancy bags are needed to keep the rigs afloat.

Working with Bridon Ropes, Dr. Julia King at Cambridge has been developing carbon ropes that would - by virtue of being five times lighter than steel for the same strength - enable oil rigs to operate in water up to 3000 metres deep. The implications for access to oil and gas sources in future, and the knock-on into the world economy through energy supplies - could be enormous.

Plastic wood

Another UK company, Save Wood Products, has developed a method of recycling waste polystyrene to make artificial wood. Fast-food packaging and other products generate thousands of tons of polystyrene waste every year. This is bulky, and landfill space is running short. It can't be burned, because the fumes are toxic. Now it could all be turned into a rot-free, extrudable wood substitute which can be worked like real wood, and needs no growing, logging, or painting.

So far this report has run from the borders of science fiction to the realities of recycling hamburger by-products. But the next item made me sit up.

There are 40,000 total hip replacement operations every year in the UK. That's 40,000 legs having their major operational part cut off and rebuilt from artificial materials (mainly stainless steel or titanium).

That's around 30,000 people who would be crippled year by year without this operation. (Some of the operations are repeats - a replacement joint has a life of about 12 years. Less if you're young.) The operation costs £3,000 a time, but this is nothing to the cost to families or the state of caring for a crippled person, not to mention the unhappy state of the person.

The operation is usually very successful, but the working life of the new joint is limited because, as Prof. Humphreys went on to report, bone grows strong in response to regular stress. In replacement surgery, the hip socket is protected from stress by a metal sheath - so the bone gradually weakens, shrinks and loosens the joint. Here again we have the Encyclopaedia without the magnifying glass.

Now, Prof. Bill Bonfield in the UK has developed an artificial bone material from hydroxyapatite reinforced polythene that mimics the properties of real bone. There is no shielding from stress, and the socket bone grows normally. The expected life of replacement hips made from this material is 30 years. If clinical trials are successful, waiting lists could be reduced, £30 million a year saved, a world market established, and most repeat operations eliminated.

Finally, perhaps the most startling new materials are those developed by Dr. Ken Evan, which seem to defy every law except that of gravity by getting fatter when stretched. Applications mentioned by Prof. Humphreys included gaskets (remember Challenger?) and bullet-proof vests.

Health indeed!

Professor Colin Humphreys is based at the Department of Materials Science and Metallurgy, University of Cambridge.

WARNING!

This product contains scenes of graphic violence and pure evil which may offend some users.

Virgin® GAMES

The CD ROM drive bundle that could *scare* you out of your wits and priced at £299* will frighten the competition.

Being Philips leading distributor of CD-ROM drives we've taken the **Philips CDD462** MPC/Photo CD external CD-ROM drive and have added two top selling CD packages **Lotus 1-2-3** for Windows with multimedia Smart Help and **Virgin's - The 7th Guest** *(a sound card will be needed to play the game properly).*

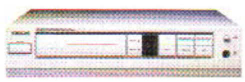
By night you can play the 7th Guest with its full screen video ghosts and by day you can use Lotus 1-2-3 to help you figure it all out.

While you may find The 7th Guest a little frightening there's no horror stories in installing the Philips CDD462 external CD-ROM drive. Simply plug the interface card into a spare slot in your PC, install the driver software, connect the CDD462 and away you go, it's as easy as 1-2-3!

CD Revolution Ltd

21 London Street, Chertsey, Surrey KT16 8AP

Tel: 0932 562000 *Fax: 0932 571999*



Philips CDD462 A workhorse external CD-ROM drive MPC/ multi-session (Photo CD). Easy to install with an AT-Bus short card. Doubles up as an easy to use CD-Audio player with full controls. MRP - **£349** + VAT

The 7th Guest - assembles a cast of 23 full screen, full motion video actors in the world's first CD Interactive Drama set inside the haunted hilltop mansion of twisted toy maker Henry Stauf - **£60** +VAT

Lotus 123 - One of the world's first spreadsheets makes another first with this CD-ROM version & Multimedia SmartHelp. The Movie Show & SmartHelp provides an impressive mix of animation & sound.

CD Revolution Audiowave-16 Full 16-bit recording/playback gives stereo sound at 44.1KHz at 4W per channel. Complete with voice recognition, Sound-Blaster & Windows Sound compatibility - **£129** + VAT

*All trade marks recognised. Specifications subject to change without prior notice. * All prices exclude VAT.*

Summer 1993 CATALOGUE

- 224 Pages
- 26 Sections
- Over 4000 lines
- Send for your copy today!

Cirkit

Cirkit Distribution Ltd
Park Lane · Broxbourne · Hertfordshire · EN10 7NQ
Telephone (0992) 444111 · Fax (0992) 464457

Access VISA