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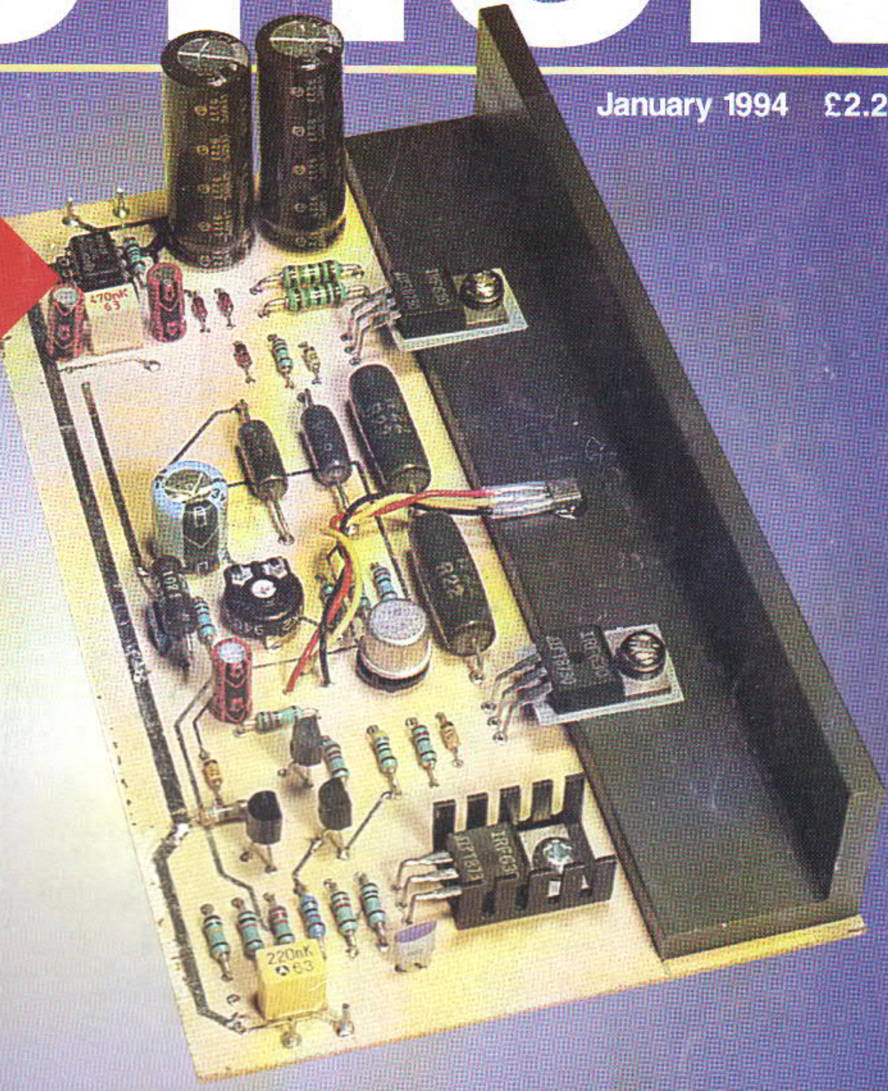
ELECTRONICS in ACTION

January 1994 £2.25



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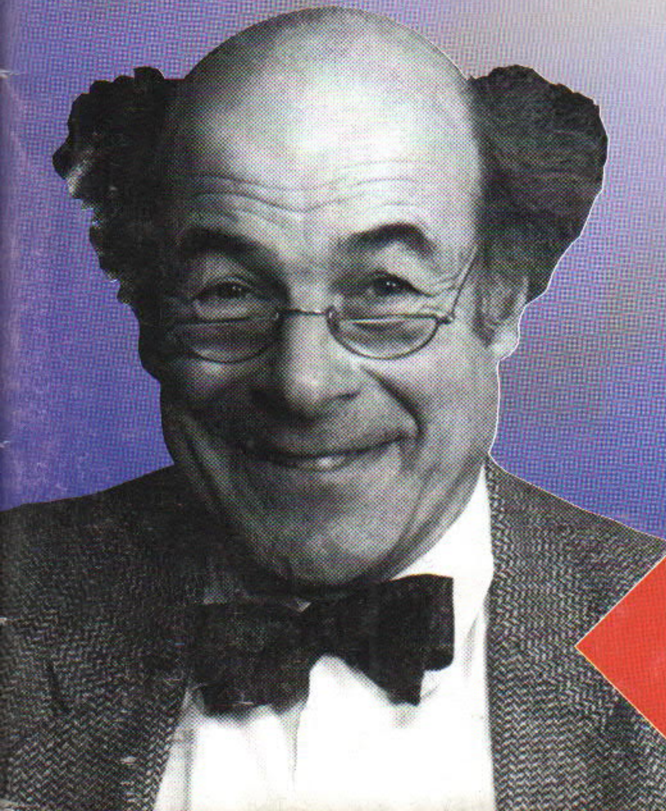

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Your thoughts in the Think Tank

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Life, the Universe and Everything
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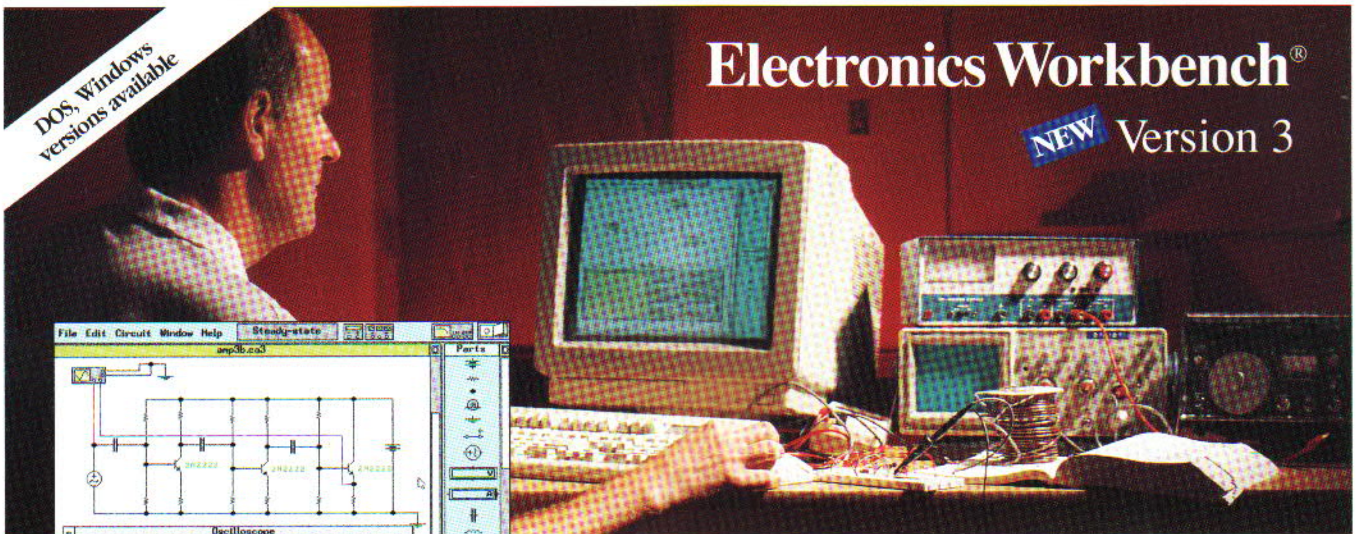

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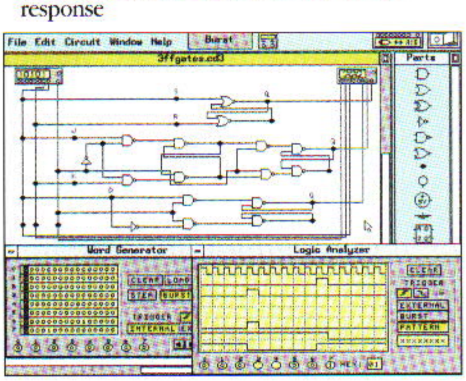

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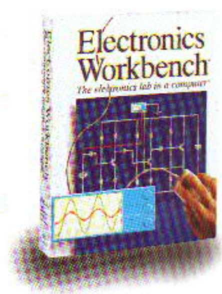

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INTERACTIVE

ELECTRONICS in ACTION

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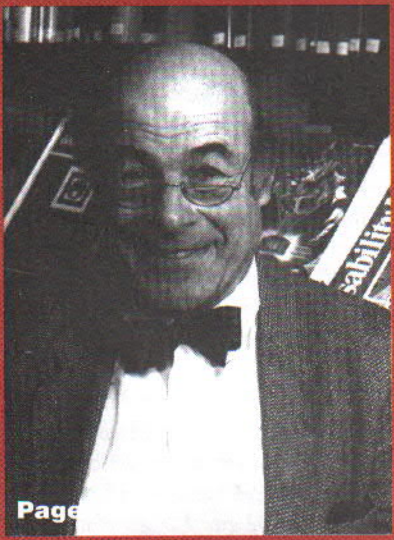

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A life saving tag

I suspect that most of us will not forget the tragic death of the little two year old, after he was taken from a shopping precinct. In order to prevent such things happening again, wouldn't it be a good idea to electronically tag young children. The aim is simple, provide the child with a short range transmitter that emits a pre-programmed digital code. Parents would carry around with them a normally silent receiver. When the child wanders out of a given range, the receiver would emit warnings to the parents. Another level of sophistication would be to locate or direction-find the child using a simple antenna.

Such tagging has been used experimentally on prisoners and would certainly serve a useful purpose here. So here is an open invite to all you designers to come up with a simple, but very effective project.

Finally it is still very gratifying to here your comments about our magazine. It is a pleasure to know we are providing an alternative and different outlook on the business of electronics. Keep your ideas and comments rolling in.

Paul Freeman-Sear

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NEWS

Bright New Monitor

Monitor screen clarity is priority for serious computer-users. Mitsubishi has designed a new aperture-grille shadow-mask for its Diamondtron non-glare K-coated monitor tubes to produce what the company claims are the highest-quality monitors on the market. Advanced autotracking, freedom from raster moire-patterning, and high-quality focusing over the whole screen with the new Mitsubishi NX-DBF gun are featured.

Software running under Microsoft Windows allows the PC to talk directly to the monitor for initial set-up and all other parameters, including resolution, grey scale, display size, brightness, contrast and colour. The automatic power management is controllable through the software: the monitor can be preset to dim its own screen, and later shut down, if it is left unused for a period while switched on - a boon for users who wander off, forgetting to turn down the brightness.

The Diamondtron's electron gun produces a small flying-spot at a higher than usual cathode current and modifies the beam on the fly to produce a distortion-corrected spot over the screen area. The static spot size at 0.5mA is around 1.1 mm compared to 1.4mm on an equivalent conventional gun. Longer monitor life is promised as a result of scandium oxide used in the cathode gun. The monitor's newly-developed K screen coating gives contrast enhancement between 5 and 20 percent and a paper-white display. Typical screen resolution is 1280 x 1024 pixels, with a maximum of 1600 x 1200.

Mitsubishi Electric UK Ltd. 0707 276 100.

Interfacing Without Agony

Plug-and-Play is a new standard for adding interface boards to computer networks without the prolonged agony of configuring both the operating system and the interface board until they are willing to talk to each other.

With plug-and-play, as the name suggests, when the new board is plugged in, the computer's BIOS will scan for the new card and interrogate it for configuration information. The card and the computer can then "negotiate" with each other for an available memory slot, and the new system should be up and running in a short time.

Plug-and-play is a new standard and not many machines have it yet, but it should make life for computer end-users easier in the future. Advanced Micro Devices (AMD) has just added three new members to its PCnet family of single-chip Ethernet controllers for PC motherboards, so the family now supports all local bus standards, and Microsoft's new ISA Plug and Play configuration standard. This puts the functions of a complete bus-mastered Ethernet adapter board onto one chip.

PCnet-PCI and PCnet-326 support high-speed PCI and VL local bus designs, and PCnet-ISA+ is the first Microsoft ISA Plug and Play compatible Ethernet chip. AMD also provides the full range of software drivers supporting virtually all local area network operating systems. The Microsoft ISA Plug and Play specification has been endorsed by a number of hardware and software sellers. The PCnet range uses bus-master architecture based on Novell NE2100/1500T adapter cards, so that a single set of software drivers can be used right across the family.

The hardware needs about 5 square inches of board space to implement (for example) a 10Base-T Ethernet system, small enough to design into PC motherboards for networking.

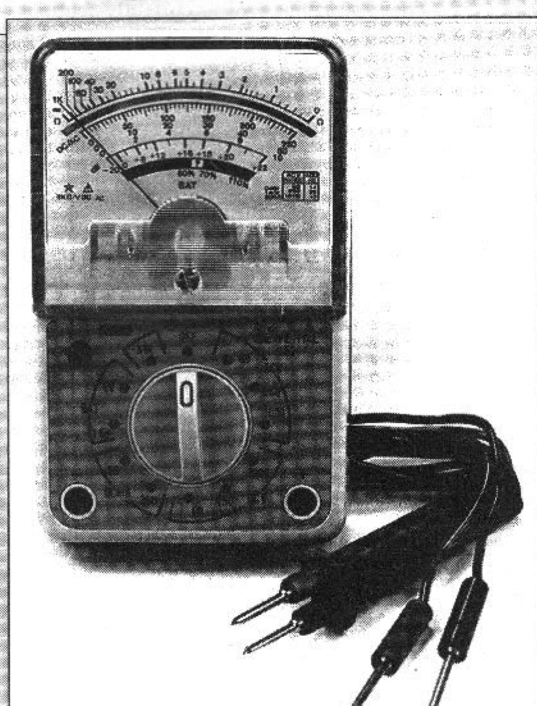
Rabbit Hangs Up

Rabbit, the last living example of CT2-based one-way mobile telephone, has died out. Hutchinson Telecom closed its Rabbit service at the end of the year, after a two-year bid to establish the one-way cordless digital pocket telephone service which left it with only 9,000 subscribers.

One-way mobile phone was an idea which was either going to run and run, or drop dead. Unfortunately, in economic terms, it did the latter. Various operators, including BT and Mercury, tried to make a go of it without success.

Stocking Fillers

Maplin have a compact three-in-one cycle computer on their stocking-filler list. Time, speed, distance on a 30 x 23 mm LCD will tell you how quickly you are outrunning the Boxing Day turkey sandwiches. Speed and distance are calculated from the output of the wheel-mounting sensor, allowing for wheel size. The timer can be a journey timer, trip timer or 24-hour clock. Speed can be set for average, actual or maximum speed, and distance selected for trip or total. The computer also functions as a trip time alarm, speed alarm and trip distance alarm. Special offer price is £19.95, and the main unit clips and unclips easily to foil zero-outlay bike-accessory collectors.

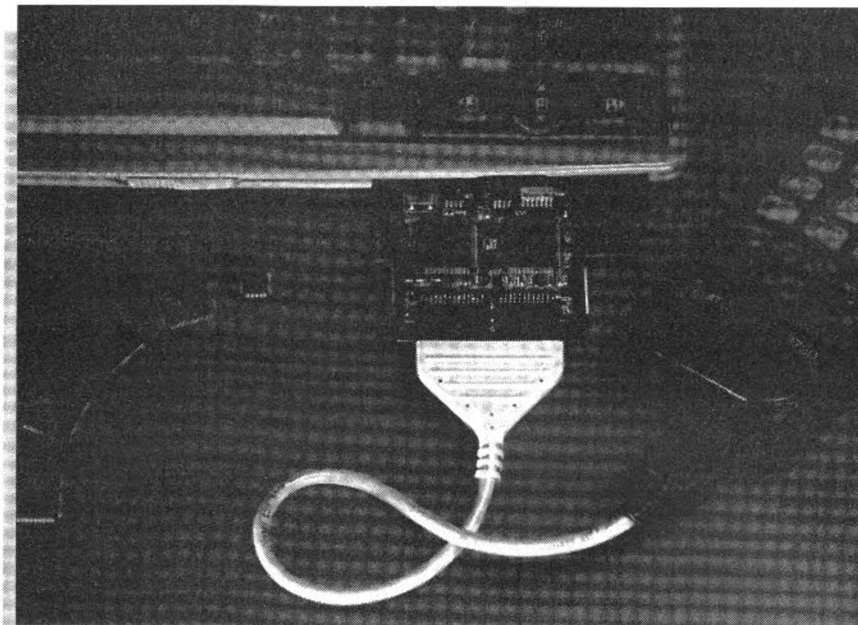


For those staying indoors, Maplin has a low-cost, high-quality pocket analogue multimeter. The Precision Gold 108 has a sensitivity of 2000 ohms/volt for AC and DC ranges. Functions are AC and DC voltage, DC current, resistance, battery check and decibels. The meter is accurate to 5% of full scale deflection on AC voltage and 4% on DC voltage and current ranges. Special offer price is £9.95 with a 1.5V battery included. Precision Gold is described as rugged and accurate, so you can nip outside to check your vehicle electrics or even take it with you on your bike.

Maplin (Sales) 0702 554161. Maplin consumer prices include VAT. £9.95 post and packing charge on most normal-sized orders by mail.

Rabbit was the last survivor.

Hutchinson is reorganising its UK telecoms business and will concentrate on two-way cellular, paging and PCN (Microtel personal communications network) operations, launching the latter in April. It looks as though we all hate being interrupted by phone less than we thought we did.



Modem Chip Integration

New high-speed modem chips now have voice, cellular phone and V.32terbo modem capabilities in one chipset. This means smaller chips, and ultimately cheaper and more function-packed modems. Chips produced by AT&T cover 9600 and 14400bit per second data rates, and are designed for desktop, laptop, and very-thin-line PCMCIA computer applications. Continuing the trend towards greater and greater integration, the new BMC microcontroller integrates microcontroller functions, power management and a 16C550 type UART with 16-byte FIFOs on one device, allowing smaller built-up sizes. Manufacturers only need to add memory chips and a DAA (data access arrangement).

The AT&T chipsets come in three varieties: a "Classic" data/fax type, a data/fax/voice option for telephone answering machines, and a data/fax/cell option for cellular telephone systems. The Classic set supports the full range of fax/data standards, including the AT command set, V.42bis, V.32terbo, V.17, V.27ter and V.21 (ch2).

The AT&T Dataline can be contacted on (US) +44 732 741221 or +44 732 742999.

The Workgroup Computing Show

Network computing was one of those dreams that came true, but left everyone still dreaming that one day it would work without a hitch. Quick interchange of information, files from other parts of the system, work passed round quickly between colleagues, fast access to all parts of the job without moving people or paperwork. The network would open the filing cabinet, unroll the drawings, draw up the plans, pass the budget, claim the expenses, circulate the memos, convene the meeting or conduct a conversation without leaving the computer terminal.

This Utopia is still in waiting. Networks are commonplace now, but so is the cry "The network's down!" As with most computer developments in their early years, the hardware and software were not advanced enough for the task they had to undertake.

Time has brought advances in speed and memory which make efficient networking simpler and more plausible. User interface software has advanced, or at least grown more complex and ingenious.

Networking is gradually acquiring a new image and appearing under a new name: Workgroup computing.

If there is a big difference between plain networking and workgroup computing, it is that software is now highly organised towards a goal - producing a report, booking a journey, filing or retrieving sales returns, file-sharing on design jobs, and so on. The results of these processes are passed on to the next stage of the job - publishing the report, requesting petty cash, analysing figures - via the network, and the response fed back along the same path.

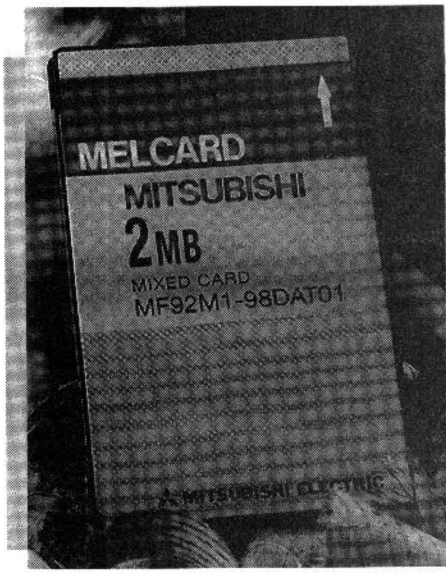
The Workgroup Computing show at London's Olympia on 3-5 November demonstrated that workgrouping is a computing revolution on the brink of happening - as soon as currently-cautious managers are convinced that new installations will bring relief instead of grief. Busy but not packed, the show attracted mainly flocks of engineering and computing consultants looking for solutions to pass on to their clients.

Many of the world's leading hardware and software houses had high-tech stands at the show, competing for acoustic space in a stream of lectures and demonstrations reminiscent of a gannet colony.

Wordperfect (0932 850555) was promoting two software packages, WordPerfect Office 4.0 and Wordperfect Informs. Forms are important news in workgrouping. I watched as a travelling expenses form automatically switched its signature box from "Manager's signature" to "Managing Director's Signature" as the claim reached £9.95 The signatures themselves - the most personal part of the senior manager's arsenal of authority - are stored in security databases, using RSA Security Data technology as approved by the USAF and security sealed. The computer signs the authorisation with the stored signature. If anyone tries to tamper, it raises the alarm.

Forms like purchase orders can save their contents straight to a central database - recording, for instance, that so many thousand widgets are on their way to Stores - acting as a mini front-end interface for the worker who uses them.

Office 4.0, in the meantime, was demonstrating information-switching and response between the "green file" and the "yellow file". WordPerfect Office is a set of workgroup tools encompassing e-mail, calendar, scheduler and task management, managed by (I quote) workflow functions of ordered distribution, rules and status tracking. Words like "strategy for information sharing", "workgroup-enabled" and



Flashcard

The Mitsubishi card in the picture is a little unusual - it's a mixed-technology plug-in memory card, carrying SRAM and Flash memory for PCMCIA (sub-notebook) computers, or OTPROM (one-time programmable) and EPROM memory useful for multifunction terminals and instrumentation, on the same unit.

The mixed cards can carry up to 2 megabytes of memory and achieve up to 10,000 Flash memory programming/erasing cycles.

"modularity" were flying around. It seems that established office network users are naturally more interested in pinning their existing applications together with workflow management software than starting from scratch with a new system. WordPerfect Office also remains the only workgroup application that allows users to communicate across three platforms - PC, Apple Mac and Unix - in a variety of message formats. Flexibility is premium when so much has already been invested in kit.

More investment seems likely. One seeker from an MOD site said that his offices used networking and liked it, but with fewer and fewer people employed in the service they needed state-of-the-art software at a lower cost. He didn't know if they would find it. For organisations like the MOD, data security is both essential and expensive.

Software managed people

Rank Xerox XSoft (0753 550022) showed off document management software. GlobalView allows the creation, management, retrieval, sharing and distribution of documents. Shared Document overlays users' existing software to give distributed applications for directory, filing, mailing and printing, with transparent access to the network services. InConcert is software which actually claims to manage people as well as procedures, prompting and tracking every stage of a task, delivering business documents - spreadsheets, forms, graphics and so on - , and providing complete progress reports to its manager.

Lotus (Staines) was promoting Lotus Notes, a client-server environment that allows its users (clients) to communicate over local (LAN) or wide-area (WAN) networks with a document database residing in one or more shared computers (servers). As an open system, it runs on all the well-known networks and desktop systems and can import files from most popular desktop applications. Lotus Notes replicates the data on each server computer as needed, so that everyone has access to it, and supports remote users by modem and e-mail. The same graphical interface appears across Windows, Macintosh, OS/2 Presentation Manager, OpenLook, Unix Motif and other platforms. Familiarity, flexibility and access to existing software and hardware are the watchwords.

Canadian company Delrina (081 207 3163) was demonstrating Formflow, an interactive object-oriented forms creation and processing program linkable to many major database applications - and into industry-standard e-mail for routing forms and information. The keyword here seems to be easy development of new forms to suit the business, even for non-programmers, and general simplicity of use. Delrina was also showing WinFax Pro for Networks. WinFax accesses up to four fax modems simultaneously on a network, or routes to the available modem if the others are in use. It receives faxes to screen, to printer, or as a background task if the user is otherwise occupied. Or alert the user if it has been set to do so. One advantage is that users are no longer queuing in a corner of the office to use the one available manual fax machine.

IBM (Personal Systems Enquiry 0256 841818) took over a sizeable part of the top floor, bathed it in blue light and uniform blue sweatshirts to show off industrial-level solutions for nearly any data need you might like to name, particularly relating to its IBM OS/2 LAN Management strategy (as they market it, being too large to describe in terms of packages or ranges). A recent release is VisualAge client/server "power tool" which allows system programmers to build up applications visually from existing software components quickly. Again, the theme is best use of already-existing resources, as well as the vast IBM support machine in the background. IBM is a Corporation's Corporation.

Over 80 exhibitors were showing wares at Workgroup Computing. Visitors were consistent in their response: they were already using networks and wanted to see the latest possibilities. There was a caution all round, sparked mainly by the knowledge that new software technology takes a long time to bed in. "It wasn't a product two years ago, but we think it is now," one consultant said of a new release of a name-brand package. "We know what computers can do for individual people, now we want to see what they can do for the business." A consultant advising small firms reckoned that he would wait 18 months before he entrusted his clients to the latest update of another well-known system. "I'll have to be here a bit longer," said a senior manager early in the afternoon. "You need to spend a good day here to digest everything."

Some of the demonstrations were marvels of clarity, but the complexity of complete document management by computer is such that the clerk of the future will have to be more organised and more literate even than today before the paperless office becomes a reality.

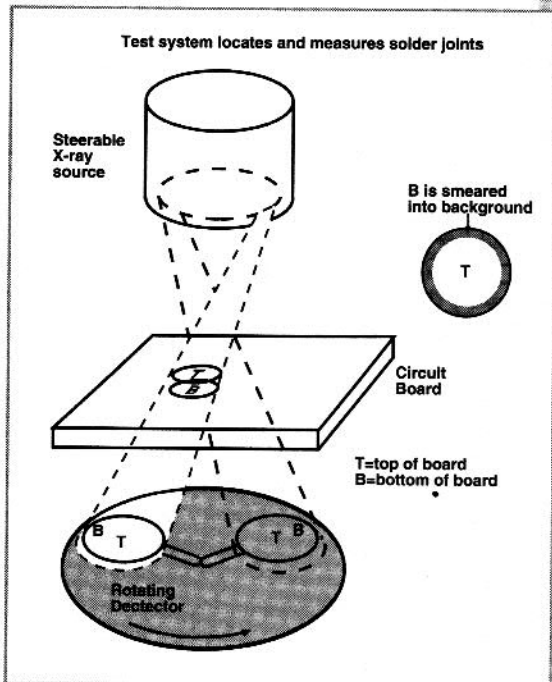
Changes

Genalog Ltd. provides chip-specific adaptors from surface-mount format to pin grid array format for Motorola MC68340, MC68333 and MC68360, and Intel 80486SX processors. Adaptors also convert various other SMT packages to PGA and other through-hole configurations, with pin compatibility, allowing use of cheaper flat-pack chips on PCBs designed for PGA-format chips. Genalog also supplies a 2mm male IDC dual-row cable assembly with a low body height of only 5.08 mm (0.2 mm), giving a depth less than 10mm when mated to various surface mount and PTM sockets.

Contact: Genalog Ltd. Tel.0580 753754.

Research World

Technical Advances from around the Globe



Test system locates and measures solder joints

Board tester

A US company, Four Pi Systems Corp., is preparing to beta test its new 5DX X-ray board tester. The machines test for solder-joint defects by taking cross-sectional X-ray images of the connections between chips and boards. With the 5DX throughput has been increased by 30% over the previous 3DX generation. The 5DX can operate in-line, performing the dual function of inspection and test. It inspects boards at an image rate of 50 to 150 joints per second. Since the machine does its imaging in tomographic slices, only the plane where the solder paste meets board pads (or the device leads) is captured. Images of ICs themselves are screened out, as are images of anything mounted on the other side of the board, leaving a clearer view of the connections.

At the same time, a real-time stream of physical measurements is made, including average solder thickness, fillet height and void volume. This data can be used directly for statistical process control, allowing operators to identify a variation in the manufacturing process before it veers out of spec and causes defects.

Solder thickness from 0.0125 to 0.625mm can be measured with a standard deviation of less than 4%. The largest size board the 5DX can handle is 18 x 18". Throughput depends on several factors, but the 5DX can inspect and test an average board - which the company defines as one with 4,000 joints - in about 2 minutes.

Test algorithms are available for a variety of joint types, including J leads, ball-grid arrays (BGA), gull-wing leads, tape-automated bonding and others. There are three different models, depending on lead pitch (0.5mm and up, 0.4mm and up, 0.3mm and up).

Visual inspection of joints is difficult, and sometimes impossible, with new chip-mounting technologies such as flip-chip and BFA.

Electronic whiteboard

Also in the US, Microfield Graphics Inc. of Beaverton, Oregon, has introduced a peripheral device that combines the functions of a wall-mounted whiteboard with the capabilities of a personal computer. Called Softboard, it displays on a PC or Macintosh screen information that users write on its surface with coded colour markers.

In addition, the information displayed can be stored, printed or transmitted in real time to other locations over conventional telephone lines. Likewise, a special encoded eraser lets users simultaneously erase data from the Softboard and the computer display.

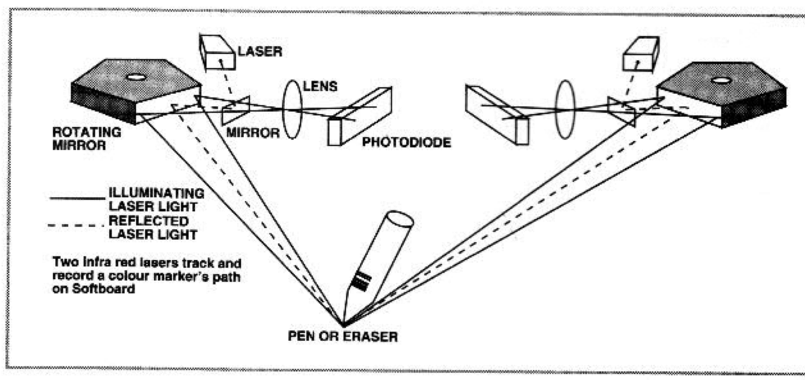
While the initial offering is aimed at large conference rooms, smaller sizes (24 x 36" writing area) are in development for offices.

The dry-erase colour markers have bar codes on their tips, so the computer can capture information written on the Softboard. Colour monitors display the colours used. Each screen is saved in a computer file, and can be concurrently shared by other computers connected to Softboard via modem, or played back when required. Consequently, participants in meetings and work sessions can keep records without having to transcribe notes.

The enabling technology uses digital signal processing. The chip computes the angle of the encoded marker or eraser and is based on input from two infrared lasers that scan the entire area of the Softboard using rotating, five-sided mirrors.

The DSP used is Texas Instruments' programmable 40MHz TMS320C26, which is rated at 10 Mips. When a user writes on the Softboard, the lasers locate, identify and track the position of the marker/eraser in real time.

The lasers are placed on the top corners of the board. The laser scanning frequency is 416 scans/second (see diagram).



Two infra red lasers track and record a colour marker's path on Softboard

The pen positioning is triangulated from the reflected beams, and sampled at a rate of 80 samples/s. That data is next sent to a photodiode that generates video signals for conversion into digital data by a 6-bit analogue-to-digital converter. At a rate of 5 to 10MHz, the converted data is then fed to the DSP chip, which computes the x-y coordinates in serial-data-stream format for transmission to the host computer via RS-232 interface.

REMAP

Technical Help for Disabled People

By Andrew Chadwick

Part 1

One of the aims of Electronics in Action is to promote active development of new ideas by you, the reader. Features such as Ideas Forum and Technoshop are intended to present challenges to your ingenuity and stimulate new applications for electronics. However it may surprise you to know that there is an organisation that has been doing just that since 1965! The name of the organisation is REMAP and it was founded by Pat Johnson an engineer at ICI Billingham. Its aim is to provide equipment for disabled people which will help them lead as normal and independent a life as possible.

When REMAP was founded there was very little equipment manufactured commercially. Nowadays there is a much wider range available but there are still many cases where no suitable device exists or a piece of commercial equipment requires modification to suit a particular individual. This is the area in which REMAP operates.

Although REMAP is a registered charity and covers the whole of the country its aim is to provide practical help and keep bureaucracy to a minimum. A National Committee co-ordinates activities by means of a number of Regional Organisers. The committee also arranges insurance cover and organises the small amount of fund-raising required.

The main work of REMAP is carried out by about 100 local panels located throughout the country. Each panel consists of volunteer engineers of all disciplines, craftsmen and handymen together with representatives of the local Health Authority Occupational Therapy and Social Services departments. Each panel has its own chairman and secretary and meets regularly to discuss jobs in progress.

Most jobs are initiated by the Health Authority representatives but any disabled person can contact REMAP directly. The Occupational Therapists on the panel provide specialised medical knowledge and are aware of the range of commercial aids available. If there is already a suitable device on the market they can normally arrange to supply it. Otherwise the problem is discussed at the meeting and then assigned to a particular engineer who will be responsible for the design and construction of an appropriate piece of equipment. A number of visits to the client and a certain amount of trial and error are usually required before a satisfactory solution is found.

Panel members are all volunteers and materials are often unwanted or scrap material from home or industry and so there is no cost to the disabled person. Much equipment is manufactured at member's homes but for large or specialised jobs the help of local industry may be sought.

The equipment constructed by REMAP panels covers a very wide range from simple mechanical gadgets to complex electronic systems. A selection of the more interesting cases is included in the REMAP yearbook which is available from the address given at the end of the article, price £3 including postage and packing.

The Epilepsy Alarm

Past acheivements

The type of challenge presented to panels in the electronics field is illustrated by a job that appears in the current yearbook.

This is an epilepsy alarm which was designed for a nine year old girl who suffered fits when asleep. It could lead to injury or death if not attended to. The system consists of a battery operated sensing unit and radio transmitter that is placed in the bed and a remote receiver to sound an alarm. The receiver is a proprietary item intended for use as a radio door bell. It is normally situated in her parents bedroom but can be up to 200m away. A block diagram of the sensing unit is shown in Figure 1. The vibration detector is a trembler type similar to those used in car alarms but with greater sensitivity. The alarm had to be sensitive enough to detect the onset of a fit but be immune to normal bed movement. This was achieved by requiring 16 consecutive pulses in a 20 second period before the alarm sounded. It is now no longer necessary for the girl to share her room with someone else yet she can be confident that her parents will be alerted if she has a fit.

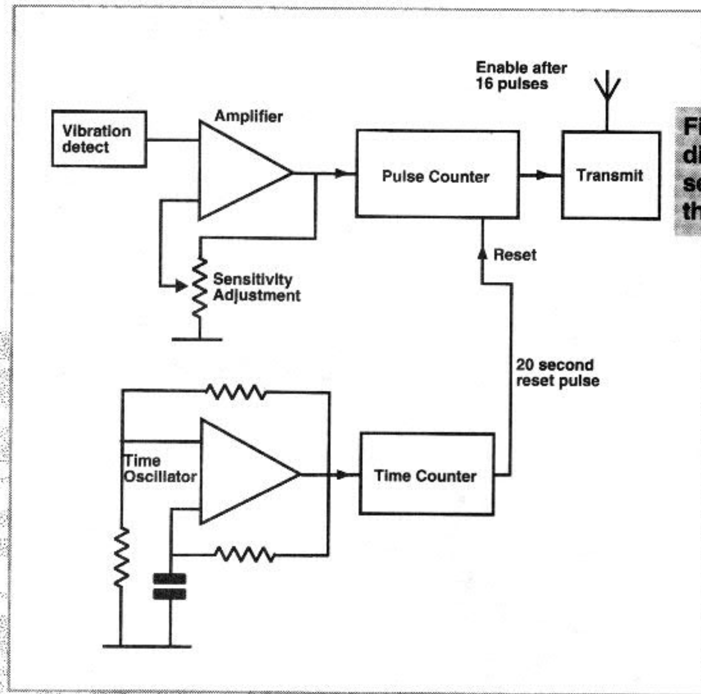


Fig.1 Block diagram of the sensing unit of the epilepsy alarm

REMAP awards

There is also an annual REMAP award for aids and equipment designed by panels with four prizes being awarded, the first one of £250. The judges look for novelty and ingenuity in the solution of an actual case that has been completed by the panel.

I have been a member of my local REMAP panel for about 7 years and my special interest in electronics has resulted in me being asked to tackle a number of interesting problems.

The first request that deserves a mention was for a reward toy for a class of children with severe mental and visual handicap. Reward toys are a very common method of training the handicapped and consist of a device that produces whatever the user views as a reward, such as music, in response to the performance of some action. This may be as simple as pressing the correct one of a pair of buttons or, something more complicated like going to the toilet (see Part 2 next month).

The idea was to encourage children to explore their environment. The final design consisted of a standard electronic doorbell which was modified to house the control circuit shown in Figure 2. This was linked by means of DIN plugs and sockets and ribbon cable to up to 6 pushbutton units which were simply plastic boxes with a large pushbutton switch on top.

In operation the teacher presses the reset button on the control unit and the pupil then presses the first pushbutton. This triggers the electronic bell circuit so that a single tune is produced. However the control circuit ensures that holding down the button or pressing it again will not produce any further sound. The pupil must find his way along the brightly coloured ribbon cable to the next pushbutton to produce a further tune. If he reaches the end of the chain the circuit automatically resets to the first pushbutton. More next month.

If you would like to know the location of the nearest REMAP panel then please contact:

Eur Ing J J Wright
REMAP GB
Hazeldene
Ightham
Sevenoaks
Kent
TN15 9AD
Tel: 0732 883818

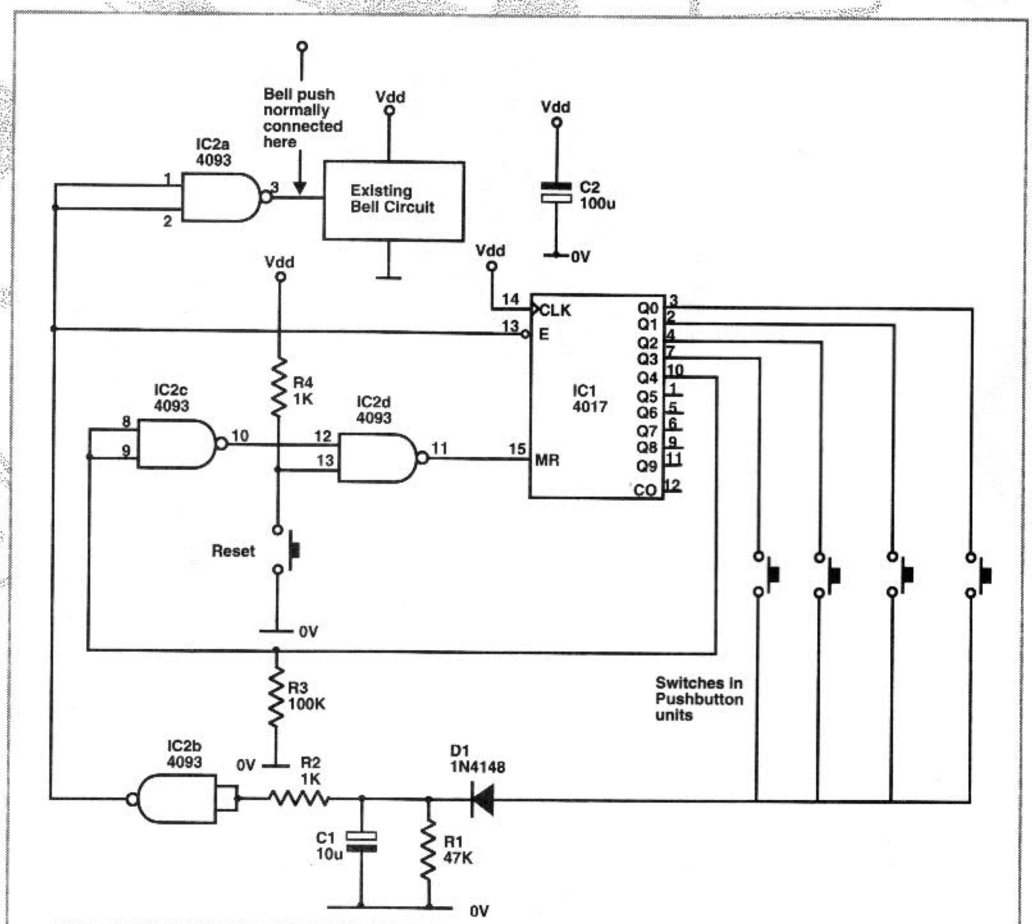


Fig. 2 Circuit diagram of a reward toy

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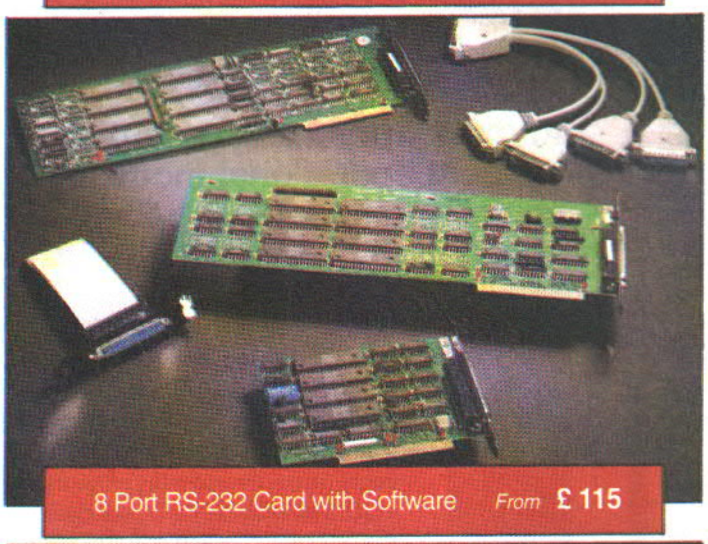

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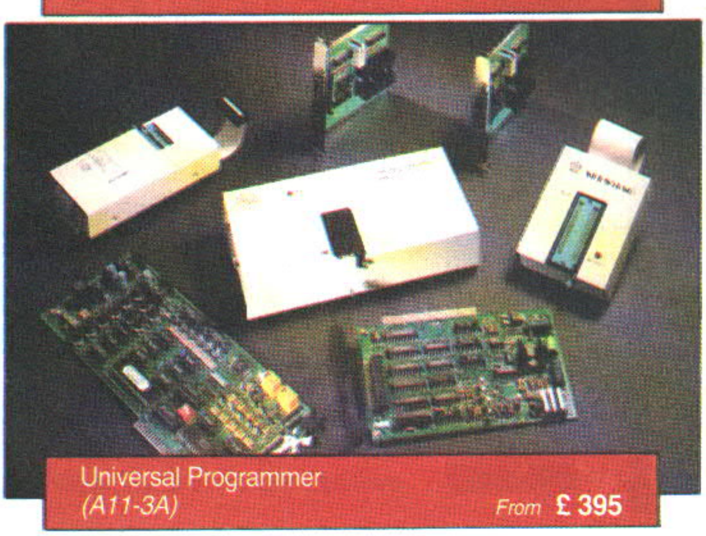

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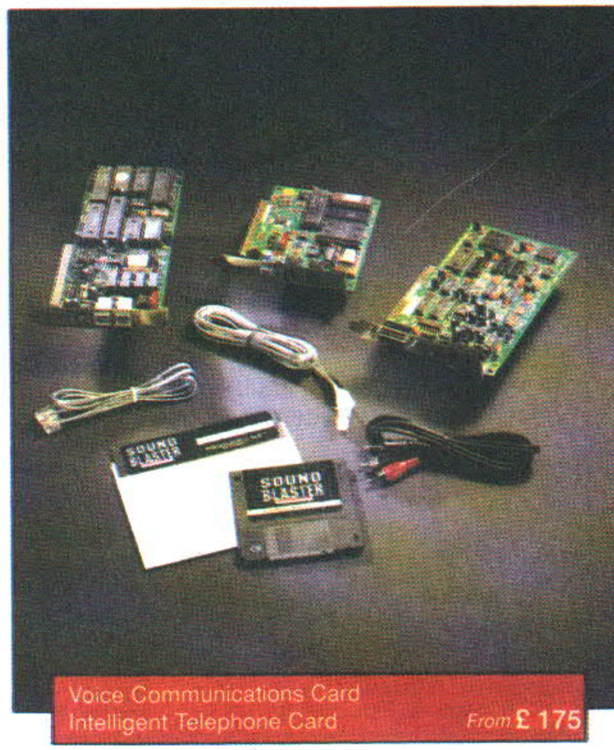

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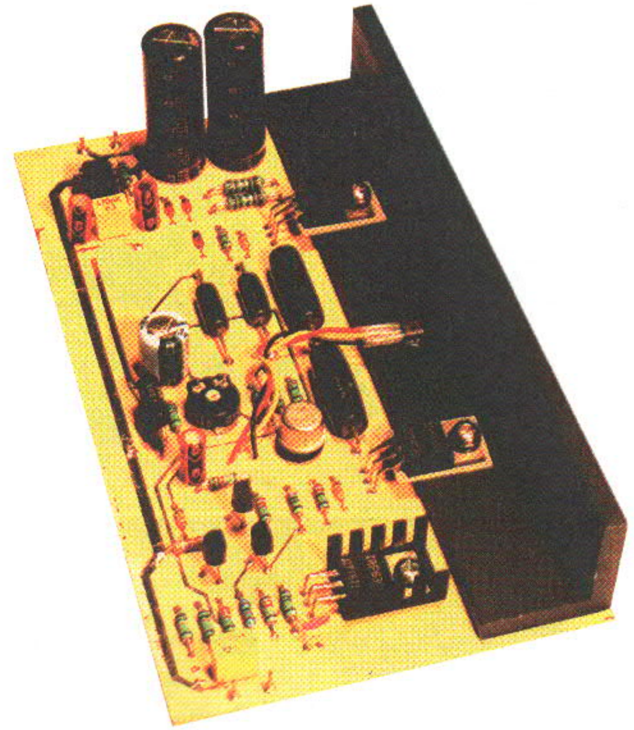


Class A Power

Andrew Armstrong provides the best operational mode for a power amplifier. Part 1 Circuit description .

Actually the title is a bit of a con, because this amplifier is not intended to work in class A all the time. It is a class A/B amplifier, but with the class A portion forming a much larger part of the operating range than usual. The efficiency of a pure class A amplifier at full output doesn't exceed about 30%, and is less at lower powers. To be able to provide 50W maximum, a class A amplifier would have to dissipate 150W (or more due to inefficiencies) constantly.

This amplifier is intended to work as a good compromise, with class A operation at the lower power levels at which crossover distortion is more of a problem.

As an added advantage, the output impedance of a class A amplifier is inherently lower than that of a class B amplifier. Negative feedback can lower the output impedance of any amplifier to impressively low levels, but the impedance rises with frequency because of the delays in the loop. Add some non-linearities corrected by the negative feedback, and I can imagine that the process of the amplifiers output damping any tendency of the loudspeaker or crossover unit to ring could add a trace of transient distortion. Perhaps this is part of the explanation for the very "clean" sound of a class A amplifier at moderate sound levels.

I have no objective distortion measurements on this amplifier, but it showed no detectable waveform distortion on sinewave tests with an oscilloscope.

On squarewave tests, a waveform with approximately 4μs risetime fed in showed a 4μs risetime on the output. This test was carried out with the input filtering capacitor, C4, removed.

MOSFET Amplifier

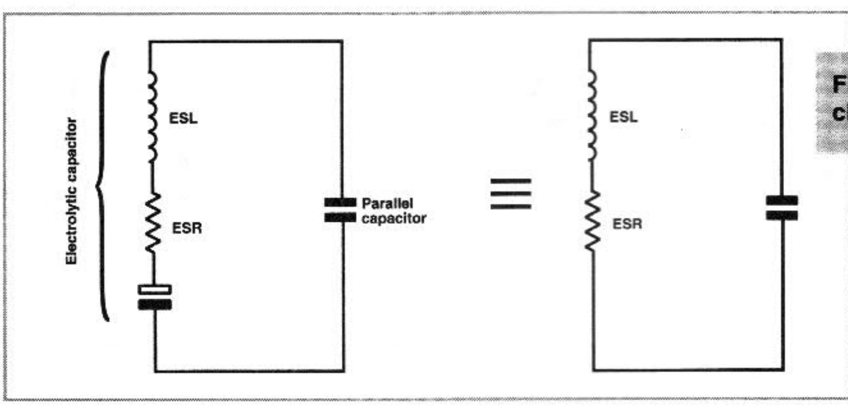


Fig.1 Equivalent circuit elements

The Signal Path

The philosophy of this design was to have a clean and simple signal path with as fast a response as possible, then to limit its frequency response in as few places as possible. The minimum turned out to be one place inside the loop to prevent instability, and at the input to limit the signal bandwidth to less than the amplifier bandwidth, so that it is never asked to do anything beyond its capabilities.

There is an op-amp, but it is not in the signal path.

Starting at the input, the signal is AC coupled into a long tailed pair, and its frequency response is limited at 72KHz at -3dB, well above audio frequency. This can be reduced by the effects of signal source impedance, but is not likely to be reduced close to the audio range.

The long tailed pair has a constant current source as the tail, so that the current does not depend at all on power supply voltage, and hence cannot be affected by noise and hum. The dissipation of the constant current source is limited by R6, which also prevents any interaction between the constant current source and the long tailed pair transistor impedances.

The value of R7 is chosen so that, for a typical turn-on voltage for TR5, approximately half the tail current must flow in TR2. Purists may choose to measure the voltage across R7 in use and then recalculate it if necessary to balance the long tailed pair. Personally I don't think that this level of care will normally yield a detectable improvement.

The output stage is driven by TR5. It is in the driver stage that the frequency response is limited inside the feedback loop. C11 rolls off the response to approximately 600KHz itself, but it is in parallel with the drain to gate capacitance of TR5, so that the actual response is limited to approximately 300KHz

The function of this frequency roloff is to control the loop gain at one point with one time constant. Left to itself, the circuit will limits its response by device parameters, and in cases where the frequency limiting effect of two stages is similar, the phase shift can reach 180 degrees before the loop gain falls below 1, and oscillation will result. The trick is to find out which stage imposes the severest frequency limitation and add sufficient extra to guarantee stability.

The gain of the driver stage is limited by R14. This makes the performance of different samples of the amplifier more uniform, and, by linearising the stage, reduces a potential source of local distortion which the negative feedback would have to control. In effect R14 provides some negative feedback, but it is local to the stage, so that the problems of delay in the loop which can make too much negative feedback a bad idea do not apply.

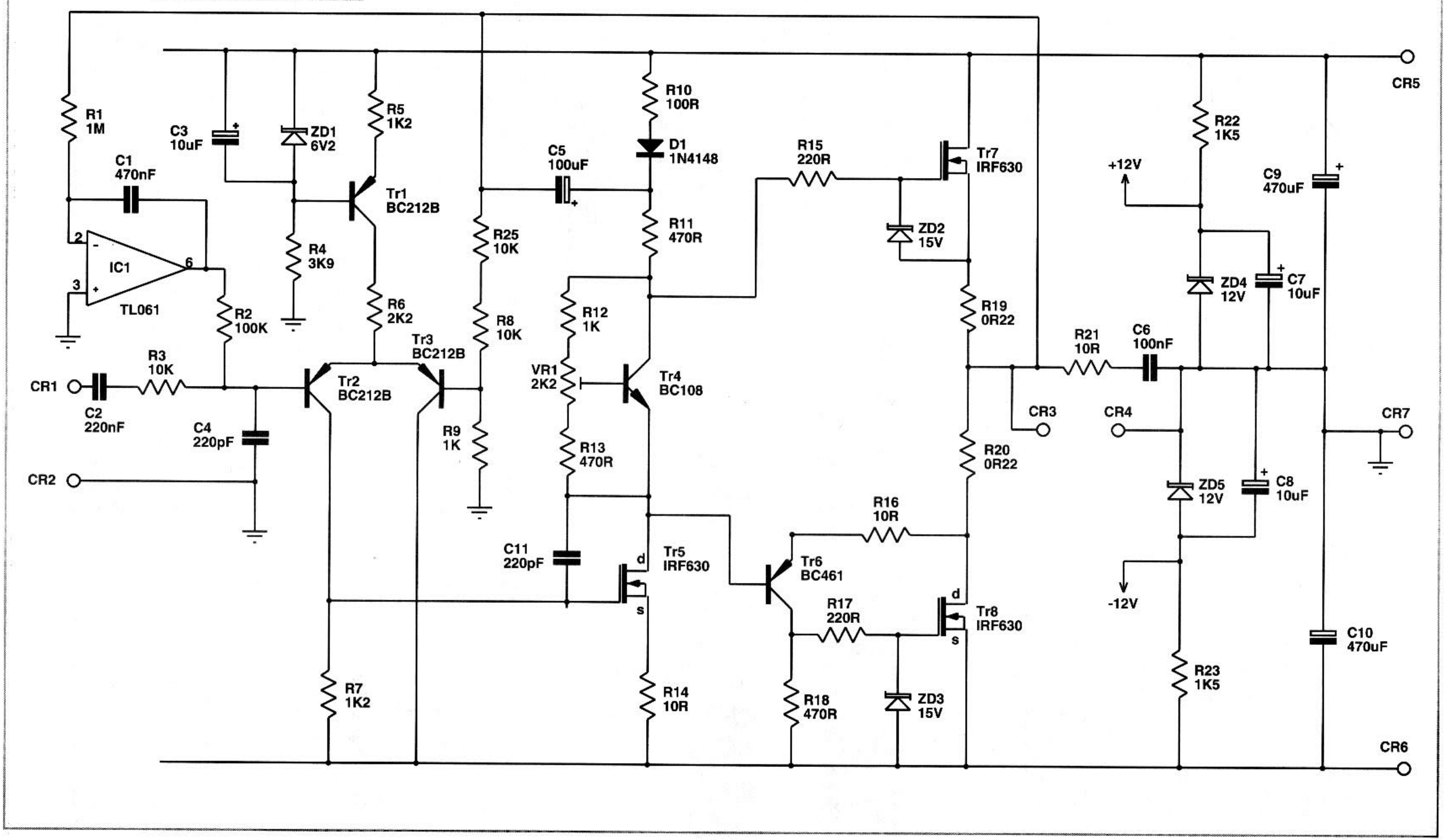
TR4 sets the output bias voltage, and hence the quiescent current. To stabilise the quiescent current as the output stage warms up, an E line transistor is used, and is glued to the heatsink. Ideally, thermal epoxy should be used. I didn't have any when I built the prototype so I used a two part cyanoacrylate adhesive, which sets quickly and hard if the accelerator is used. The thermal conductivity seemed adequate under test, and the quiescent current was reasonable stable.

The current for the driver stage flows through R10, D1 and R11. Bootstrapping is provided by C5, so that the current in R11 remains substantially constant throughout the entire signal range, though, of course, C5 is charged via R10 and D1 only when the instantaneous signal voltage is below the positive supply rail by an amount at least equal to the voltage across C5.

The output stage itself is of quasi-complementary design. TR7 is an N-channel FET working as a source-follower, with its gate protected from over-voltage by R15 and ZD2. TR6 and TR8 together form the complementary transistor. R19 and R20 add a little extra quiescent current stabilisation, while R21 and C6 ensure that the output sees a resistive load at high frequencies.

Negative feedback is provided by R8, R25, and R9. R25 was an addition at the layout stage. It seemed a bad move to run a track carrying the full output signal past the input stages, but equally it is not ideal to run a long track connected directly to the negative feedback point.

Fig.2 Complete circuit of power amplifier



A resistor at each end of the track seemed the best answer.

DC Offset

This amplifier uses an op-amp, but not in the signal path. Op-amps can be very useful, but it can cause problems to include them within the feedback loop of a multi-stage amplifier. The extra delay imposed can permit individual stages to be overloaded while the negative feedback settles, and the extra gain inside the loop can make it difficult to stabilise the amplifier without unduly vicious frequency tailoring. Here, however, the op-amp performs the useful function of stabilising the DC output level of the amplifier, while not taking any direct part in the signal processing. The op-amp, IC1, integrates the output voltage of the amplifier and adjusts the bias of TR2 to bring the average DC level as close to zero as the inherent offset of the op-amp in use.

A fet input op-amp is used because it has a very low bias current, and can therefore successfully be used with a high source resistance. This permits an adequate time constant to be obtained, while using a non-polarised capacitor as integration capacitor.

The op-amp is powered from decoupled, zener regulated supplies because it cannot operate on such high power supply voltages as the rest of the amplifier.

Assembly

It is best to build the amplifier on the PCB designed for it. The layout does affect the performance, and this layout is designed to keep heavy circulating currents clear of the sensitive input stages. In particular, the local decoupling capacitors chosen for this project have a particularly low ESR and ESL (equivalent series resistance and equivalent series inductance).

It is the fashion in some hi-fi circles to add non-polarised capacitors in parallel with electrolytics to lower their impedance at high frequency. I do not think this is a good idea unless the characteristics of the electrolytic are well known and consistent. Because electrolytic capacitors have inductance, it is possible for a resonance to occur. To understand this, see Figure 1

I have managed to measure this resonance in practice. On a switched mode power supply under test, the addition of a 220nF transformed a 150mV spike into a 50mV ring lasting the whole ON time of the switching transistor. Though the spike had a higher amplitude, the ring contained more energy.

The two output MOSFETs need to be insulated from the heatsink bracket by silicone rubber pads, or by mica washers and heatsink grease. The heatsink bracket itself should be coated with heatsink compound before it is bolted to the heatsink.

Do not be fooled by the 6W resistors used on the prototype for R19 and R20. The prototype layout was carried out quickly, and has been revised for the pcb service.

Power Supply

No power supply has been shown here. The prototype has so far only been used on a regulated supply, though it is designed to work on unregulated one. You may carry out your own experiments, or wait until next month when I will provide a suitable power supply design.

I am sure that a +/- 25V regulated supply will work well, because I have tested the amplifier using such a supply.

More on construction next month.

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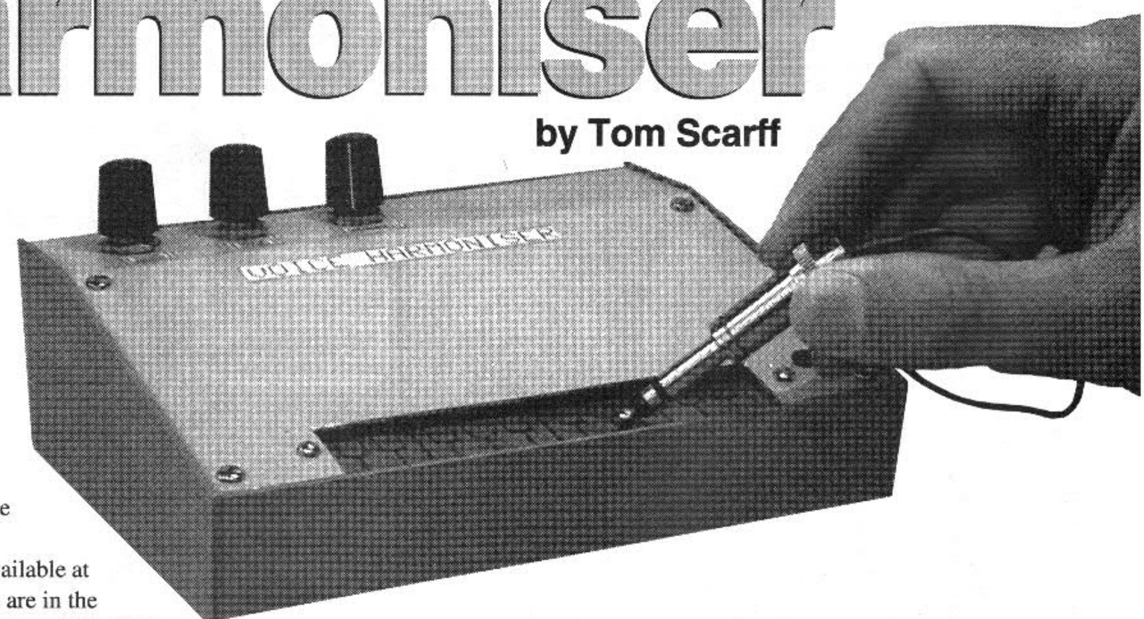
Voice Harmoniser

by Tom Scarff



Ever wanted to be in perfect harmony with yourself? Well from a singing point of view this unit allows you to achieve that goal. There are a couple of vocal harmony processors available at present but their prices are in the hundreds of pounds range so I decided to design and build my own unit.

Digital Section

The circuit is based around the MSM6322 real time audio pitch controller. The IC contains a fourth order low pass filter and an eight bit analogue to digital converter for input signals and a nine bit digital to analogue converter and third order low pass filter for the output signal. It also contains a built in microphone and line preamplifier. The block diagram and associated pinouts of IC3 are shown in Figures 1 and 2 and Table 1.

The circuit is set to operate in binary mode by connecting the mode select (MS) pin to the supply voltage. This enables the IC to be controlled by the binary code that is fed to input pins 5,2,1 and 3, according to the pitch conversion table shown in Table 2. From the table it can be seen that both the sampling frequency and the low pass filters are variable relative to the pitch changes, which reduces the chances of aliasing occurring.

Compression involves reducing the dynamic range of the input signal being processed so that with a 2:1 compression ratio if the input increases by 12dB then the output increases by only 6dB.

Conversely expansion increases the dynamic range, so when the input to the expander increases by 6dB the output will increase by 12dB, which is a 1:2 expansion ratio or, alternatively, if the input falls by 6dB the output drops 12dB. At the same time the noise introduced in the system will be reduced

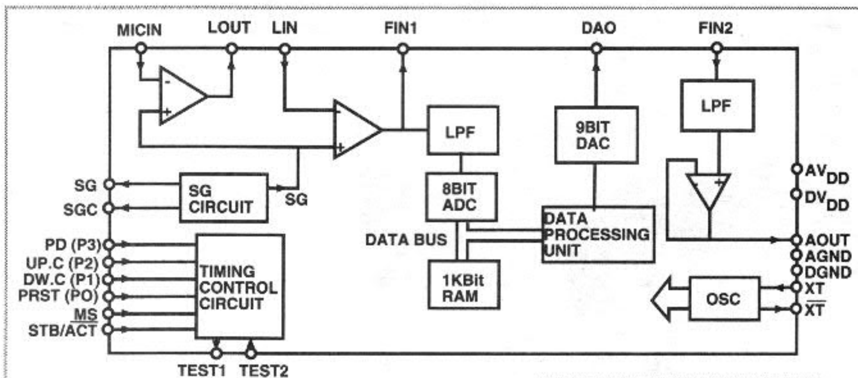


Fig.2 IC Block diagram

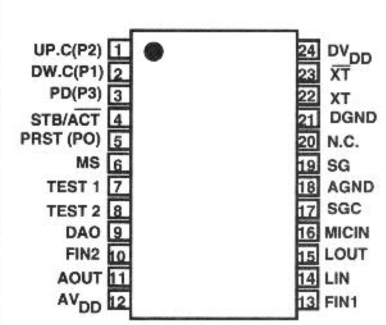


Fig.1 MSM6322 Pin-out

The Works

Analogue Section

The microphone input is fed to two pre-amplifiers, one contained in IC3 whose mid-band gain is set by R2/R1, and a direct feed based around IC5A whose mid-band gain is set by (1+R3/R4), and used in the non-inverting mode to allow in-phase mixing of the direct and effect voices. A summing amplifier IC5B combines three inputs: direct voice, effect voice and external source and feeds them to the line output.

In order to improve the signal-to-noise ratio the audio signal is routed through a compander consisting of compression via IC4B and expansion via IC4A. The mic amplifier output from IC3 is fed to the compressor IC4B and then to a line amplifier in IC3 whose mid-band gain is set by R14/R13. The analogue output, Aout, from IC3 is fed via expander IC4A to the summing amplifier IC5B.

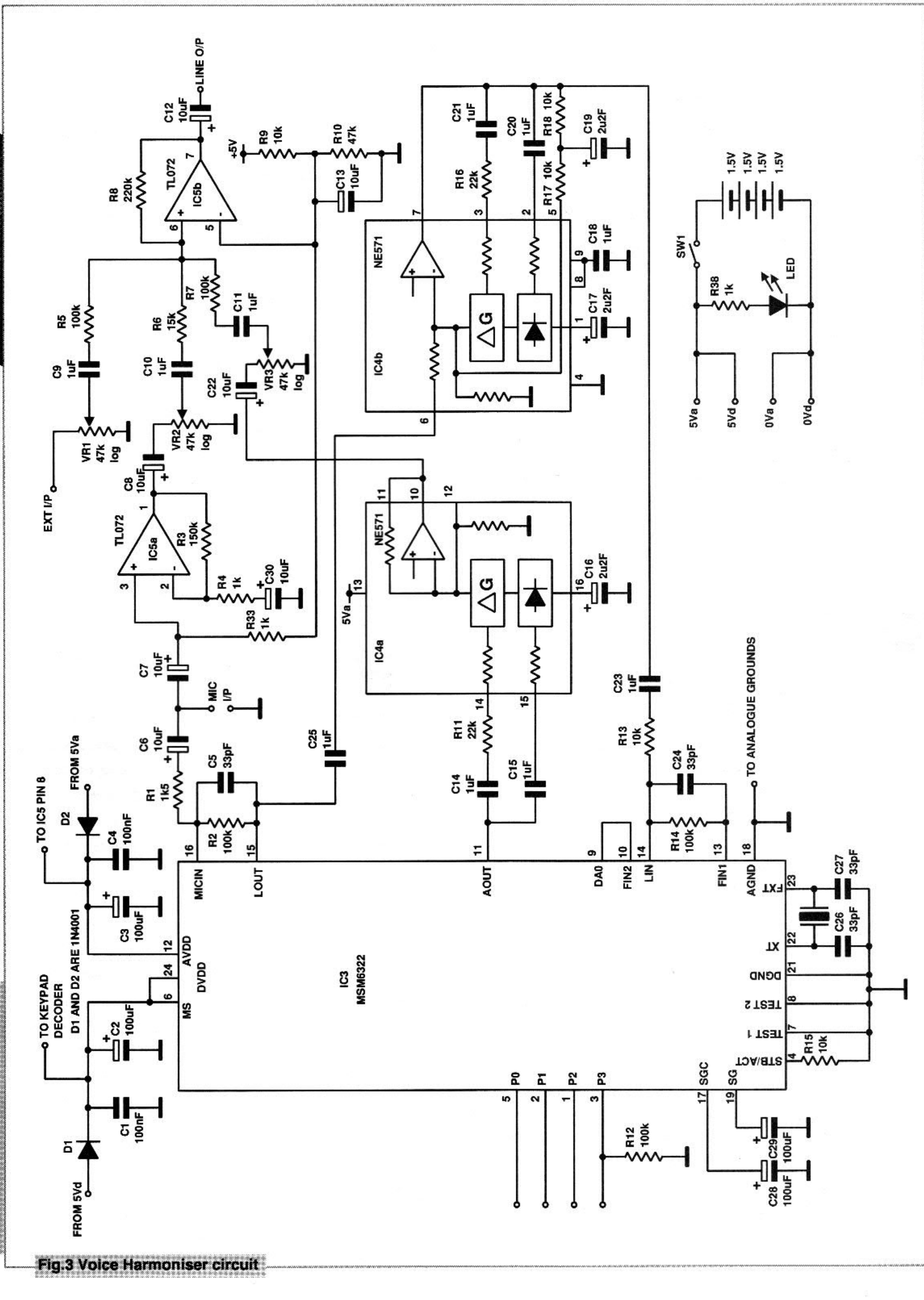


Fig.3 Voice Harmoniser circuit

Table 1 Pin Functions

Pin Name	Pin Number	DI/AI/AO	Function
MICIN	16	AI	Input to mic preamp. Must be capacitively coupled
LOUT	15	AO	Output of mic preamp
LIN	14	AI	Input to line amp. Must be capacitively coupled to either LOUT or the line out signal from audio sources
FIN1	13	AO	Sets the input audio signal amplitude in combination with the LIN pin
STB/$\overline{ACT}$	4	DI	Chip select pin. The processing is interrupted by stopping clocks other than the oscillator when the chip select pin is at the H level
TEST1	7	DI	Manufacturerrs test pins
TEST2	8		Must be connected to 0V
XT,$\overline{XT}$	22,23		External capacitors are connected here to stabilise the internal analogue voltage references of ½AV_{DD}
DAO	9	AO	Output from the digital to analogue converter
FIN2	10	AI	Input pin for internal low pass filter (for output)
AOUT	11	AO	Output of low pass filter (for output)
D_{GND}	21		Digital power supply pins
DV_{DD}	24		
A_{GND}	18		Analogue power supply pins
AV_{DD}	12		

Note: DI Digital Input AI Analogue input AO Analogue output

...the keypad encoder and voice harmoniser are built on separate PCBs. More than one pitch controller could then be used...

on expansion since it was not subject to the initial compression treatment and is therefore expanded downwards below the lowest dynamics of the audio signal. This process is illustrated in Figure 5.

Operation

The PCB keyboard switches are designed in the shape of a musical keyboard for an octave above and below middle C, which when selected gives no pitch change. The selection is achieved by connecting +5V via the limiting resistor R37 to the required PCB keyboard input. This allows the relative harmony to be selected no matter what key a person sings in, so that if a fourth above is required then F above middle C (ie five semi-tones up) is selected and the output produced is a relative fourth above the input.

So when a song is being sung the harmony at the output can be changed by the keyboard selection at any part in the song. However since there are only 16 possible pitch changes every semitone of the keyboard is not operational. The pitch changes that are available are shown in Table 2.

Table 2 Pitch Conversion table

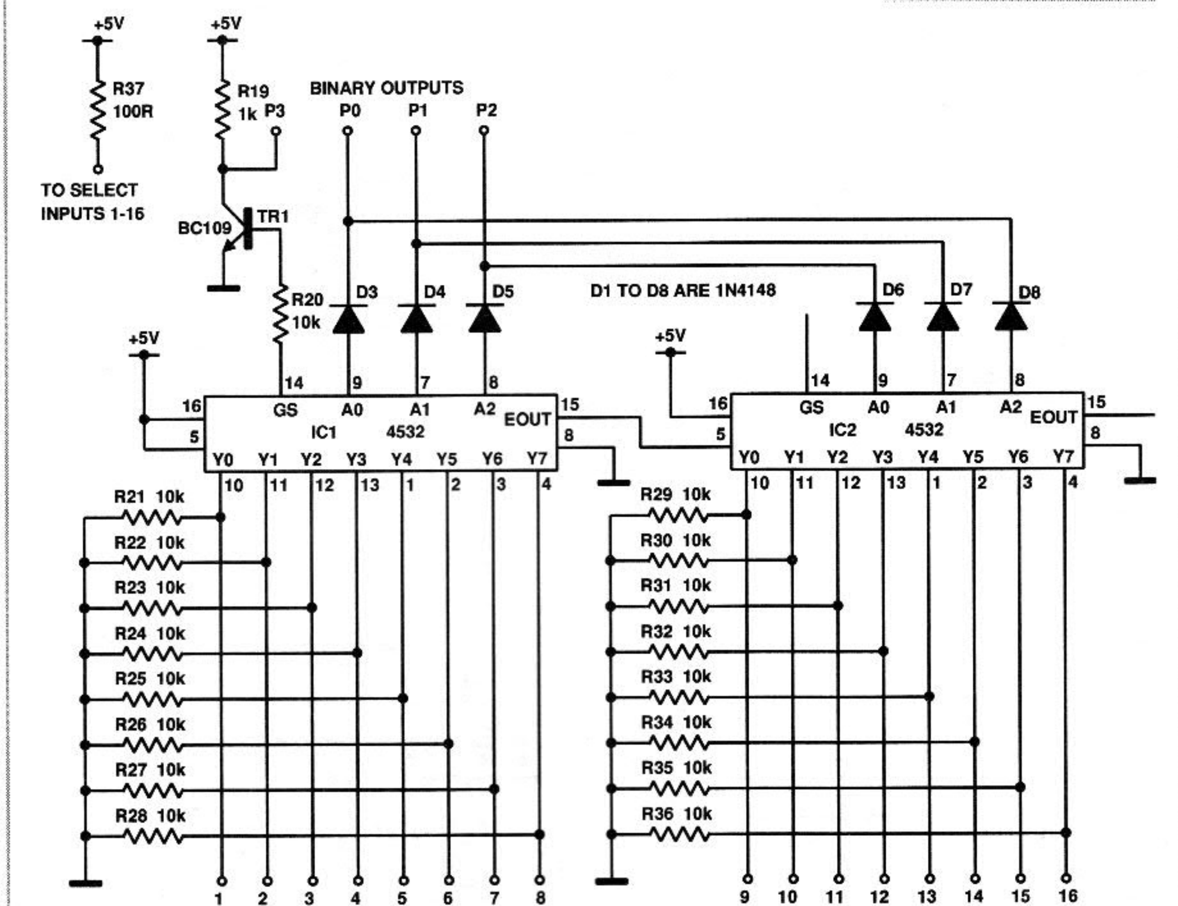
BIN Mode settings P3	P2	P1	P0	Scale Stage	DA sampling cycle(μs) frequency (KHz)	LPF cut-off frequency (KHz)	Pitch Change
Not available				16	60/16.6	7.6	1 octave up
1	1	1	1	15	71/14.0	7.6	9 semitones up
1	1	1	0	14	76/13.1	5.7	8 semitones up
1	1	0	1	13	80/12.5	5.7	7 semitones up
1	1	0	0	12	90/11.1	5.7	5 semitones up
1	0	1	1	11	95/10.5	5.7	4 semitones up
1	0	1	0	10	101/9.9	4.56	3 semitones up
1	0	0	1	9	113/8.84	4.56	1 semitone up
1	0	0	0	8	120/8.33	3.8	No pitch change
0	1	1	1	7	127/7.87	3.8	1 semitone down
0	1	1	0	6	143/6.99	3.26	3 semitones down
0	1	0	1	5	151/6.62	3.26	4 semitones down
0	1	0	0	4	160/6.25	3.26	5 semitones down
0	0	1	1	3	180/5.55	2.85	7 semitones down
0	0	1	0	2	190/5.26	2.53	8 semitones down
0	0	0	1	1	202/4.95	2.53	9 semitones down
0	0	0	0	0	227/4.4	2.07	1 octave down

The relative levels of the direct and harmonised voices can be controlled via the built in mixer controls VR2 and VR3. Also the external input, controlled via VR1, can be fed from a previously recorded mix of voices thus allowing the building of exciting multi-part harmonies.

Power Supply

The circuit is designed for battery operation using 4 off 1.5V type AA batteries, and the current consumption is 20mA. The analogue and digital power supplies need to be kept isolated to reduce the chance of digital noise introducing itself into the analogue signal path. The 6V battery is feeds the digital supply inputs of IC1, IC2, IC3 via D1 and via D2 to the audio DC supply input of IC3,4 and IC5. The earth PCB tracks for the digital and audio circuits are kept separate and joined only at the battery terminals.

Fig.4 Keypad Decoder



The Works

The binary code is derived from the keyboard via the two linked 8 to 3 priority encoders IC1 and IC2. These encoders convert 16 inputs into the required 4-bit binary number to operate the pitch controller IC3. Since no pitch change occurs with the binary input equal to 1000 this is achieved by taking the gate-select (GS) pin of IC1, which is normally low with no input selected, to the transistor Tr1 which acts as an inverter, thus providing the required high output on the most significant binary (MSB) bit.

However when any of the 8 inputs of IC1 are selected then the GS pin goes high and the transistor output goes low, with the corresponding 3-bit binary number being fed out via the diodes D3, D4 and D5 to the pitch harmoniser IC3 binary inputs. So since the MSB is set to zero these 8 selections from 0000 to 0111 produce corresponding downward pitch changes.

Similarly the 8 inputs when selected on IC2 produce a binary output via diodes D6,D7 and D8. However in this case the GS pin of IC1 remains low, so the transistor inverter output is high, giving a binary output ranging from 1000 to 1111 corresponding to upward pitch changes.

Construction

The components should be mounted in the following order: links, resistors, diodes, DIL sockets, capacitors and last, electrolytic capacitors. The 4MHz crystal should be mounted flat on the PCB with its legs connected at 90 degrees into the PCB. The microphone input should be connected to the jack-socket via screened cable to reduce the chances of noise and hum pickup.

The MSM6322 IC3 is a surface mounted device and is soldered to the underside of the PCB. When mounting this component the smallest possible size soldering bit should be used (<1mm), with 22SWG solder. Place the IC squarely on all 24 pins and solder the opposite diagonal pins first, then solder the remaining pins allowing several

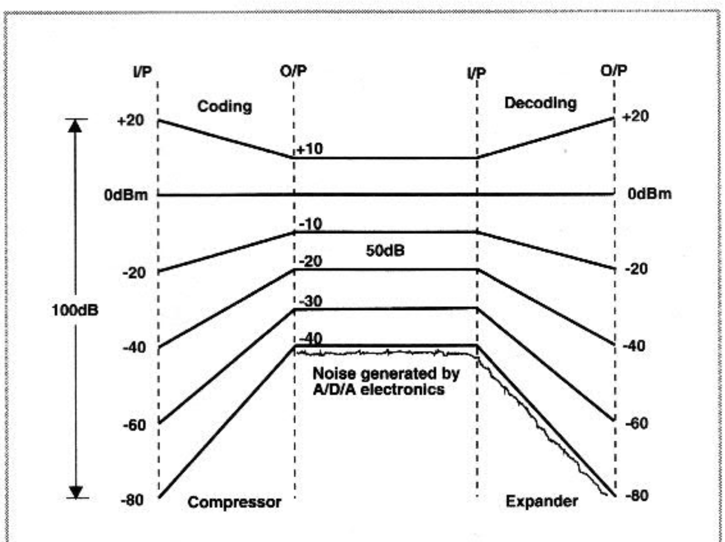
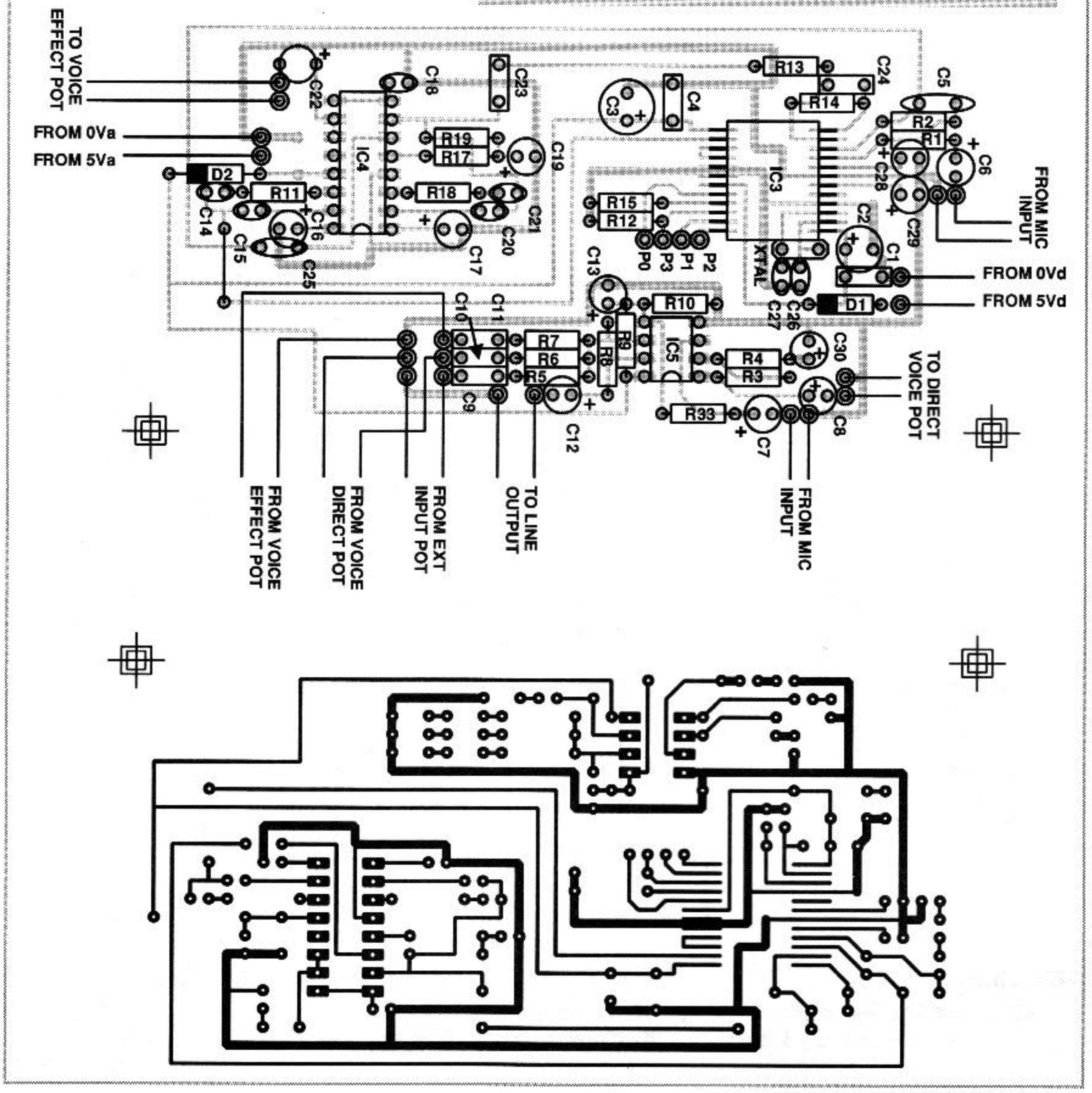


Fig.5 Operation of a Compression/Expansion system

Fig.6 Component positioning for Voice Harmoniser



seconds between each solder joint to allow the IC to cool down. The other ICs are mounted in DIL sockets to allow ease of changing for test or fault-finding purposes. Also the correct orientation of IC3 is achieved by noting pin 1 being marked on the PCB.

The Keyswitch Encoder PCB is mounted so that the PCB musical keyboard can be accessed and played via an electronic control stick consisting of a conductor mounted in an insulated container. I used the centre conductor on a 1/4 inch jack-plug.

Further Development

To allow further development the keypad encoder and voice harmoniser are built on separate PCBs. More than one pitch controller could then be used to produce up to four or five-part harmonies controlled via the output port of a microprocessor. These harmonies could be stored in preset programmes or controlled in real-time by an external synthesiser keyboard through MIDI. EIA

Parts

Resistors

(All 1/4W Metal Film)

R1	1K5
R2,5,7	100K
R12,14	100K
R6	15K
R3	150K
R8	220K
R9,10	47K
R11,16	22K
R13,15,17	10K
R18,19	10K
R21-28	22K SIL
R29-36	22K SIL
R4,20	1K
R38,39	1K
R37	100
VR1,2,3	47K Log

Semiconductors

IC1,2	4532
IC3	MSM6322
IC4a,b	NE571
IC5a,b	TL072
D1,2	1N4001
D3,4,5 D6,7,8	1N4148
Tr1	BC109

Capacitors

C1,4	100nF/16V Minidisc
C2,3	220µF/10V Min Elect
C28,29	100µF/10V Min Elect
C5,24 C26,27	33pF Ceramic
C6,7,8 C12,13 C22,30	10µF/16V Min Elect
C9,10 C11,14 C15,18 C20,21 C23,25	1µF (non-electrolytic)
C16,17,19	2µ2F/16V Min Elect

Additional Items

IC holders 8-pin (1 off)
16-pin (3 off)
Xtal 4MHz
SPST switch
LED
6mm jack sockets (3 off)
4 x 1.5V battery holder and enclosure, of external size 170 x 143 x 55/31mm.

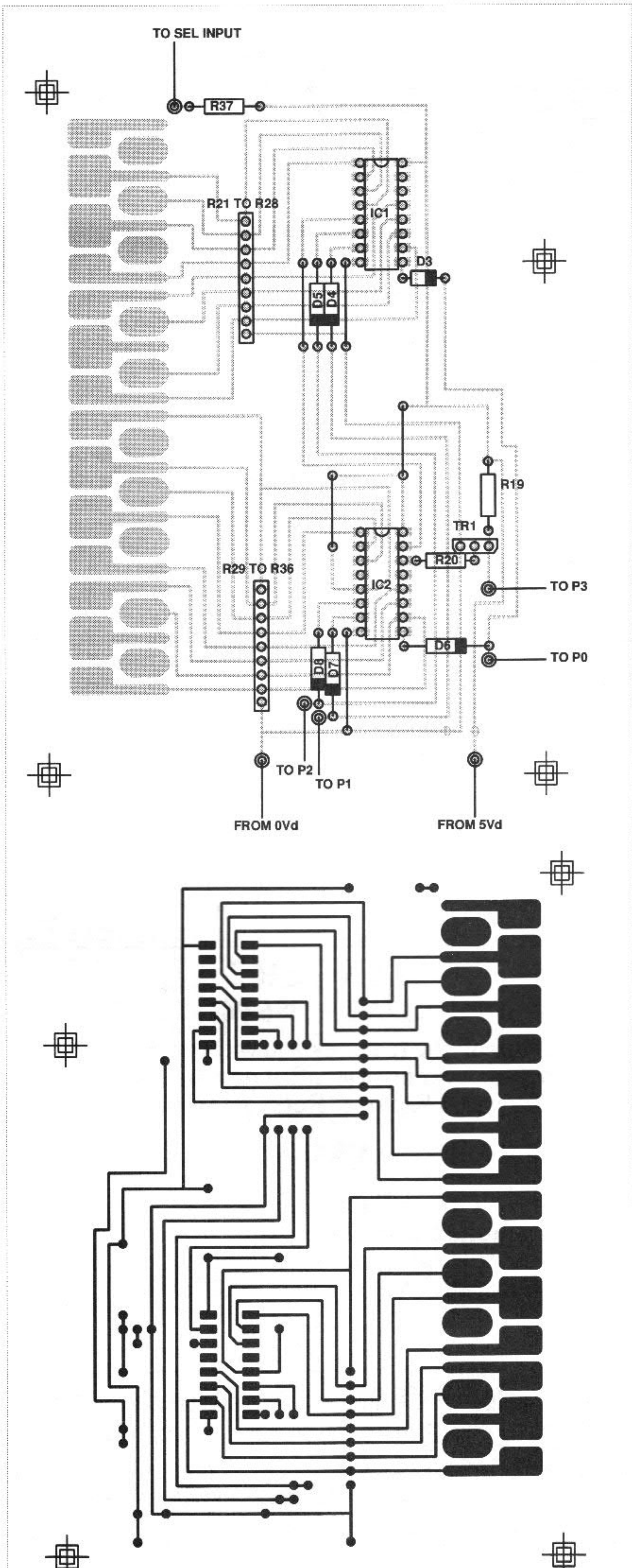


Fig.7 Component positioning for Keypad decoder

Signal to NOISE

A Selection of your views and thoughts

Tele-scope Offer

As a contributor to EIA, the following appears to be a biased view, but this is not the case.

I would like to congratulate everyone involved with EIA for producing an extremely interesting, varied and different magazine. I look forward to reading each issue. Whilst some other electronics magazines apppear to be faltering or cost cutting, your new publication is going from strength to strength.

Speaking as a contributor, I find it very easy to write for EIA, unlike some magazines who seem to regard contributors as a necessary nuisance.

Whilst writing, I would like to reiterate my offer published in issue two. I am willing to donate my proto-type Tele-scope project to a suitable charitable or non profit making organisation. I am particularly keen to give it to a school or club where many people, preferably children, can gain advantage from it. Would any interested parties please write to me via the EIA offices by January 31st.

The response to this offer when it first appeared at the end of the article was not particularly encouraging, hopefully, reprinted here in the letters page, more people will see it!

Paul Stenning
Hereford

Launching EIA is most welcome!

There has not been a publication since the 70s solely devoted to practical matters and I'm sure will be welcomed by the fraternity of project builders.

Like HWC Hollings in the December issue, I too have an affinity for electro-music and would welcome constructional articles on keyboards, expanders and sequencers. However if Mr Hollings would care to get in touch with me via the EIA office, I can oblige with a photo stat of the pipe voicings of the Blackpool Organ, I believe the voicings to produce 'The Sound' are Tibia 8 & 16 strings or reeds.

I have asked Yamaha for the information on the rendering of the tune 'Beside the seaside' on their keyboard PSR5700 (an organ voice) and they replied that the R & D fellows in Japan have the answer.

So much for my comments. May I wish you full steam ahead for the magazine. I am sure it will cater for many and perhaps looking further ahead to car utilities like an exhaust gas analyser.

Another well-past retirement reader, wishing you every success.

W Robinson, Walsall

COMPONENTS

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74LS01	0.10
74LS02	0.10
74LS03	0.10
74LS04	0.10
74LS05	0.10
74LS07	0.38
74LS08	0.10
74LS09	0.12
74LS10	0.10
74LS11	0.10
74LS12	0.10
74LS13	0.17
74LS151	0.25
74LS14	0.21
74LS15	0.11
74LS20	0.11
74LS21	0.11
74LS22	0.11
74LS24	0.32
74LS26	0.11
74LS27	0.11
74LS28	0.11
74LS30	0.11
74LS32	0.12
74LS33	0.12
74LS37	0.13
74LS38	0.13
74LS40	0.13
74LS42	0.22
74LS44	1.60
74LS47	0.50
74LS48	0.45
74LS49	0.61
74LS51	0.11
74LS54	0.11
74LS55	0.13
74LS73	0.20
74LS74	0.15
74LS75	0.21
74LS26	0.21
74LS77	0.42
74LS83	0.34
74LS85	0.34
74LS86	0.22
74LS90	0.24
74LS91	0.50
74LS92	0.29
74LS93	0.24
74LS95	0.38
74LS96	0.46
74LS107	0.25
74LS109	0.25
74LS112	0.25
74LS113	0.25
74LS114	0.25
74LS122	0.32
74LS123	0.32
74LS125	0.27
74LS126	0.21
74LS132	0.28
74LS133	0.24
74LS136	0.21
74LS137	0.62
74LS138	0.23
74LS139	0.25
74LS145	0.57
74LS147	0.86
74LS148	0.69
74LS153	0.27
74LS154	0.70
74LS155	0.24
74LS156	0.24
74LS157	0.20
74LS158	0.24
74LS160	0.31
74LS161	0.31
74LS162	0.31
74LS163	0.31
74LS164	0.29
74LS165	0.47
74LS166	0.52
74LS168	0.58
74LS169	0.52
74LS170	0.65
74LS173	0.55
74LS174	0.23
74LS175	0.23
74LS181	1.46
74LS182	1.56
74LS183	1.56
74LS190	0.24
74LS191	0.23
74LS192	0.28
74LS193	0.38
74LS194	0.38
74LS195	0.23
74LS196	0.23
74LS197	0.23
74LS221	0.35
74LS240	0.31
74LS241	0.31
74LS242	0.31
74LS243	0.31
74LS244	0.31
74LS245	0.32
74LS247	0.31
74LS249	0.65
74LS251	0.23
74LS253	0.34
74LS256	0.50
74LS257	0.23
74LS258	0.23
74LS259	0.48
74LS260	0.28
74LS266	0.14
74LS273	0.31
74LS279	0.24
74LS280	0.85
74LS283	0.48
74LS290	0.23
74LS293	0.23
74LS295	0.57
74LS298	0.62
74LS299	1.16
74LS322	1.56
74LS352	0.76
74LS353	0.86
74LS365	0.23
74LS366	0.26
74LS367	0.25
74LS368	0.27
74LS373	0.31
74LS374	0.31
74LS375	0.33
74LS377	0.31
74LS378	0.61
74LS390	0.24

MINI TOGGLE SWITCH.

SPDT. 240V 3A	0.39
SPDT C/O 240V 3A	0.43
DPDT	0.47
DPDT C/O	0.51

LINEAR ICs

TL061	0.33
TL062	0.39
TL064	0.43
TL071	0.30
TL072	0.33
TL074	0.44
TL081	0.31
TL082	0.32
TL084	0.44
TBA120S	0.61
TMM2016	24.99
TMS320C	9.99
UA1489	2.90
UA723DC	0.52
UA747	0.55
UA749	1.60
UA78S40	1.10
UA9636	3.70
UA9667	0.48
UDN2982	2.38
UHP400	4.99
UHP402	5.90
ULN2002A	0.60
ULN2003A	0.24
ULN2004A	0.39
ULN2803A	0.44
ULN2804	1.55
ULN3008	6.99
UM82C11	6.99
UPB8212	6.99
UPB8286	2.60
UPB8287	3.99
UPB8288	7.40
UPD2114	1.75
XR2206	3.95
Z086810P	3.99
Z80A CPU	0.99
Z80ACTC	1.35
Z80BCTC	1.95
Z80BS10	2.45
Z8530	4.50
ZN414Z	0.77
ZN416E	1.14
ZN423	0.92
ZN425E	3.48
ZN426E	1.96
ZN427E	6.34
ZN428E	5.14
ZN435E	4.35
ZN448E	6.58
AD558	0.65
AD562	19.50
AD574	14.90
AD7501	0.80
AD7541	8.20
AD7581	8.75
AM2147-70	4.99
AM2167	4.99
AM25LS07	1.50
AM25LS374	1.80
AM25LS377	1.90
AM25S05	19.99
AM25S07	4.99
AM25S08	3.99
AM25S10	4.99
AM27S20	1.99
AM27S29	8.99
AM27S37	4.99
AM27S45	4.99
AM27S49	18.99
AM2841	8.75
AM2901	28.99
AM2918	4.50
AM2952	8.99
AM2955	8.99
AM29818	4.99
AM29822	8.99
AM500	9.60
AM7910	14.50
AM7911	8.99
AM8035	8.99
AM9122-25	2.78
AM9122-35	9.99
AM9150-35	14.99
AM91L12	4.99
AM91L22-45	9.99
AM92L44	8.99
AM9551	8.99
AMPAL16H	15.00
AMZ8120	12.99
CA3046	0.35
CA3080E	0.49
CA3081	4.99
CA3130E	0.73
CA3140E	0.38
CA3240E	0.99
CA3290	1.35
CNY51	2.99
CNY71	1.40
D2125H-2	2.50
D2147	9.30
D2148	7.75
D4016C-5	7.50
D416C	1.80
D8041	12.99
D8048C-127	5.50
D8155	18.99
D8251	8.99
D8253C-2	10.19
HD465D8255	12.50
D933-1	6.80
DAC0800L	14.99
DF320ADJ	5.80
DG126	1.75
DG189	5.80
DG190AP	3.80
DG308	2.80
DP8304	5.20
DP8308	3.75
DS8838	3.75
H104D	6.80
H117	2.80
H11A2	9.50
H11C4 (OPT)	1.99
H148	5.75
H157	1.75
HD45505	6.99
HD46505	5.50
HD46850	9.75
HD63A03	8.99
HM6116P-2	0.98
ICL7106	4.85
ICL8038	3.05
ICM7555	0.29
ICM7556	0.78
IH5025	6.50
IH5029	5.25
IH5033	5.75
IM6403	7.60
IMS1400.35	3.99
IM1600.45	13.99
IT132	15.99
KR2376	8.99
KR3600	19.50

ROTARY SWITCHES

ALL AT 0.55 P EACH.

1 POLE/12 WAY
2 POLE/6 WAY
3 POLE/4 WAY
4 POLE/3 WAY

RESISTORS

0.25W CARBON 5 % ALL AT 0.02 EACH OR 15 P FOR 10 OF THE SAME VALUE. METAL FILM AT 0.03 EACH OR 15 P FOR 10 OF SAME VALUE

TRANSISTOR

AC125	0.30
AC126	0.29
AC127	0.29
AC128	0.28
AC176	0.34
AC187	0.35
AC188	0.36
AD142	1.80
AD161	0.78
AD162	0.85
AF124	0.78
AF126	0.46
BC107	0.12
BC107B	0.13
BC108	0.11
BC108B	0.13
BC108C	0.14
BC109	0.13
BC109C	0.14
BC140	0.24
BC141	0.26
BC142	0.30
BC143	0.33
BC147	0.33
BC148	0.33
BC149	0.11
BC157	0.11
BC158	0.11
BC159	0.11
BC160	0.29
BC169C	0.16
BC169C	0.16
BC171	0.11
BC177	0.17
BC178	0.17
BC179	0.17
BC182	0.07
BC182L	0.07
BC183	0.07
BC183L	0.07
BC184	0.07
BC184L	0.07
BC212	0.07
BC212L	0.07
BC213	0.07
BC213L	0.07
BC214	0.07
BC214L	0.07
BC237B	0.08
BC238B	0.08
BC308B	0.08
BC327	0.09
BC328	0.09
BC337	0.09
BC338	0.09
BC477	0.33
BC478	0.33
BC479	0.33
BC517	0.19
BC547B	0.07
BC548B	0.07
BC549B	0.07
BC557B	0.07
BC558B	0.07
BCY90	0.20
BCY71	0.19
BCY72	0.19
BD115	0.49
BD131	0.36
BD132	0.36
BD135	0.19
BD136	0.19
BD137	0.19
BD138	0.19
BD139	0.22
BD140	0.23
BF180	0.30
BF182	0.30
BF185	0.30
BF194	0.18
BF195	0.18
BF196	0.19
BF197	0.19
BF198	0.19
BF199	0.19
BF257	0.32
BF258	0.35
BF259	0.32
BF337	0.35
BFR40	0.38
BFR80	0.38
BFR81	0.38
BFX29	0.28
BFX84	0.30
BFX85	0.30
BFX87	0.43
BFX88	0.43
BFY50	0.28
BFY51	0.25
BFY52	0.27
BFY53	0.46
BFY55	0.46
BFY56	0.46
BSX20	0.26
BSX29	0.52
BSY95A	0.46
BU205	1.39
BU206	1.40
BU208	1.55
MJ2955	0.75
MJE340	0.35
MJE520	0.44
MJE521	0.59
MJE3055	0.84
MPSA05	0.27
MPSA06	0.27
MPSA12	0.27
MPSA56	0.17
MPSU06	0.55
TIP29A	0.30
TIP29B	0.30
TIP29C	0.31
TIP30	0.31
TIP30A	0.31
TIP30B	0.30
TIP30C	0.30
TIP31A	0.30
TIP31B	0.30
TIP31C	0.31
TIP32A	0.30
TIP32B	0.30
TIP32C	0.31
TIP33A	0.65
TIP33C	0.71
TIP34A	0.68
TIP34C	0.74
TIP35A	0.99
TIP35C	0.99
TIP36A	0.99
TIP36C	0.99
TIP41A	0.35
TIP42A	0.35
TIP120	0.37
TIP121	0.34
TIP122	0.36
TIP141	1.05
TIP142	1.05
TIP147	1.10
TIP2955	0.59
TIP3055	0.60
ZTX107	0.17
ZTX108	0.17
ZTX109	0.17
ZTX300	0.16
ZTX302	0.19
ZTX341	0.22
ZTX500	0.14
ZTX501	0.22
ZTX502	0.22
ZTX504	0.22
2N2219A	0.27
2N2222A	0.15
2N2369	0.23
2N2484	0.24
2N2646	0.57
2N2904	0.24
2N2904A	0.24
2N2905	0.20
2N2905A	0.20
2N2906A	0.20
2N2907	0.19
2N2907A	0.19
2N2926	0.14
2N3053	0.26
2N3054	0.83
2N3055	0.55
2N3442	1.32
2N3702	0.09
2N3703	0.09
2N3704	0.09
2N3705	0.09
2N3706	0.09
2N3773	1.68
2N3819	0.26
2N3866	0.99
2N3903	0.09
2N3904	0.09
2N3905	0.09
2N3906	0.09
2N4026	0.16
2N6027	0.33

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78L05	0.21
78L12	0.21
78L15	0.21
79L05	0.23
79L12	0.23
79L15	0.23
7805	0.23
7812	0.23
7815	0.23
7905	0.25
7912	0.25
7915	0.25
78S05	0.37
78S12	0.37
LM323K	1.95
LM317T	0.43
LM200	0.78
LM723	0.34

IC SOCKET

8 PIN	0.06
14 PIN	0.10
16 PIN	0.14
18 PIN	0.14
20 PIN	0.15
24 PIN	0.18
28 PIN	0.20
40 PIN	0.24

TURNED PIN AVAILABLE AT EXTRA CHARGE.

MINI.PUSH TO MAKE SWITCH.

0.19P EACH COLOURS: RED.BLACK.GREEN. BLUE.YELLOW.WHITE.

DIODES.

IN4001 10 PACK	0.22
IN4002 ..	0.23
IN4003 ..	0.24
IN4004 ..	0.25
IN4006 ..	0.26
IN4007 ..	0.27
1N4148 ..	0.22
IN914 5 PACK	0.20
1N4149 ..	0.40
OA47 ..	0.95
OA90 ..	0.40
OA91 ..	0.45

ZENERS AVAILABLE AT
400 MW 0.03
1.3W 0.07

CERAMIC CAPS.

THESE VALUES COST 0.05 P EACH AL VALUES IN PF.
1.8,2.2,3.3,4.7
6.8,10,12,15,22
27,33,47,56,68
82,100
THE FOLLOWING COST 0.07 P EACH.VALUES PF
120,150,180,220
270,330,390,470
560,680,820
1N,1N5,1N8,2N2
3N3,3N9,4N7
6N8,10N,20N
100N.

POLYESTR.

ALL AT 0.05 P EACH. ALL VALUES UP TO 880N

AXIAL ELECTROLYTIC

1 UF 25 VOLT	0.06
2.2UF 25VOLT	0.06
4.7UF 25 VOLT	0.07
10UF 25 VOLT	0.07
10 UF 63 VOLT	0.08
22UF 35 VOLT	0.08
47UF 10 VOLT	0.06
47UF 16 VOLT	0.09
47UF 25 VOLT	0.06
47UF 35 VOLT	0.08
100UF 16 VOLT	0.09
100UF 25 VOLT	0.09
100UF 63 VOLT	0.12
220UF 16 VOLT	0.10
220UF 25 VOLT	0.11
470UF 16 VOLT	0.19
470UF 25 VOLT	0.22
1000UF 16 VOLT	0.28
1000UF 25 VOLT	0.35
2200UF 16 VOLT	0.45
2200UF 25 VOLT	0.52
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3300UF 35 VOLT	1.90

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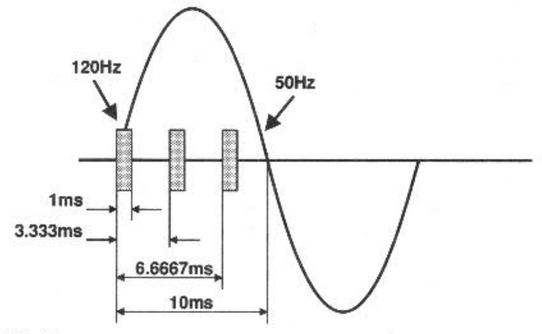


Fig.1

How would you like to be able to turn your coffeemaker on automatically before you get out of bed in the morning, or turn your washing machine on from the next room? Or perhaps even draw the curtains without moving from your comfy chair, or turn off your child's radio or night light from your bedside?

Perhaps you could to do all these and many another function just by phoning home from anywhere in the world!

Celtel has launched a range of home automation products which will do all this and more. The X10-Powerhouse home automation system consists of central control consoles and remote receiver modules. The controllers transmit signals to the modules over existing house wiring. Lamps plug into lamp modules, appliances into appliance modules, and wall light switches can be replaced with wall switch modules. The operator can then control virtually everything electrical in the home.

Home automation has definitely arrived. Some people may glaze over at the thought, considering it to be just a hobby for boffins. In fact, it isn't: it's simple to install and inexpensive enough for any home.

Home automation offers two major advantages: the ability to control a number of devices, such as domestic appliances, heating and entertainment systems, from a central control panel, and the ability to monitor, over-ride and change the original instructions from outside the home, using the telephone or other means. In an environment where an increasing number of parents are returning to their careers after bringing up their families, home automation could help out.

Systems can be programmed to fit in with domestic needs, but if plans change and you have to work late at the office the instructions can be altered over the phone.

Home automation also offers help to the disabled and elderly, giving them control of their home from an armchair or bed.

To give you some idea, before was disbanded, the National Economic Development Office (NEDO) estimated the world demand for this type of control as a market of around £8,000M, and predicted that this would grow to about £2,000M in the UK alone by the year 2000.

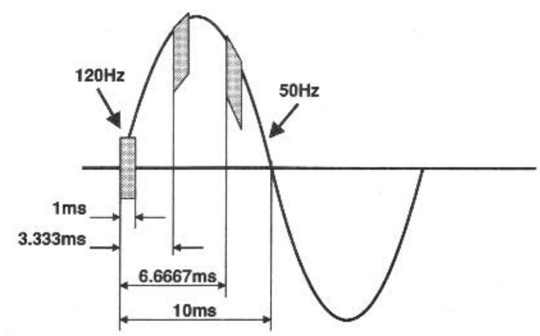


Fig.2

Where it all began

The technology used in home automation was developed way back in the late 60s by a group of engineers in Glenrothes, Scotland, who began designing microelectronic chips at the time when large scale integration circuits (LSI) were first being introduced. The company's basic philosophy was simple: to design products which used readily-available ICs to meet specific objectives, suitable for high volume, low-cost production in the Far East. The result would be to keep the prices down to highly competitive levels.

The Corporate View

The company first launched itself onto the US market in 1978. Prior to this, two label agreements had been signed, one with Sears Roebuck and the other with Radio Shack (the American electrical supplier linked with Tandy's in the UK). Significant shipments began the following year.

Today, Radio Shack is the biggest customer for the X-10 system. To date, more than 30 million X-10 units have been shipped to customers worldwide, meaning more than 2 million homes in the US and Canada. More recently X-10 turned its attention to the UK market through Celtel, which is now their sole European distributor.

The X-10 code format is the de facto standard for Power Line Carrier (PLC) transmission. The method of communicating is by superimposing a binary code onto the mains supply. X-10 transmissions are synchronised to the zero crossing point of the AC power line. A binary 1 is represented by a 1-millisecond burst of 120kHz at the zero crossing point, and a binary 0 by the absence of this 120kHz. These 1-millisecond bursts are actually transmitted three times to coincide with the zero crossing points of all three phases in a three phase distribution system.

Figure 1 shows the timing relationship of these bursts relative to zero crossing. For clarity, the signals in Figure 1 are shown as they would be seen through a high pass filter. The

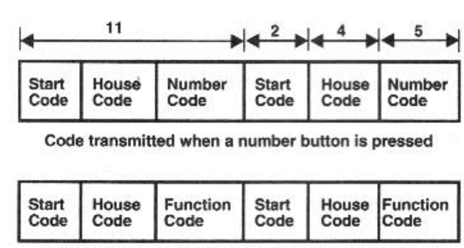


Fig.3

The Home of

50Hz waveform is only shown for reference. In reality the signals are actually superimposed onto the 50Hz waveform (Figure 2).

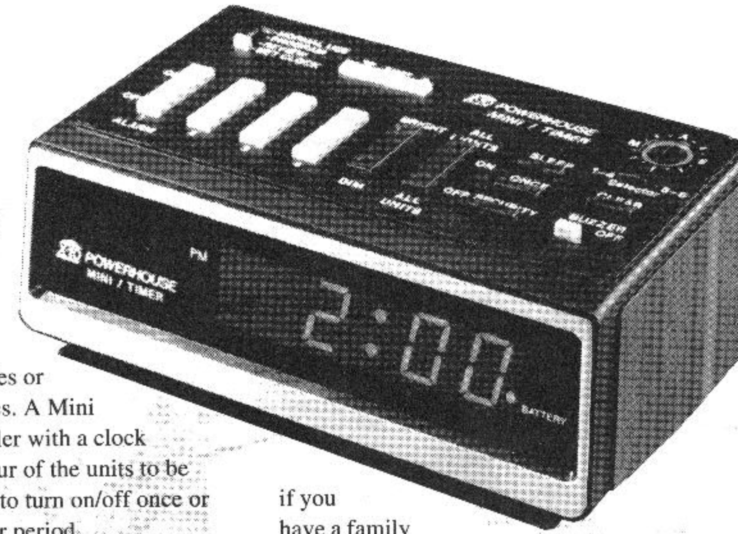
A complete code transmission encompasses eleven cycles of the power line. The first two cycles represent a Start Code; the next four cycles represent the House Code, and the last five cycles represent either a Number Code (1 to 16) or a Function Code (On, Off etc).

This complete block (Start Code, House Code, Key Code) is always transmitted in groups of two with three power line cycles between each group of two codes. Bright and dim are exceptions to this rule and are transmitted (at least twice) with no gaps between codes (Figure 3).

Within each block of data, each four or five bit code is transmitted in true and complement form on alternate half cycles of the power line, that is, a 1-millisecond burst of signal is transmitted on one half cycle (Binary l); no signal is transmitted on the next half cycle, (Binary 0). As previously mentioned, the X-10 range consists of controllers and appliance modules.

The Modules

The wall Switch Module replaces existing wall switches in a room, allowing lights to be turned on or off, or dimmed as required. The Lamp Module features an on/off and dimming facility for free-standing lamps that would normally be plugged into a wall socket. The Appliance module can be used to control equipment normally plugged into a 13-amp wall socket.



The Controllers

Mini and Maxi Controllers control between 8 and 16 individual modules or groups of modules. A Mini timer is a controller with a clock enabling up to four of the units to be pre-programmed to turn on/off once or twice in a 24 hour period.

Other modules have a built-in photocell, and will turn on up to four lights when the sun goes down, turning them on again automatically at dawn. The Telephone Responder will allow you to call home from anywhere in the world and control your system.

Just like an answering machine, it plugs into a standard mains outlet and telephone jack. It takes about 30-35 seconds to answer. After hearing three tones, you enter your commands from the telephone's touch-tone keypad to turn on or off any of up to 10 modules.

Applications are wide ranging. You can call your holiday home and turn on heating or air conditioning before you visit. Similarly, you can call your main home and turn the heating on before you return from your holidays. You can also flash selected lights around the house when the phone rings - infinitely useful if you have a family member who is hard of hearing. If there's a heatwave while you're away, you can call home and turn on your sprinkler system. Or off in the case of a hosepipe ban!

Lastly, the Home Automation Interface will link into a computer enabling up to 256 individual or groups of modules to be controlled automatically. The Interface was evolved in the US in early 1983 following the home computer price wars, which drove retail prices down sharply. Buying shot up, and many people bought computers with nothing more in mind than to play video games. In three months, X-10 designed and developed a $70 retail package of hardware and software that gave a personal computer the power to control anything electrical in the home using X-10 technology. The Celtel Home Control Interface allows a personal computer to control lights, appliances, heating and cooling, all in the aid of convenience, security and energy savings. Furthermore, the

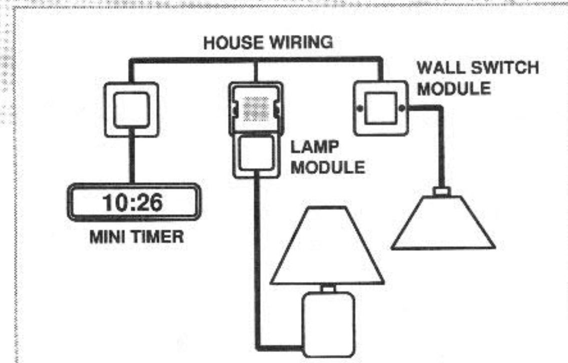


Fig.4

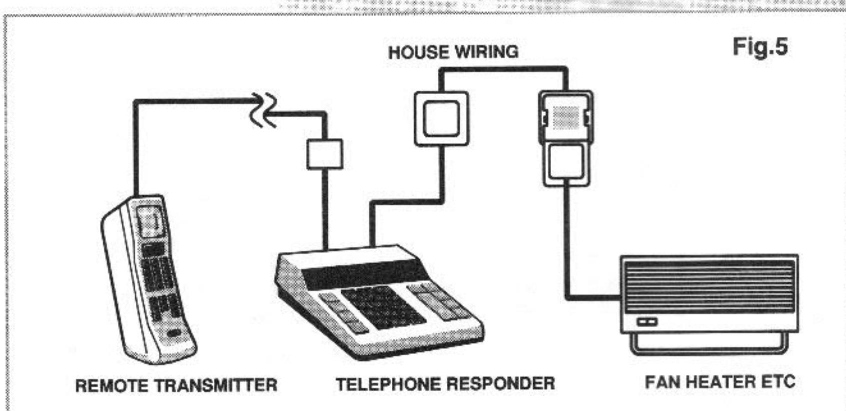


Fig.5

the Future

by Steve Brown
Managing Director,
Celtel Ltd

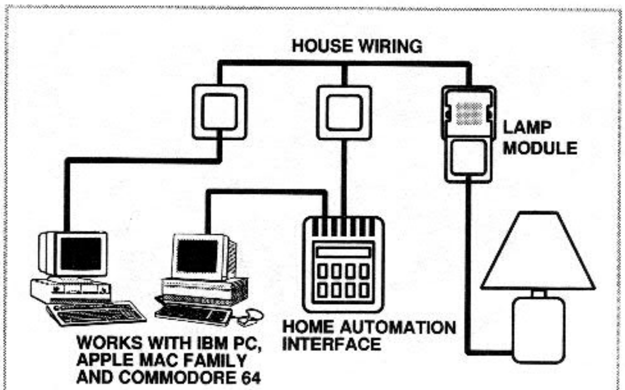


Fig.6

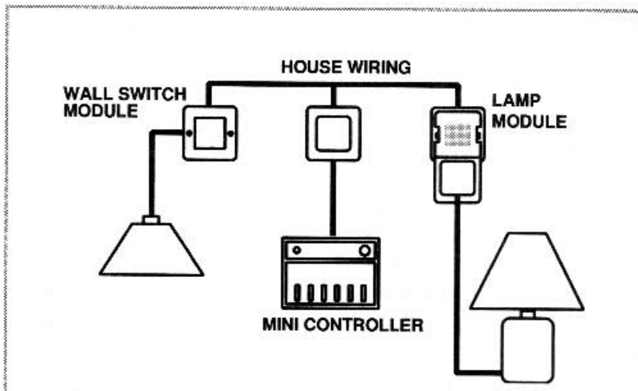


Fig.7

computer interface is actually a self-contained micro-computer that does not continuously tie up a personal computer while it performs home control functions.

Home Control software has been developed for the most popular personal computers, including the IBM PC and compatibles, and the Apple Macintosh. The only hardware changes from one machine to another are related to the connecting data cable. The key differences are in the specific software presentation displayed on a video monitor while the user is programming the interface.

If you use a different computer, you can write your own software with the aid of the programing guide supplied. The Interface can address all 256 X-10 codes (16 Unit Codes X 16 Housecodes). The actual number of modules which can be controlled is software dependent (256 for IBM and Macintosh, 72 for Apple IIe/IIc, 95 for Commodore 64/128). You can program a variety of times and days and the brightness level of lights.

The Interface can store 128 'Timed Events'. It has its own real time clock, and battery back-up to protect its settings in case of a power failure. An ideal tool for those who like to experiment with their computer is to use the interface's real time clock to add a clock to their own system for use with other programs. Take in inputs to your computer (through joystick ports and so on) so that your program can make decisions based on these inputs and download instructions to the Interface. You could turn on outside lights when a photocell tells your computer that it's dark outside, or turn off a water heater when your computer detects that power use has exceeded a predetermined limit. Combine the CP-290 with the telephone responder and you have a system which can be operated from anywhere in the world!

On a very simple level, a basic system can be yours for about £100 - the cost of a mini controller and three modules.

The system also provides an effective home security system in the shape of the DIY SK 8000 home security kit, which works as follows: the sensor units are battery powered and communicate to a base control station via radio frequency (RF) signals. The sensors are monitored by the base station and faults registered. The base station communicates to the audio alarm and light modules via signals through mains wiring. The system components are placed where required, their batteries connected and a code button operated to "register" the units to the base console. There is an Arm button which is operated after you leave home, and a Disarm button operated by a remote control key fob as you return. Each system can have up to eight individual controllers to cater for every member of the family, and extra units are available which enable the system to be expanded to include a maximum of 16 separate sensors to protect all doors and windows in the house.

With its range of 30 metres, the unit could be used to protect the family car or tools in the garage. Another big plus point with wireless systems such as this is simply the fact that they are wireless! On a practical level carpets do not to have be taken up for new wiring. In the case of outhouses or outbuildings, protection can be provided without having to rip up concrete or lawns to lay cable.

On the home entertainment front, Powermid, X-10's remarkable remote control extender system, is proving a winner. The first of the X-10 Powerhouse products to hit the UK market, it is now in more than 30 countries. DTI-approved, it allows remote controlled equipment to be controlled from more than one room

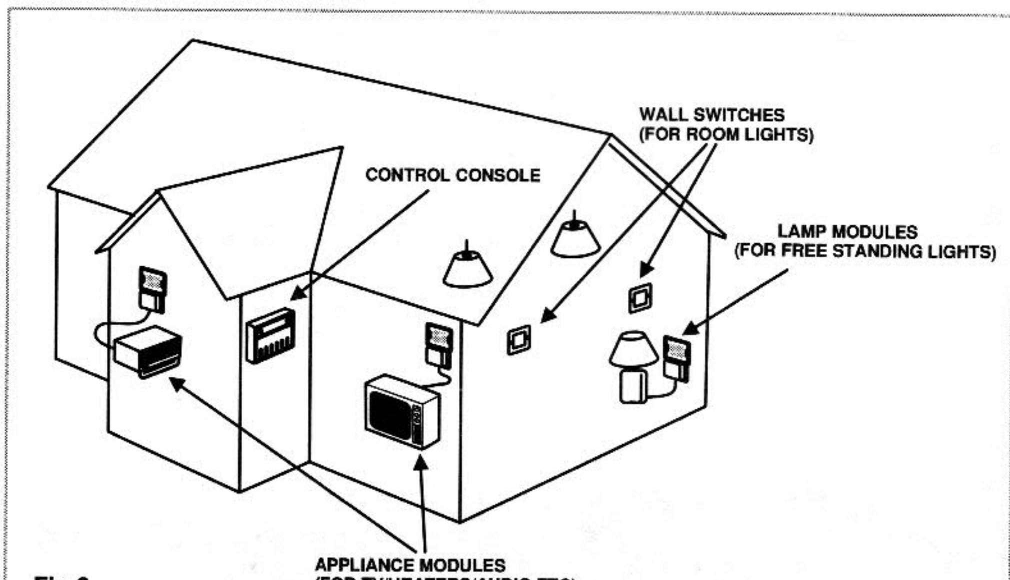


Fig.8

in the house. It consists of a pair of pyramid shaped boxes, one of which, the receiver, has a short telescopic aerial. The transmitter is plugged into the mains supply in the room from which the user wishes to operate, and the receiver in the room where the equipment is situated. The user then simply points the remote control at the transmitter to send a radio message to its counterpart, which then controls the equipment in any way it is told. Powermid is particularly useful where satellite television is wired through to a second room - and current statistics show that 17% of homes with dishes have done just that. If you're one of them you will appreciate the problem of changing channels!

Powermid can also be used with other infra-red remote controlled equipment such as VCRs and audio equipment.

In conclusion, the intelligent home has arrived. On a very simple level, it can be yours for about £100 - the cost of a mini controller and three modules. But for less than £500 you could fully automate an entire three bedroom semi. **For further details contact Celtel on 0256 474900.**

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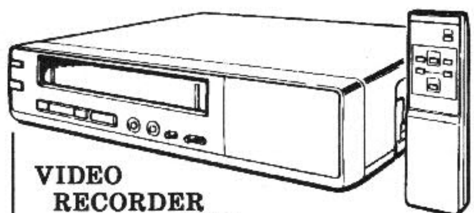

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Remote Possibilities

From the bedside, Paul Stenning controls his downstairs video via the TV aerial.

I like many people, have a second television set in the bedroom, which is connected to the video and satellite equipment downstairs. However, the pleasure of watching TV while lying in bed is lost by having to go downstairs to stop the video or change channel on the satellite receiver.

This project allows one to take the video recorder and satellite receiver remote controls upstairs, and operate the equipment from there. There is no additional cabling to install, the signal being carried along the existing coaxial aerial cable linking the two rooms.

The unit is in two sections, the infrared receiver which lives upstairs by the TV, and the infrared transmitter which lives downstairs and points at the equipment to be controlled.

RF Connections

The units are connected to the aerial cable as shown in Figures 3a & 3b.

The DC voltage is isolated from the TV/video equipment by C9 and C10. This is a silver mica component which gives good performance at UHF frequencies. The high frequencies are blocked by L1 to L4, which prevent the circuit loading the signal.

There is inevitably some slight loss to the UHF signal; this has not been measured due to the author not having suitable equipment! No picture degradation occurred with the prototype, although problems may be experienced in poor reception areas.

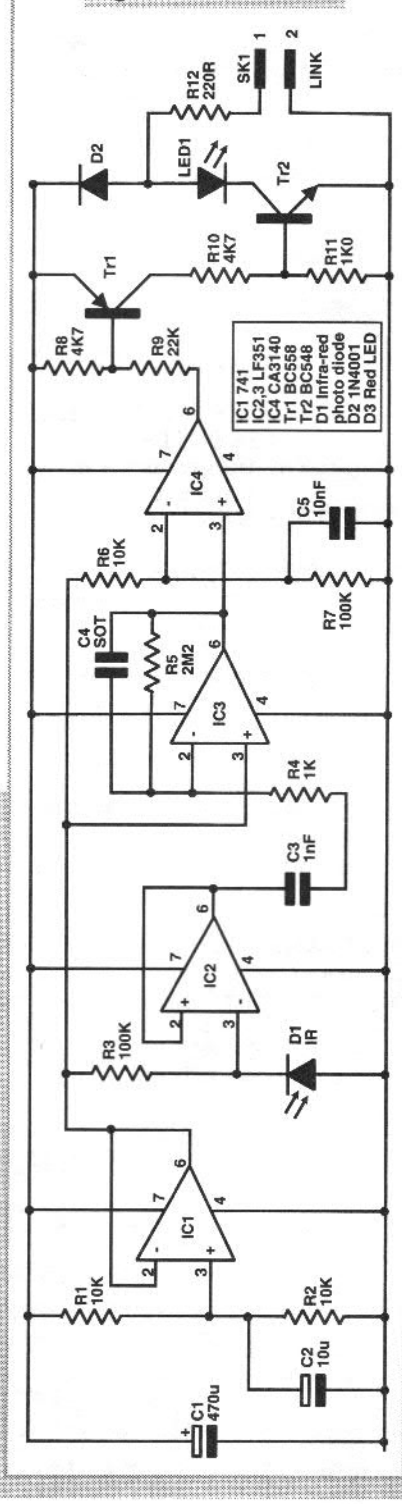
...this unit will allow you to be even more lazy, just don't forget to take the remote control with you!

Construction

For convenience the PCBs for the two parts of the circuit are supplied in one piece. The first job is to cut this PCB in half. Fix the PCB to a bench or table with a small G-clamp, and cut along the dotted line using a hacksaw fitted with a fine blade. The four fixing holes in each section should now be drilled out to 3mm.

The component positions are shown in

Fig.1 Receiver circuit



The Works

For now, assume that the two sections of the circuit are connected directly (SK1 joined to SK2). The connections to the aerial cable will be described later.

Infrared Receiver

The receiver circuit is shown in Figure 1.

The infrared signal from the remote control is received by D1 (TIL100), which is connected in reversed bias mode. The reverse leakage of this device increases when it is exposed to infrared, causing a variation in the voltage on pin three of IC2.

IC2 (LF351) buffers the signal, which then passes to IC3 via a high pass filter. This filter removes low frequency variations caused by

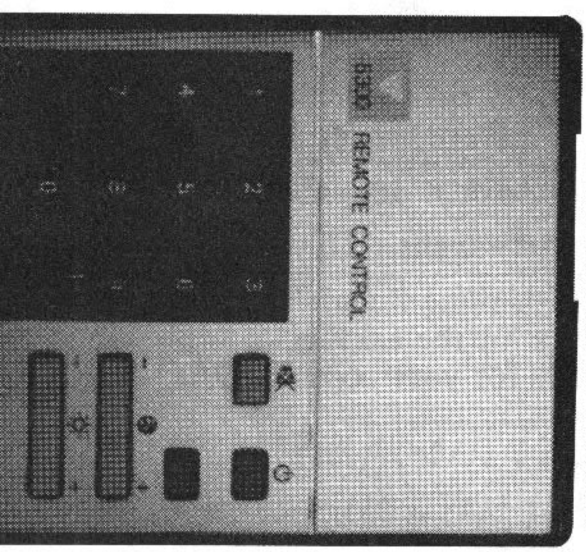
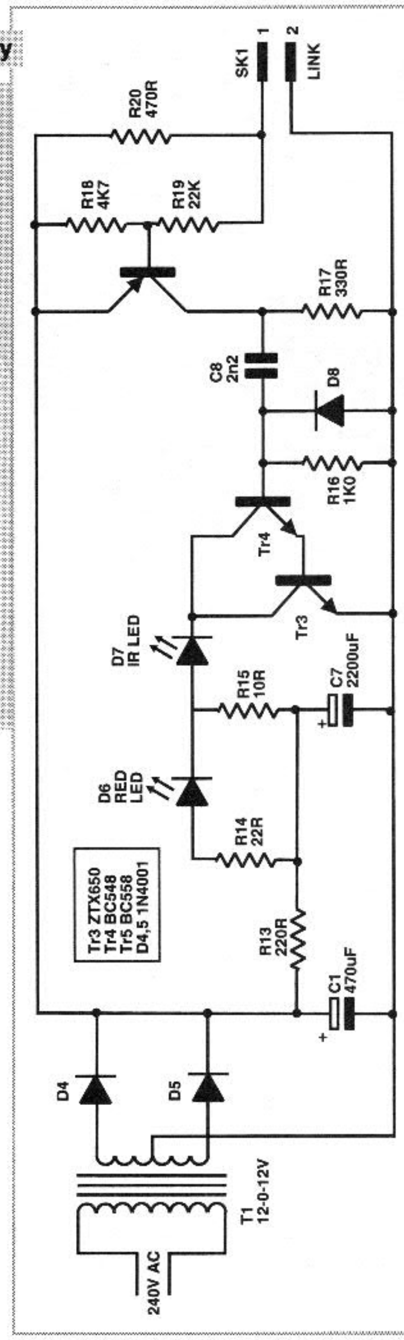


Fig.2 Transmitter/power supply



The Works

Infrared Transmitter/Power Supply

The circuit diagram is shown in Figure 2.

The variations in supply current to the receiver section cause a varying voltage drop across R20. This is converted to logic pulses by TR5 (BC558). C8, R16 and D8 cause short (8μs) pulses to be applied to the base of TR4. TR4 (BC548) and TR5 (ZTX650) are in a Darlington arrangement, and control the infrared LED. The infrared LED (D7) has a maximum continuous current rating of 100mA, which would give a range of only a few centimetres. However the device has a pulse rating of about 2A, providing the duty cycle is short and the mean current does not exceed 100mA. This gives a much improved range and is the technique used in commercial remote controls, as well as this unit. C7 acts as a reservoir for the LED current, and is charged when the LED is not lit via R13. The current to D7 is limited to about 1.5A by R15; a red LED (D6) is connected across this resistor to give a visual indication that the unit is operating.

The circuit is powered by a small transformer, giving an unregulated supply of about 18V across C16. The supply reaching the infrared receiver section will be about 13V. A 100mA transformer is adequate since the current consumption is only a few milliamps when the unit is idle.

Figure 3. There is nothing out of the ordinary about the PCB assembly - simply fit the components in the usual size order. The ICs may be fitted in sockets, but since they are low cost devices this is not really necessary. Terminal pins should be used for the off-board connections. Do not forget the two links on the receiver section.

The LEDs and infrared photodiode are mounted in line with the edge of the PCB, about 10mm above the surface. The infrared diode used in this circuit is sensitive on its flat side and used accordingly see Figure 4. Other makes may not be, so check with the data sheets. Check the height of the larger electrolytic capacitors, it may be necessary to lay these components on their sides or obtain small modern devices.

The prototype infrared receiver is housed in a plastic case 110mm x61mmx30mm, which was purchased from Tandy. However, cases of this size do not appear to be readily available by mail order. It would probably be better to obtain something larger, such as a type MB2, which is readily available and will match the transmitter case. A metal case may reduce the probability of interference from the TV set (this has not been tested), however this would be more difficult to machine.

The receiver case has a rectangular window in one end, approx. 30mmx14mm. Remove any PCB mounting guides from this area. A piece

mains lighting. IC3 (LF351) has a gain of about two thousand, which increases the minuscule signal to something usable.

The unit can receive the signals from a remote control up to about three metres away, which will generally be adequate. If necessary the sensitivity can be increased by changing the value of R5 to 10M, however this will not make a huge difference and may make the unit more susceptible to noise.

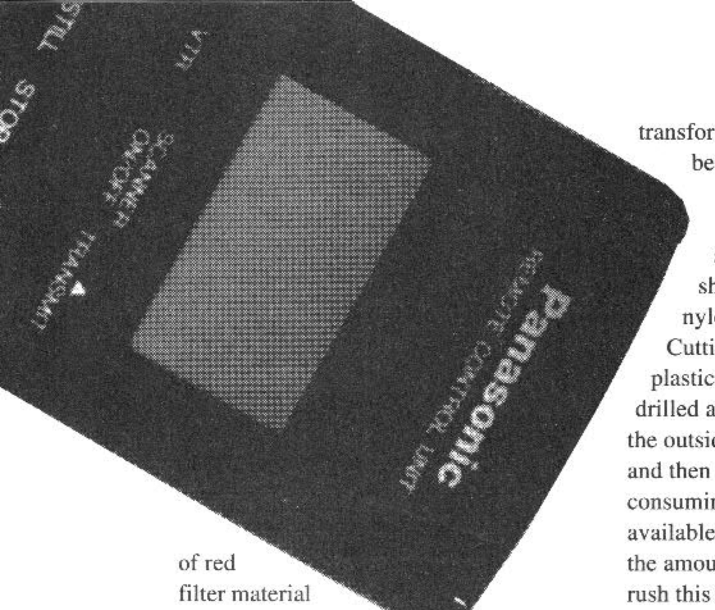
C4 is not normally required, but may need to be fitted if the unit is prone to RF interference. A value between 2.2pF and 10pF would be suitable here, although this will decrease the sensitivity.

Note that the unit may pick up interference from the line output circuit of some television receivers. Since this is at 16KHz, fitting C4 will have no effect. Filtering out this interference would require a fairly steep filter, which would defeat the objective of trying to produce a simple low cost unit. If the unit is moved one metre away from the TV set the problem disappears.

The output from IC3 is converted to a squared logic signal by IC4 (CA3140), which is configured as a comparator. The output of this is connected TR1 (BC558), which in turn drives TR2 (BC548). TR2 connects the LED D3 across the power input to the circuit. The purpose of this is to cause pulses of increased current consumption in time with the received infrared, which are detected by the other section of the circuit. The LED flashes in time with the received infrared.

The circuit is powered from the other section of the circuit via SK1. D2 and C1 ensure that the power supplies to the ICs does not vary significantly when the LED is lit. IC1 produces a power rail at half the main supply level.

The author is aware that infrared receiver ICs are available which will achieve similar results to the above circuit. However these only appear to be available from the larger distributors, and are not likely to be found in the average constructor's junk box. Besides, there is more satisfaction in designing from scratch, rather than just lifting a circuit from a data sheet.



of red filter material is then fitted behind the cutout, in the prototype this was held in place by the PCB and LED. If the filter has a non-reflective surface this should face outwards. The PCB is positioned in the case immediately behind the window, and fitted with M3 screws, nuts and spacers. The two coax sockets are fitted on the opposite end of the case to the window.

The infrared transmitter is housed in a type MB3 plastic box, 118mm x 98mm x 45mm. A similar rectangular window is made in one end, 50mm * 14mm. The red filter material is again retained by the PCB and LEDs. The PCB is fitted behind the window, with the red LED in the centre of the window. The transformer and connectors may now be fitted. The hole for the power cable should be fitted with a grommet, and the cable secured. The transformer should ideally be fitted with nylon screws.

Cutting tidy rectangular holes in plastic cases is not easy! The author drilled a series of small holes around the outside, removed the centre section, and then filed the edges smooth - a time-consuming approach. If a fretsaw is available this could significantly reduce the amount of filing required. Do not rush this section if you want to achieve a tidy job.

The red filter material used in the prototype was obtained from RS, however any type should be suitable. Thin material (0.5 - 1.0mm) is ideal since this can be cut with a pair of scissors. Test that the material chosen does not block infrared, by holding it in front of a remote control, and checking that the range is not significantly reduced.

The units can then be wired up as shown in Figure 3. The two core mains flex is joined to the transformer leads with a choc-block connector. The secondary leads from the transformer connect to the terminals on the PCB as shown.

The screen connectors of the two coax connectors should be linked with a heavy piece of wire - the braid from a piece of screened cable is suitable. Connect the silver mica capacitor directly between the centre conductor pins.

The inductors consist of about five turns of enamelled wire, approx. 22 SWG. Cut four 5" lengths and wind the six turns round the shank of a 3mm drill bit, towards one end of the wire. Connect the inductor wires as shown in figures 3a & 3b, with the coil towards the coax sockets.

Testing

No setting up is required, testing merely involves connecting the two sections and seeing if they work! When testing, ensure that the light from the transmitter does not reach the receiver, or feedback will cause odd results.

Connect the two sections with a good length coaxial aerial cable between the Link sockets. Alternatively a length of two-core cable may be used; this may be soldered directly to the pins on the PCB's for convenience.

Connect the transmitter section to the mains and position it such that it is pointing at a video recorder, from about 2 metres away. Take the receiver and the video's remote control into another room, and try using the remote control about 2 metres from the receiver.

When the remote control is

Fig.3a Component positioning and interconnections of receiver

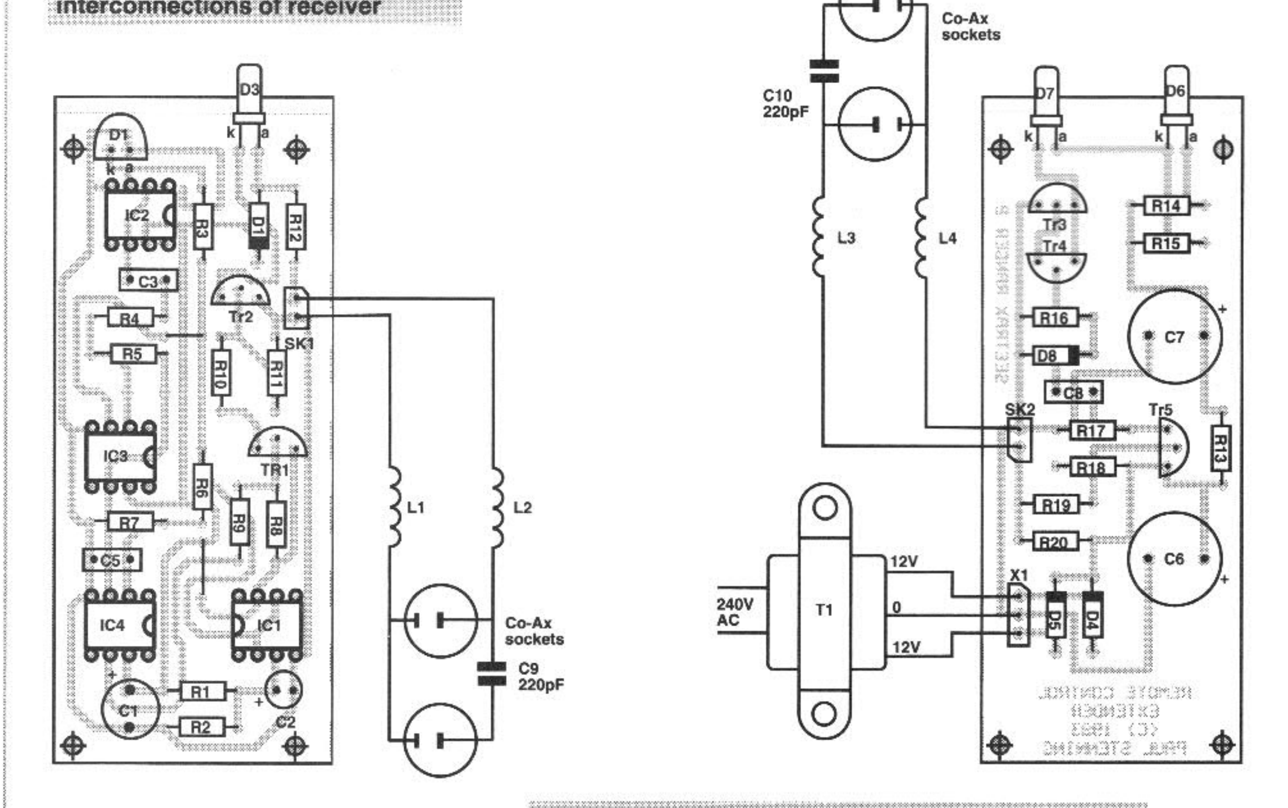


Fig.3b Component positioning and interconnections of transmitter and power supply

operated, the red LEDs on the receiver and transmitter should flash. If the channel change buttons are operated, the corresponding changes should be heard from the TV in the other room.

Fault Finding

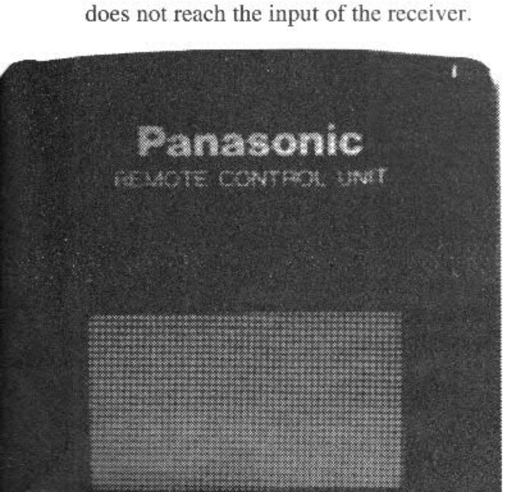
If the unit does not work, there are a few points to check before embarking on a full faultfinding procedure.

First check the power supply voltages. There should be about 18V across C6 and C7, and around 15V at SK2. The power supply rail in the receiver should be about 13V, and the voltage on pin six of IC1 should be half this.

Check the polarity of D1, this device is used in reverse biased mode, and should have around 6V across it when the unit in inactive. Measure the voltage on pin six of IC2, if the voltage is around one volt or less then D1 is probably the wrong way round. If the input of IC2 is touched with a finger the red LEDs should light or flicker. Make sure the infrared sensitive face of D1 is towards the window - with the half-round types available from Maplin (TIL100 equivalent) this is the curved side.

Check that the LEDs are the right way round. The details in catalogues and data sheets can be confusing when it comes to identifying the polarity of LEDs, and different manufacturers use different arrangements. However, there is a foolproof method. Look at the innards of the LED from one side, the larger piece of metal is the cathode and the smaller bit is the anode. The author always uses this technique and it hasn't failed him yet! Check the aerial fly-leads for continuity and short circuits. One of the two purchased by the author for these units was found to be open-circuit on the centre core!

If all this checks out, it's down to good old fashioned fault finding procedures. The circuit is not complicated so this should not take too long. As mentioned before, make sure the infrared output of the transmitter does not reach the input of the receiver.



Installation and Use

In the interests of safety, all equipment should be isolated from the mains before making any connections.

The receiver should be positioned about one metre from the television, in clear sight of the normal viewing positions. Unplug the aerial cable from the TV, and connect it to the Link socket of this unit. Using a standard aerial fly-lead, connect the TV socket on this unit to the aerial socket on the TV.

The transmitter positioning is more involved, and is left to the ingenuity of the individual constructor. The unit needs to be located so that the infrared output reaches the front of the equipment to be controlled. In addition the cables need to reach (or be extended), and the installation should look tidy if peace is to be maintained! The prototype was placed on a cabinet on an adjacent wall. Even though the infrared beam reached the equipment at an angle of about 45 degrees, no communication problems were experienced.

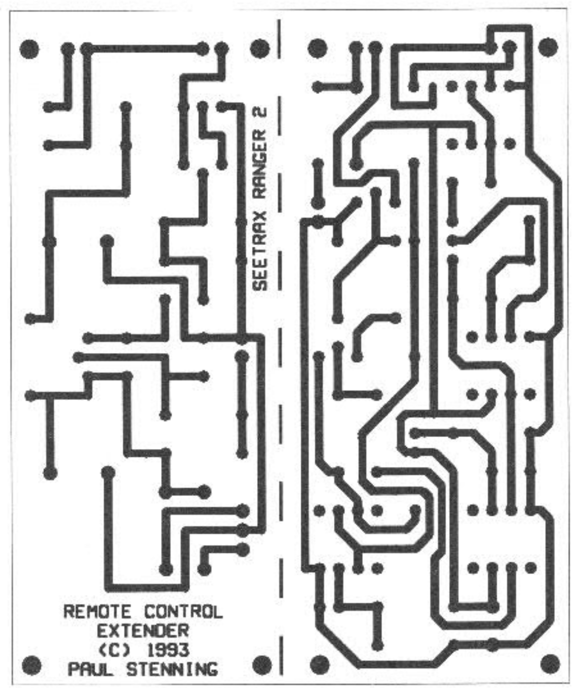


Fig.5 Foil for transmitter/receiver

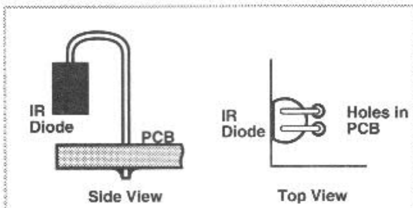


Fig.4 Infrared diode positioning on board

It may be easier in some cases to mount the infrared LED remotely, and link it to the electronics with a length of thin two core cable. Two or three LEDs could be wired in series, and placed near the receivers on the control equipment.

Some constructors may wish to experiment by bouncing the infrared beam off any reflective surface, although sometimes the distances involved may be too great.

There will presumably already be a Y-splitter connected to the output of the video recorder, with its outputs connected to the local and remote TV sets. Unplug the lead to the remote TV, and connect it to the Link socket on the infrared transmitter unit. Connect the Video socket on the infrared transmitter to the splitter.

Note that the infrared transmitter and infrared receiver must be at opposite ends of the link cable. There must be no splitters, attenuators, filters or other equipment between the two units, since this will block or load the DC path.

Finally connect the system to the mains (via a 3-Amp fuse) and test it.

If the LED on the receiver remains lit, it is picking up interference from something. Try moving it further away from the TV set or other electronic equipment.

The receiver should respond from a distance of about three metres, if the remote control is aimed reasonably accurately. The range will vary somewhat with different makes of remote control. If the signal is weak the LED may still flash, but the remote equipment will fail to respond. This is caused by the receiver picking up only part of the signal. Try moving closer or putting new batteries in the remote control.

The transmitter should control the equipment from a distance of three metres or more, although this will drop off as the angle increases. Again this will vary with different equipment.

There should be no reduction in picture quality with this system installed. In areas of very poor reception it may be preferable to install a separate cable for this system. Thin two-core cable (used for doorbells and speakers) is ideal. In this case, omit L1 to L4, C9, C10, and coax sockets from the units. Fit spring loaded loudspeaker terminals or similar, connected directly to the PCBs.

Hopefully, this unit will allow you to be even lazier, but don't forget to take the remote control with you. Happy viewing.

Acknowledgement

The author would like to thank Seetrax CAE for their continued help and support with the superb Ranger 2 electronic CAD software.

EIA

Parts

Resistors

(0.25W, 5% or better)

R1,2,6	10K
R3,7	100K
R4,11,16	1K0
R5	2M2
R8,10,18	4K7
R9,19	22K
R12,13	220R
R14	22R
R15	10R
R17	330R
R20	470R

Capacitors

C1	470µ 16V
C2	10µ 16V
C3	1n0
C4	(See Text)
C5	10n
C6	1000µ/25V
C7	2200µ/25V
C8	2n2
C9,10	220p Silver Mica

Semiconductors

D1	IR Photodiode
D2,4,5	1N4001
D3,6	Red LED
D7	IR LED
D8	1N4148
TR1,5	BC558
TR2,4	BC548
TR3	ZTX650
IC1	741
IC2,3	LF351
IC4	CA3140

Additional Items

PCB
12-0-12V 100mA Transformer
2 Cases (see text)
Red Filter
4 Co-Ax Sockets
22 SWG Enamelled Wire for L1-L4
2 Aerial Fly-Leads or Leads to Suit
2 Core 3 Amp Mains Flex
13 Amp Plug with 3 Amp Fuse

The Power behind the MOSFET

Part 3

From flyback converters to high current analogue switches, Andrew Armstrong provides a guide to the MOSFET

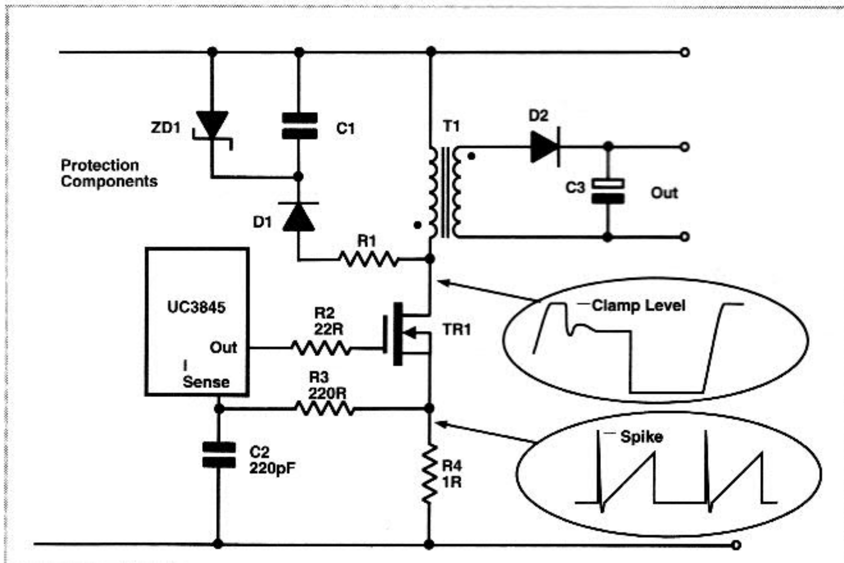


Fig.1 Isolated Flyback converter

In this final part of the power MOSFETs series, I shall illustrate a transformer coupled flyback converter, which is a widely used isolated type of power supply for mains and DC-DC converter use. For contrast I shall show the design of a micropower linear regulator, a low-loss reverse battery protection circuit, and a high power analogue switch.

The circuit of Figure 1 shows the output stage of a transformer-coupled flyback converter. The means of powering the control chip is illustrated separately in Figure 2, in order to break down the process into related parts. When the output of the control chip switches on, the gate capacitance of TR1 is charged via R2, to limit the peak current drawn from the control chip. After an initial switch-on spike, the current in the primary of T1 ramps up more or less linearly as energy is stored magnetically in the core. The current is sensed by measuring the voltage drop in R4. The filtering network formed by C2 and R3 filters out the worst of the switch-on spike. When the current has ramped up to the level set by the control chip (either the current limit value or a lower value determined by the voltage control loop), the output of the chip is switched off, so that TR1 switches off to as well.

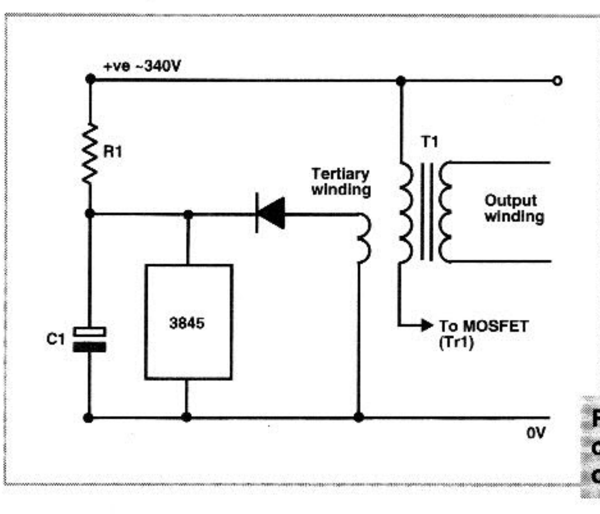


Fig.2 Powering the control chip in an off-line switcher

Leakage Reactance

At this point, most of the energy stored in the magnetic core starts to discharge into the output. However, a small proportion of the magnetic flux linking the primary does not also link the secondary. This effect is referred to as leakage reactance, and it has the same effect as a small extra inductance placed in series with the primary. The energy stored in this part of the inductance cannot be transferred to the secondary, and will discharge itself wherever it can. If no specific discharge path is provided, this energy will charge up the drain capacitance of the mosfet and, if in so doing the voltage rises high enough, will destroy the MOSFET.

A snubber network consisting of R1, D1, C1 and ZD1 is provided to place a resistive load onto the leakage reactance once the voltage overshoot has reached a certain level. These components are chosen in the light of the characteristics of T1, and the voltage

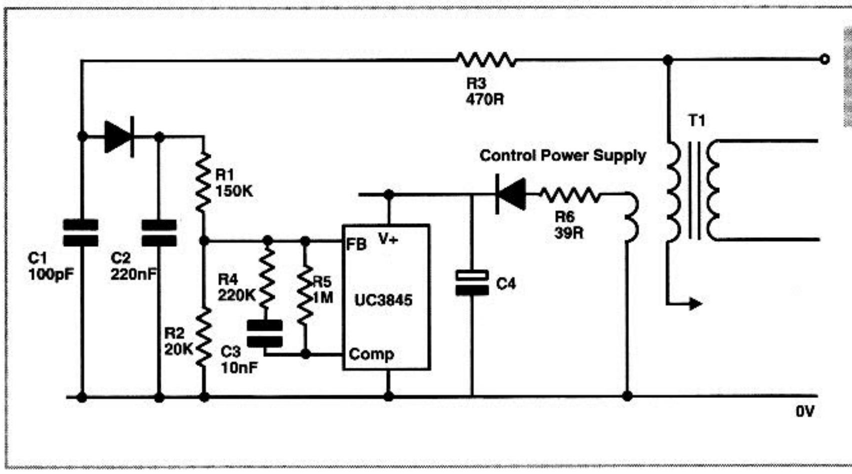


Fig.3 Deriving voltage feedback from tertiary winding

rating of TR1. The higher the voltage rating of TR1, the less energy needs to be dissipated in the snubber network, and hence the higher the efficiency of the circuit.

Control Power

Power to drive the control chip is normally derived as shown in Figure 2. While the circuit is running, power is derived from the output. This is an efficient method of providing the correct voltage for the chip. Unfortunately, it does not work until the circuit has commenced switching, which cannot happen until the chip has been powered up. In order to make the circuit start in the first place, an auxiliary source of power is provided via a dropper resistor from the unregulated supply.

This supply is likely to be rectified mains, with an approximate DC level of 340 volts. To provide the current required to operate the chip from this voltage would cause a lot of dissipation in R1. So, most of switched mode power supply control chips are designed to draw a low quiescent current, and to start switching at a significant higher voltage than that at which they stop. Power up then occurs as follows: C1 charges to the upper voltage, typically 16 volts, then the chip starts to switch. It continues to provide output drive pulses until its voltage falls to typically 10 volts and, long before then, if nothing is wrong with the power supply, the chip is being powered from its own output. R1 need only supply enough current to charge the capacitor slowly while also supplying the quiescent current of the control chip.

Voltage feedback to control the output voltage of the converter can be provided in several ways. If very accurate output regulation is not required, then the power supply to the control chip may be potted down to the voltage control input. This power supply voltage approximately reflects the output voltage, but because of the leakage reactance, the output voltage will sag under load by perhaps 5%. If a slightly superior feedback is required, then the circuit of Figure 3 can be employed.

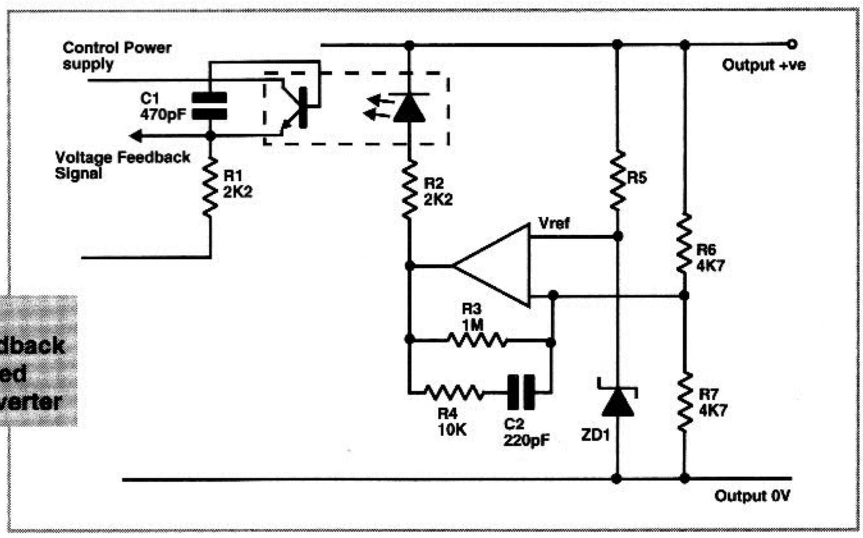


Fig.4 Opto-isolated feedback for an isolated flyback converter

This minimises the effect of the flyback spike, and other leakage reactance effects on the measuring voltage.

In applications where you really must have accurate output voltage control, an opto-isolator is normally used to provide the feedback signal. To do this, it is normal to use a voltage regulator and an op-amp powered from the output to drive the opto-isolator, as illustrated in Figure 4. Note the capacitor between the base and emitter of the opto-isolator transistor. This is to keep switching noise from being picked up and amplified by the high impedance of the base of the transistor. Too high a value of capacitor will introduce phase shifts within the control loop bandwidth and make the circuit oscillate.

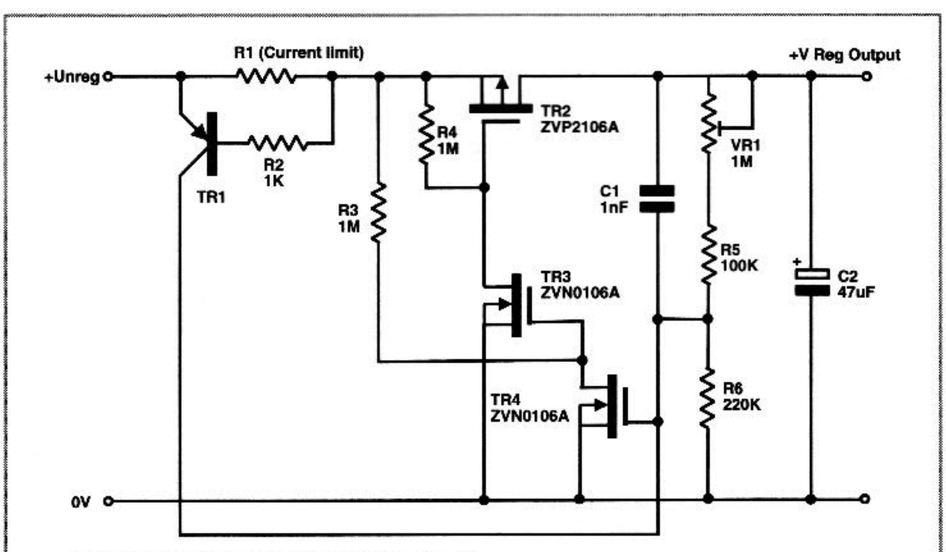


Fig.5 Micropower linear regulator

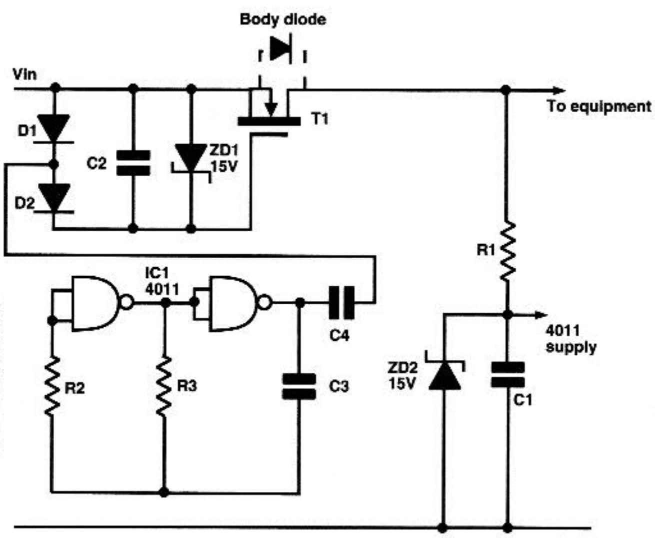


Fig.6 Very low voltage drop reverse power supply protection

Micropower Linear

Much as I like switched mode power supplies, even I have to admit that there are some occasions when they are inappropriate. Figure 5 shows a linear regulator which consumes very little quiescent current, and which is therefore ideal for battery powered equipment. It uses a p-channel FET as the pass transistor, so it can give very low input to output voltage drop, and, because the pass transistor is not of a type which draws base current, it can give this low voltage drop without the normal penalty of a high power consumption when providing a high output current.

Its output voltage is set by the turn-on voltage of TR4. This can vary from device to device, so this is a circuit which absolutely must include a voltage adjustment pot. That is no doubt one reason why this type of design is not used in standard 3-terminal voltage regulators. Among other reasons are the fact that the turn-on voltage of TR4, and hence the output voltage, is not completely stable with temperature, and that the response of the circuit to changing load is very slow, so it must have a significant value of output capacitance. Finally, it is vulnerable to damage by input voltage spikes which, with this simple circuitry, can induce a high voltage across the gate insulator of TR2, causing instant destruction. However, this is not a problem for a battery powered system (except car electrical systems, which can produce spikes).

Reverse Protection

Have you ever come across the situation where you want to add reverse battery protection to a design, but you cannot afford the voltage drop of a series diode? One answer is to use a parallel diode and a fuse, so that reverse power supply connection will blow the fuse. This is certainly better than nothing when it comes to protecting valuable equipment, but it can be a nuisance. The circuit of Figure 6 shows one answer. I have used this design in a situation where a circuit was drawing 10 amps from a 12-volt car electrical system, and even the voltage drop and dissipation of a Schottky diode was causing a problem. It works as follows: when power is applied, current initially flows through the reverse body diode of T1. At the same time, IC1 starts to generate a square wave and charge up C2. This turns on T1, so that the channel starts to conduct. Some of the best modern power mosfets have on-resistances as low as 10-20 milliohms, giving a voltage drop of 0.1 to 0.2 volts at 10 amps.

The same principle can be applied to equipment powered from a lower voltage, where the voltage drop of a Schottky diode may still be a problem even at lower current levels than 10 amps. This technique is only relevant in those rare cases where the absolute minimum voltage drop is needed, but in those cases it is a life-saver.

Analogue Switching

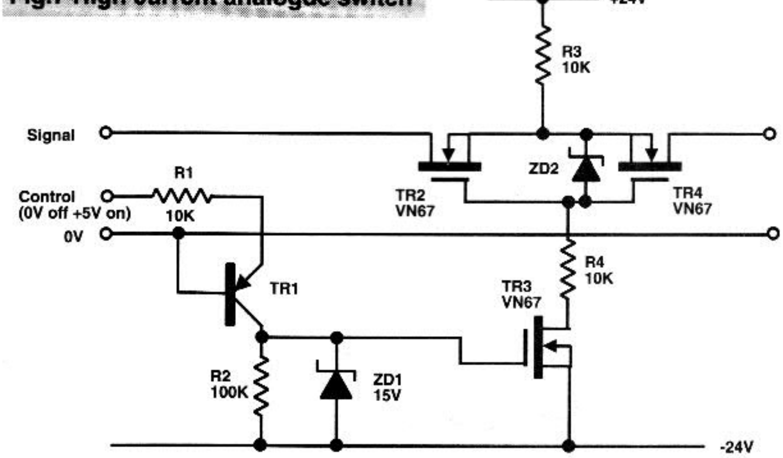
MOSFETs are commonly used to switch analogue signals in chips such as the 4066 and the 4053. These are fine to switch low-powered signals, but sometimes higher power or higher voltage is needed. That is where the circuit of Figure 7 can help. Depending on the type of mosfet chosen, this circuit can switch amps of signal at a voltage limited by the gate breakdown voltage of the FETs. Currently I am attempting to use this principle in switching drive current to a series of multiplexed magnetic excitation wires in a magnetic code reader.

Audio Amplifiers

FETs are often used in audio amplifier designs because they are thought to give an inherently cleaner performance. I suspect that part of the reason for this is that FETs perform more like valves than like bipolar transistors, and there is a fashion for valve amplifiers among some hi-fi enthusiasts. However, it is true to say that the crossover region in a conventional MOSFET class A/B amplifier, is not so sharp as that in a bipolar transistor amplifier. This reduces the need for the negative feedback to correct errors, and may reduce both intermodulation distortion and transient intermodulation distortion.

It is slightly more difficult to bias the output stage in a mosfet power amplifier, and because of the variation between devices a quiescent current adjustment pot is almost always required. However, the improved linearity in the crossover region can allow simple mosfet designs to perform very well and, in my view, power MOSFETs are marginally to be preferred to bipolar transistors for most audio amplifier applications. EIA

Fig.7 High current analogue switch



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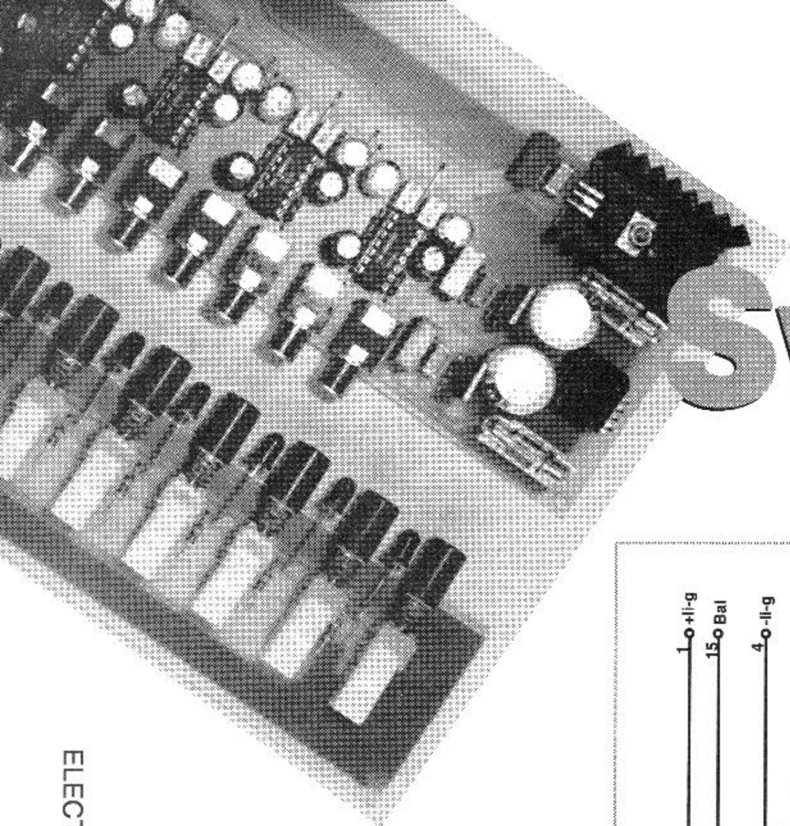

The Switcher

Part 3

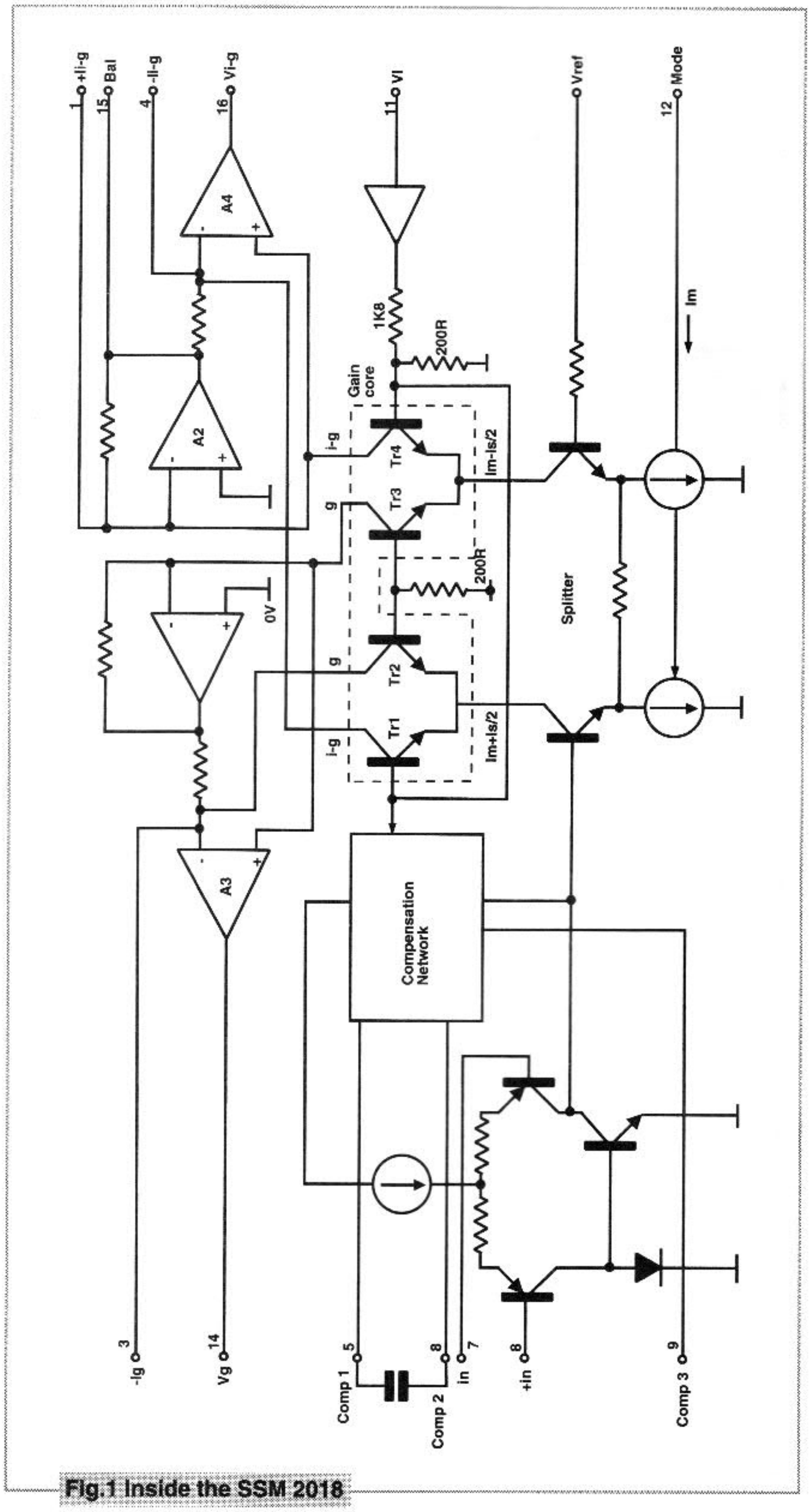

Fig.1 Inside the SSM 2018

We undertake an in-depth analysis of the SSM2018 VCA, and show how it fits into an optional Volume Control circuit in The Switcher. By Mike Meechan.

An OVCE IC uses a somewhat unusual operational voltage-controlled element (OVCE for short) in its architecture. This allows many different configurations to be realised simply by altering the device feedback connections. This type of circuit topology combines the function of an op-amp and a voltage-controlled amplifier into a single integrated device, and because two traditionally separate blocks are combined in a single package, much higher performance can be achieved from it.

The OVCE is comprised of three basic elements

1. Input differential pair and compensation network
2. Programmable current splitter which generates the biasing current for the gain core
3. Four transistor gain core (a dual two-quadrant multiplier) and the output buffers

Figure 2 shows the OVCE device symbol, and Figure 1 gives details of the various component parts of it.

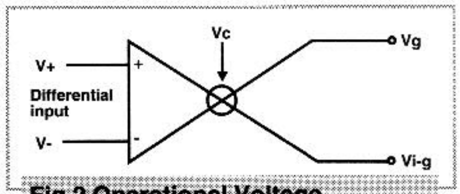

Fig.2 Operational Voltage controlled element (OVCE) symbol

Differential Pair

The differential pair structure is identical to that of operational amplifiers, creating a single-ended output current which is proportional to the differential input voltage. Traditionally, maintaining optimal compensation over a wide range of selected gains has been a problem faced by the designers of all variable gain amplifiers. The problem is solved in the SSM 2018 by fitting an adaptive network. This is connected after the input section and effectively divides the external compensation capacitor by a value corresponding to the current value of device gain. In a VCA configuration, the network maximises the internal closed loop gain of the device independently of overall system gain. Conversely, where the IC is configured as a voltage-controlled potentiometer, global feedback remains constant with changes in gain, and the adaptive network is defeated, replaced instead by a fixed value of compensation capacitor. In panning circuits requiring moderate gain, the value of the compensation capacitor can be reduced in order to obtain wider signal bandwidth.

Programmable Current Splitter

The current generated by the input differential pair is split and used to drive the the gain core transistors. Each transistor is driven with currents containing equal and opposite signal components. The common mode component of these two currents, I_M, determines the class of operation of the device. The current injected into pin 12, and which is determined by an external bias resistor, corresponds to this common-mode component. It follows that there is a trade-off between noise from the semiconductors of the gain-core section, and the magnitude of this current.

The Gain Core

The gain core consists of two very carefully matched differential pairs. These utilise large-geometry, high gain transistors which are designed to produce minimum noise and distortion. Again, refer to Figure 1. The differential pair - which is forward-biased by the current source - divides the tail current I into two currents I_{C1} and I_{C2} according to the applied voltage V_B. S ince the transistors have high beta, I_E is approximately equal to I_C, and can be expressed in the form;

$$I_C = I_S \times \exp(a\, V_{BE})$$

where I_S is the reverse saturation current
Since

$$I_{C1} + I_{C2} = I, \text{ and } V_{BE} = V_{BE1} - V_{BE2},$$

the ratio of currents can be expressed as follows:

$$1 = \frac{\exp(aV_c)}{1 + \exp(aV_c)}$$

and

$$1\text{-}G = \frac{I_{c1}}{I} = \frac{1}{1+\exp(aV_b)}$$

These relationships are precisely reproduced in both pairs of the gain core. This results in differential collector currents which accurately correspond to a function of the applied control voltage. This IC is unique in that it provides both gain-multiplied and remainder-multiplied outputs, and so provides for an infinite number of gain block configurations. The differential outputs of the gain core transistor pairs are applied to differential current-to-single ended voltage converters comprised of buffers A1 to A4, with A1

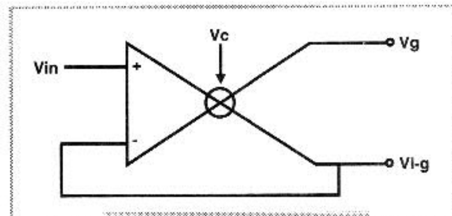

Fig.3 OVCE Follower/ VCA connection

and A2 configured as precision current mirrors, whilst A3 and A4 behave as current-to-voltage converters. The connections to A2 have been arranged so that the user is able to balance the current mirror gain. Doing this achieves perfect symmetry in the positive and negative half-cycles of the output waveform. The error contributions from the current mirror circuitry are cancelled because the non-inverting inputs of A3 and A4 are connected to the inverting inputs of A1 and A2 respectively. Because of this arrangment of the internal architecture, any additional current sourcing components required for high output drive applications must be connected outside the feedback loops and buffered in order that OVCE

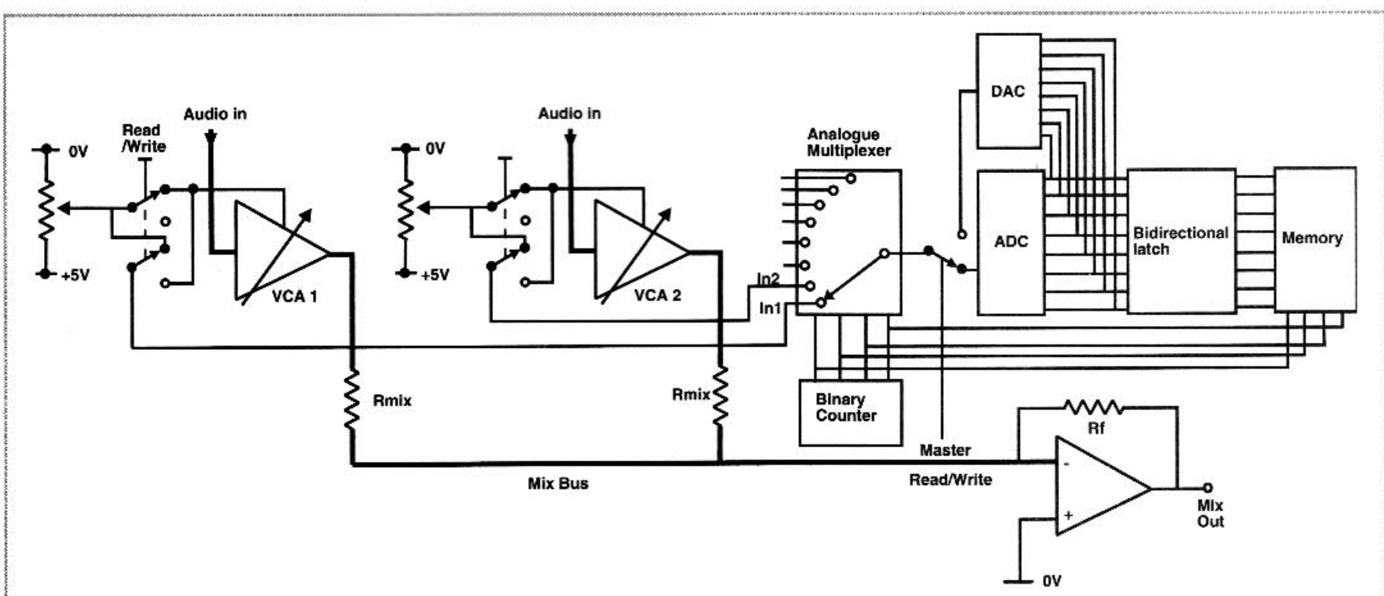

Fig.4 VCA application in typical mixing desk fader automation system

response and dynamic range aren't compromised.

Real Applications

The OVCE has two inputs, V_G and V_{1-G}. Both respond to the input waveform but in a ratio determined by the magnitude of the control voltage V_C applied to Control Port, Pin 11. The transfer function for each of the two inputs is as follows;

$$V_G = \{V_+ - (V_-.G.A)\}$$

and $$V_{1-G} = \{V_+ - (V_-.1\text{-}G.A)\}$$

where A is the open loop gain of the circuit and

$$G = \frac{\exp(aV_c)}{1+\exp(aV_c)}$$

Consequently, the ratio of the outputs is;

$$\frac{V_g}{V_{1-G}} = \exp(a.V_c)$$

The control constant a is approximately -4 at room temperature. In the intersets of an easy explanation of the OVCE operation under real signal conditions, assume now that the input voltages are both equal, and refer to Figure 3 which shows the basic VCA realisation. V_{IN} drives the non-inverting input, while the V_{1-G} output pin is tied to the inverting input. (This is analogous, in many ways, to the simplification done when considering negative feedback in basic op-amp configurations). In closed loop operation, we assume that both inputs are at approximately the same voltage, and so the V_{1-G} output follows the input for all control inputs. However, since

$$V_G = V_{1-G} \times \exp(a.V_C)$$

then $$V_G = V_{IN} \times \exp(a.V_C)$$

The transfer function, therefore, is for a voltage follower at the V_{1-G} output, and that of an exponential Voltage Controlled Amplifier at the V_G output. As with operational amplifier circuits, the hard-wired direct feedback connection could be replaced by any reasonable network to yield the desired transfer function.

The VCA and The Switcher - A Marriage Made in Heaven?

One of the main attractions of the SSM 2018 device - apart from its superb sonic performance and reasonable cost/easy availability - is in the low number of parts needed to realise a workable, good-sounding circuit. A further desirable attribute is that there is a maximum of only two trim pots which need adjusting

The Works

There are three parts to the VCA. These are the Front Panel Interface incorporating the Up/Down Counter section, the D/A Converter and the VCA itself. We'll look at each in turn.

Front Panel Interface/Up Down Counter

The heart of the system, (apart from the VCA, which is fairly dumb and does what it is ordered), is the counter section of ICs 5 and 6. These are 4-bit binary up/down counters with terminal count (TC) and presettable (jam) input facilities. On power up, the PL parallel load pin is held high while C4 charges through R4. This allows the value stored on the parallel input pins P_0 to P_3 to be latched through to the counter output pins Q_0 to Q_3 on each device. This 8 bit number corresponds to an attenuation setting of 20dB - any live signal source connected to the input selection circuitry is thus muted to a safe level on power-up.

Once the capacitor is fully charged, the parallel load pin is held low and further parallel loading into the counter from this particular source is inhibited. The counter can now operate normally, ie under full control of the clock and up/down signals.

The oscillator is a semi-latching ring-of-two astable type (comprised, somewhat fortuitously, of IC2c and IC3c, "leftover" gates of ICs 2 and 3). The semi-latching astable differs from the more conventional gated type in that the clock signal does not terminate immediately after the gate signal is removed (which would mean that any noise present at the gate terminal would appear at the output). This attribute means that it allows only whole cycles of the clock through, and so is immune to noisy gating pulses, a feature which lends itself ideally to our application since we have interfaced the circuit directly to the front panel switches. The gate signal for IC2c NAND is derived both from the front panel switches, SW1 and SW2, and from the output of IC3c NOR (via the diode OR gate of D1-D3 and R2). As soon as the astable is gated from an external source - via D1 or D2, the output of IC3c NOR self latches the gating via D3 for the duration of one half clock cycle, thus eliminating the effects of a noisy external source. This oscillator runs at a frequency of around 20Hz. This means that it takes approximately 13 seconds to change the attenuation from full to zero but it is a simple matter to change this frequency to suit personal preference.

It has to be said that for most listeners, the 8 bit accuracy of the attenuation setting is slight overkill, but it is actually much harder to reduce the resolution of the incremental changes than to accept the system as it stands and the resultant small changes in volume level from one 8 bit setting to the next. While the oscillator is enabled, an LED connected to the output of it flashes to indicate that the system is operating correctly. When full volume or maximum attenuation levels have been reached, the LED is extinguished to indicate that the available range of control has been exhausted.

Local (front panel) control of volume level is expedited through SW1 and SW2. Pressing SW1 generates a logic low when depressed. This is NANDed in IC1a with the signal from the appropriate part of the Infra Red Remote Control board (which is normally also pulled high), and so a logic high is generated. This sets bistable IC4b, forcing its Q output high and the two counters into count up mode. While the button is depressed, clock signals are gated on by the enabled AND combination of IC1c NAND/IC3b NOR gate. (The inhibit signal, a NORed version of the two terminal count signals from the counter, will be at a logic low unless full count - all - 1s has been detected in "count up", or empty count when counting down. This "inhibit" signal is NANDed with the Q complement output of IC4b and so the NAND gate of IC2b remains high unless inhibit and this pin are high simultaneously. When this happens, the corresponding NAND output is forced low and disables the AND gates formed from the NAND/inverter combination of ICs 2c and 3b. The astable, when this state has been forced, is no longer gated on. Conversely, pressing SW2 clears bistable IC4b, forcing its output low and the counters into count down mode. Again, clock signals are gated through to the counters only while the IC2a/3a AND combination isn't inhibited by the "all 0s" detection circuitry of IC3d and IC2d).

Just what does happen when the counter Q outputs reach the "all 1s" state when counting up and the "all 0s" state when counting down? The Terminal Count pin - which generates a logic low when all of the Q outputs are high and the device is counting UP, or a logic low when all of the Q outputs are low and the device is counting DOWN, and is normally used to cascade devices - is employed here to disable the oscillator when a "counter full" or a "counter empty" state is detected in count up and count down modes of operation respectively. The TC signals from each of the counters are NORed by IC3d and so an "inhibit" signal is generated whenever both TC pins are simultaneously at a logic low level ie full count in the down or up direction respectively has been reached. NANDing this signal with the UP/DN signal gives a high (disable) signal for the UP switch, while inverting the UP/DN signal, (using the not Q output), and NANDing this with the INHIBIT signal generates a disable signal for the DOWN switch. The attached truth table shows what all of this means.

You may be wondering why the front panel labelling of the volume control switches is reversed in comparison to the action that it has upon the counters (ie the "down" switch causes the system to count up and vice versa). This is because full attenuation corresponds to +5V or thereabouts, so an all 1s output from the counters causes the full analogue output voltage from the DAC.

SW3 provides the Mute function. C1, R1, part of the resistor array, and IC1b debounce the switch and the resulting, clean, negatively-going pulse is used to toggle bistable IC4b. The not Q output of this is used as a secondary Parallel Load signal (ORed with the "power on" pulse) and loads a value into the counter registers which, again, corresponds to 20dB of attenuation. LED 2 is driven directly from the not Q output and gives some indication of when the Mute condition has been invoked by the user.

As well as control signals from the front panel pushbuttons, control of the counters can also be invoked from the remote handset and are input to the board via PL2. In essence, the UP and DOWN signals from the remote control receiver section are ORed with those of the pushbuttons. Part of the count inhibit interlock

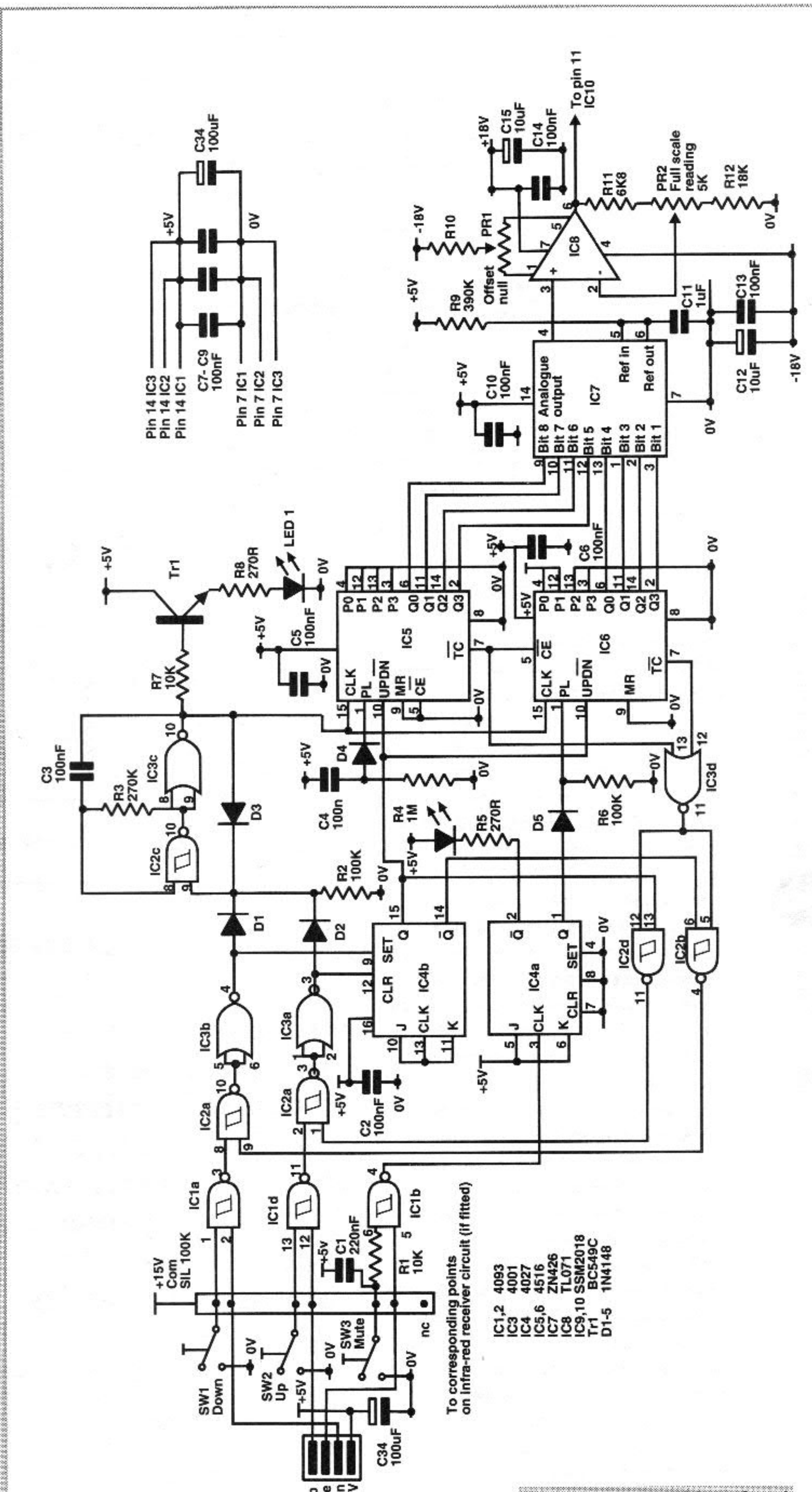

Fig.5 Front panel interface/ D to A converter

system of the front panel pushbuttons co-exists with the up and down signals which originate from this section, with the remote inhibiting logic being essentially another part of the main inhibit circuitry.

The Mute function is realised similarly. This section will be covered in more detail in the Remote Control section when it is presented next month.

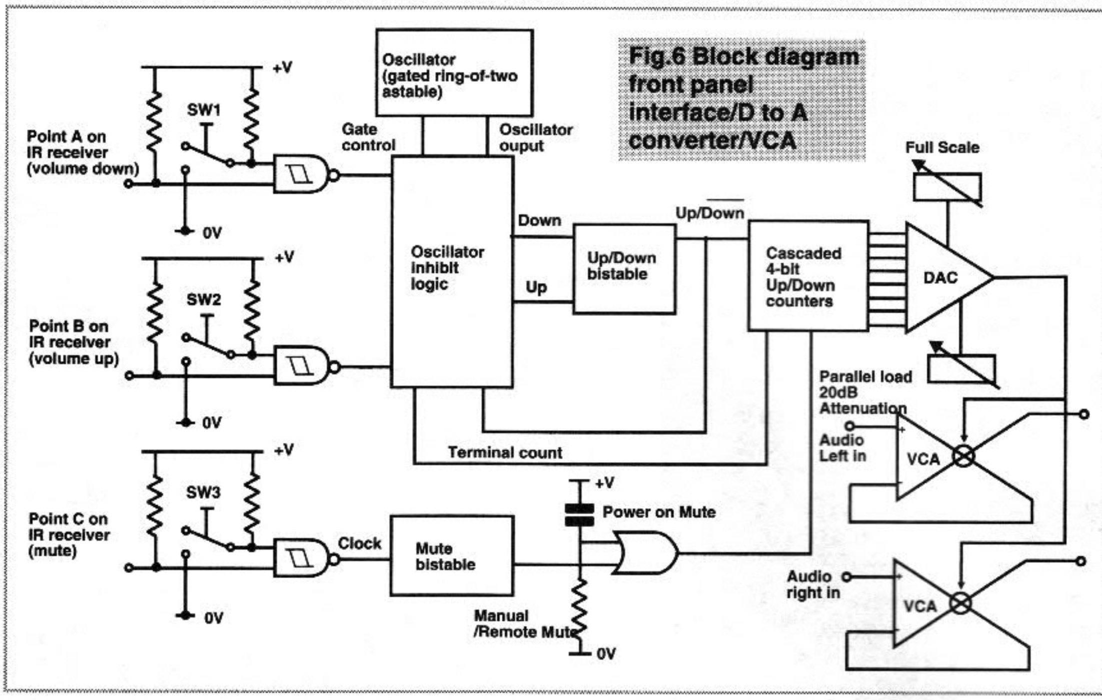

Fig.6 Block diagram front panel interface/D to A converter/VCA

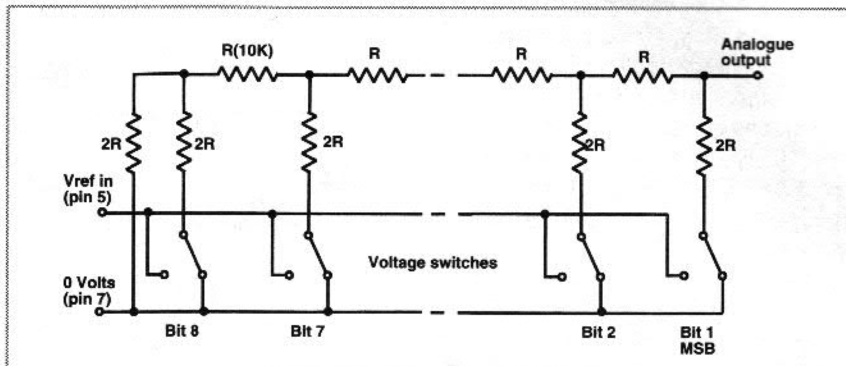

Fig.7 The R-2R ladder network

for correct audio performance, and one of these - the offset adjustment - is more of a nicety than a necessity, especially in less critical applications. However, it does have some effect on control feedthrough performance, as does the symmetry adjustment pot. This control, too, could be considered optional when the device is operated in pure Class A. I say this because many hobbyist constructors balk at the thought of having to tune or fine tune a design before it will work properly, and abandon the project rather than persevere with a few simple adjustments requiring only the most rudimentary test equipment, and the bare minimum of manual dexterity.

Constructors of this ilk need have absolutely no misgivings of this nature as far as The Switcher VCA is concerned - it performs commendably well with no trimming whatsoever, although it has to be said that ultimate performance is attained only after a little tinkering and SOME patience on the part of the constructor. I'm sure I'm right in saying that out-and-out audiophiles who demand the best of their equipment won't mind this, and indeed will consider it time well spent as they strive to attain audio perfection (or as near as you can get with a £4.00 chip and a handful of components)!

Design Considerations

I mentioned the AD7110 CMOS audio attenuator last month, and also the fact that its price put it out of bounds as far as our application was concerned. Nevertheless, it is a feature-packed IC, not least because it accepts a digital number directly as the control for the gain or atttenuation setting of the device. Some background information as regards the normal implementation of VCA ICs might be in order if we are to realise why direct digital control of attenuation is a very desirable attribute.

Cheaper versions - which dispense with the on-chip reference - are available, but the cost of a precision bandgap reference diode quickly gobbles any apparent saving

Most VCAs find primary use in sound processing units and mixer automation systems. The early FX units made only very limited use of microprocessors - they undertook some of the housekeeping of the unit, controlled the front panel display and perhaps scanned a keyboard. However, much of the audio signal control was still done using conventional pots and knobs, with signal control still effectively realised in the analogue domain. Nowadays, cheaper processors, interface adapters, A/D convertors etc mean that all of the signal control is done in the digital domain, since numerical values are much easier to store, manipulate and access later if they are kept in the digital domain and represented as binary numbers. This is to the extent that the control of some parameters - which would be much better left and done in the analogue domain, where continuous rather than discrete control can be realised - can now only be accessed via up/down keys or intricate menu systems.

The fader automation systems of professional mixing desks do illustrate the point clearly. Consider Figure 4 which shows a typical arrangement. The fader is used to derive a DC control voltage, which, in Manual mode, provides direct control of the VCA attenuation level and indirect control of the audio level (since no audio actually passes THROUGH the fader). Often, rather than needlessly impair the quality

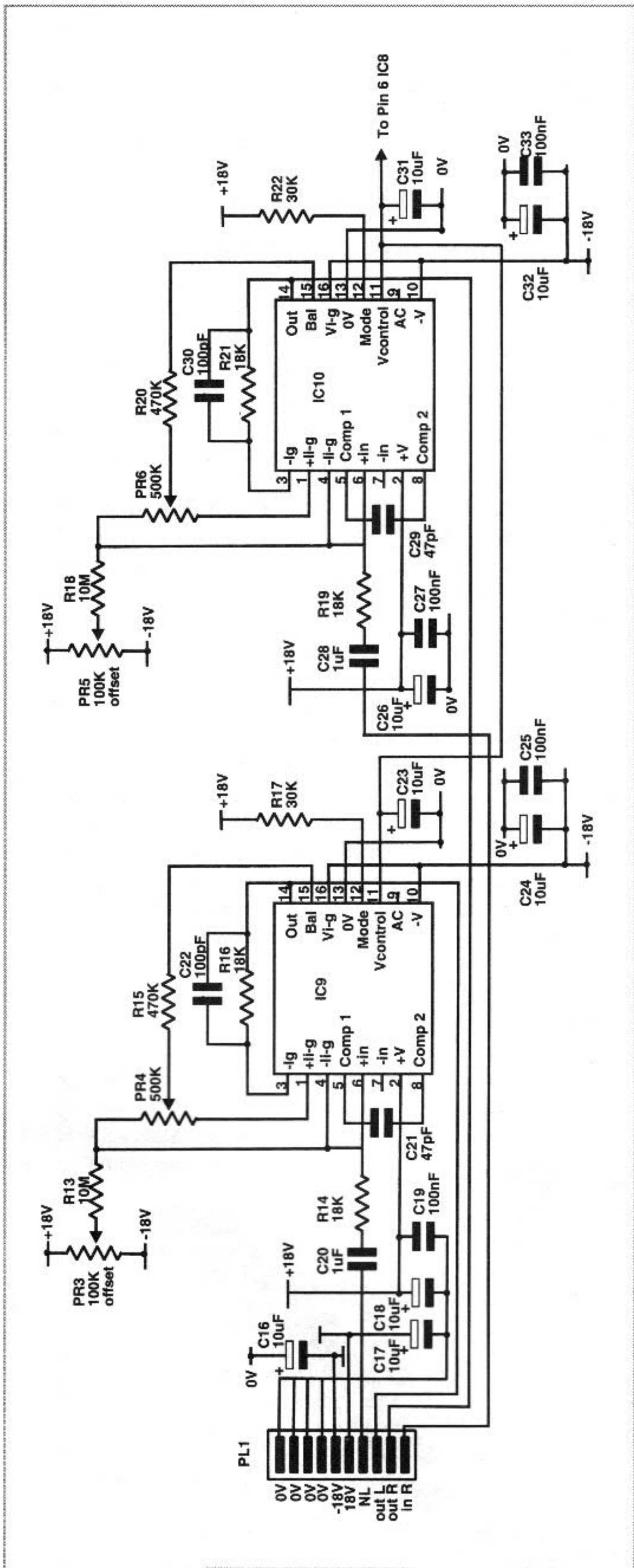

Fig.8 VCA Circuit

VCA

Just about all of the VCA architecture has been explained already in the main body of text. We'll deal, therefore, only with its application in The Switcher Volume Control board here. Signal input is via pins 9 and 12 of PL1. The SSM 2018 is configured in VCA mode using differential current feedback. Trim controls for both symmetry and offset have been included, but either or both of them could be omitted if the class of operation permits and the constructor wishes to save money. It should be reiterated, however, that omission of the trim components worsens control feedthrough.

Amplifier A4 is defeated to allow the differential current feedback method of operation outlined earlier. This enhances the frequency response and slew rate characteristics of the OVCE. Feedback from the $+I_{1\text{-}G}$ output to the inverting input, and from $-I_{1\text{-}G}$ input to the non-inverting output creates differential virtual ground inputs. This allows inverting or non-inverting configurations. In our application, input is via one 18K resistor, and the device is operated in non-inverting single-ended input mode of operation. The inverting input is thus left unconnected. The shunting capacitors, C22 and C30, across the feedback resistors R16 and R21 respectively, roll off gain around 50KHz. The programming resistors, R17 and R22, are shown as being 30K in value. This gives the lowest possible distortion figure at the expense of a slight increase in noise, ie Class A operation. I found that with Class A, noise performance was still good enough that it could be considered to be typically below the noise floor of most pieces of equipment likely to be connected to The Switcher. The trade-off in noise/distortion performance only really becomes of significance when a number of VCA controlled inputs are feeding onto a common bus (ie in a mixing desk). Under these circumstances, noise rapidly can become objectionable because there is a 3dB increase in noise voltage for every doubling of the number of sources feeding to and sharing a common bus - noise signals are uncorrelated so that vector summation of the voltages concerned is done, rather than just simple doubling (which would, instead, give rise to a 6dB increase). This is where the ability to program the devices to trade distortion against noise becomes important. It is the eternal question of the audio designer - what distortion level gives acceptable noise performance?

of the audio by passing it through a superfluous piece of electronics, audio is routed away from the VCA and does pass through the fader when the automation facilities of the system aren't required. Also, the fader generates a DC voltage proportional to its setting, so the system is still able to memorise, fader settings for any channels configured to have their VCA's OUT of the audio pathway. This analogue DC voltage is multiplexed along with all of the outputs from the other channels' VCAs, converted to an 8 or a 12-bit binary word using an A-to-D converter, and stored, together with the channel's particular unique address, in some form of memory - RAM, floppy or hard disk. All of the aforementioned would comprise a "record" operation.

Replaying the gain setting for a particular channel at a particular point in the mix would involve pulling the numerical fader attenuation level from memory, matching its address with that of one of the channels, latching it into the channel's local memory (an 8-bit latch), then converting this binary word into an analogue voltage which the VCA recognises as an attenuation or gain setting. There are a lot of conversions from analogue to digital, and back again, and involve numerous, converters and or multiplexers. Using a digital input VCA makes life a lot easier for the designer.

Our design faces the same problems, albeit on a smaller scale, and without any storage medium being required, although the system must power up in a safe output attenuated state if speakers and the neighbours' nerves/goodwill are to be preserved. Rather than fiddle about with presettable up/down ramp generators, sample-and-holds, summers, analogue multiplexers etc, I've used digital circuitry throughout. (Stored binary number values don't change, but analogue voltages can drift and do all manner of nasty things). The final 8-bit number which represents the volume level required of the system is then stored and converted into an analogue voltage which is used to control the VCA.

D/A Converter

The D/A Converter (IC8) is one of the cheapest available since it dispenses with facilities such as tri-state outputs, separate analogue and digital grounds, latches, write enable and output enable pins and so on. For our application, these and related items are superfluous, so it is nonsensical to use an IC with features we don't need. It is made by Ferranti and since it is one of their earlier types, it couldn't be described as state-of-the-art. Nevertheless, it performs adequately well in an undemanding application such as ours. The device in question is the ZN426E, a 14 pin device with just three other pins in addition to the 8 binary input ones. These are $V_{REF\ IN}$, $V_{REF\ OUT}$ and ANALOGUE OUT. (Cheaper versions which dispense with the on-chip reference are available, but the cost of a precision bandgap reference diode quickly gobbles any saving). Furthermore, there are no complicated trim or null procedures to follow, so setting it up and using it is easy - the ZN426E is made for our application. The DAC is a voltage switching type and employs an R-2R ladder network and an array of precision bipolar switches in addition to a precision voltage reference. The R-2R ladder network is shown in Figure 7. Each 2R element of the network is connected either to 0V or to V_{REF} by transistor switches which have been specifically designed for low offset voltage (1mV maximum which equates to 1LSB. Binary-weighted voltages are produced at the output of the R-2R ladder, the value depending on the digital number applied to the bit inputs. A precision active bandgap circuit, which is the equivalent of a 2.5V zener diode with very low slope impedance, is used as a chip reference voltage, although $V_{REF\ IN}$ and $V_{REF\ OUT}$ pins allow connection of an external reference if desired.
Although the ZN426 gives an analogue output voltage directly at pin 4 - no current-to-voltage conversion is therefore necessary -a buffer amplifier is required to remove the offset voltage inherent to the D-A process, and also to calibrate the converter. Furthermore, Z_{IN} of the buffer amplifier should be in the region of 6K if temperature drift (caused by the temperature coefficient of the Analogue Output resistance, R_{O}.) is to be minimised. There are two trims to be made - PR1 nulls any offset and is adjusted for 0V when all of the input data bits are set to logic 0. PR2, on the other hand, adjusts Full Scale Reading (FSR) and is adjusted with all of the input bits set to logic 1.

Mixing analogue and digital signals on the same boarad can cause all manner of problems. While audio consists of a continuously changing signal, digital signal transfer involves step responses. In a well-designed system, never the twain shall meet, so that digital noise - switching transitions and spikes are isolated absolutely from analogue noise inherent to any VCA applications. Performance in this respect depends upon careful design of the PCB, with analogue and digital grounds carefully isolated, all ICs decoupled near the ICs in question, ground plane-type audio signals, with sensitive signal pathways kept clear of potentially noisy digital tracks. This design adheres rigorously to these demands, and superlative sonic performance is thus assured.

Next month, we finalise the constructional details of the VCA and the yet-to-be-shown Remote Control.

References

Ferranti Data Converter Technical Handbook
Analog Devices Data Sheet - SSM 2018 Voltage-Controlled Amplifier/OVCE

Parts

Front Panel Interface/DAC/VCA

Resistors

R1,7	10K
R2,6	100K
R3	270K
R4	1M
R5,8	270R
R9	390R
R10	0R
R11	6K8
R12,14	
R16,19	18K8K
R21	18K
R13,18	10M
R15,20	470K
R17,22	30K
PR1	10K vertical multiturn preset
PR2	5K vertical multiturn preset
PR3,5	100K horizontal preset
PR4,6	500K horizontal preset
SIL1	100K 7-way single-in-line resistor array

Capacitors

C1	220n polyseter
C2-10,13	
C14,19	
C25,27,33	100n polyester
C11,20,28	1u0 polyester/ polycarbonate
C12,15-18	
C23,24	
C26,31,32	10µF
C21,29	47p polystyrene
C22,30	100p polystyrene
C34	100µ 25V miniature electrolytic

Semiconductors

IC1,2	4093
IC3	4001
IC4	4027
IC5,6	4516
IC7	ZN426
IC8	TL071
IC9,10	SSN2018
LED1,2	0.1" Red LED
D1-5	1N4148
Tr1	

Additional Items

PL1	10 way Minicon right-angled plug
PL2	4 way Minicon plug
SW1-3	DPDT Alps non-latching pushbutton
PCB	
DIL sockets	to suit

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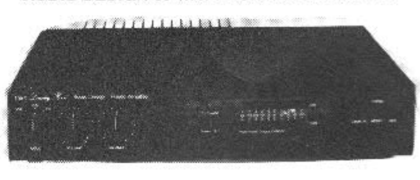

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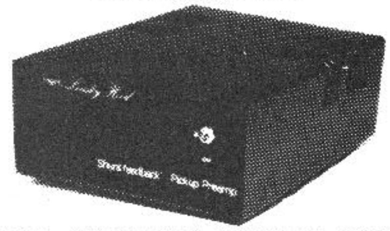

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"MAKING MS DOS WORK FOR YOU"
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160 pages. 198 x 130. Publ. 1993.
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Following on from our Photo CD article and competition last month, we present another great offer for you from Boots the Chemist.

Take Your Pics

Imagine seeing your own photos on TV. Now you can, thanks to the new Kodak Photo CD system and Boots the chemists. Kodak Photo CD uses digital technology to scan your colour photos, store them on a Photo CD disc, and then play them on television with stunning clarity.

Simply take your photos on any 35mm camera, take your film to your Boots photographic department for developing and transfer to a Kodak CD disc as well as your usual negatives and glossy prints, slip the disc into a Kodak Photo CD player and enjoy your memories in bright, high-resolution colour on any TV.

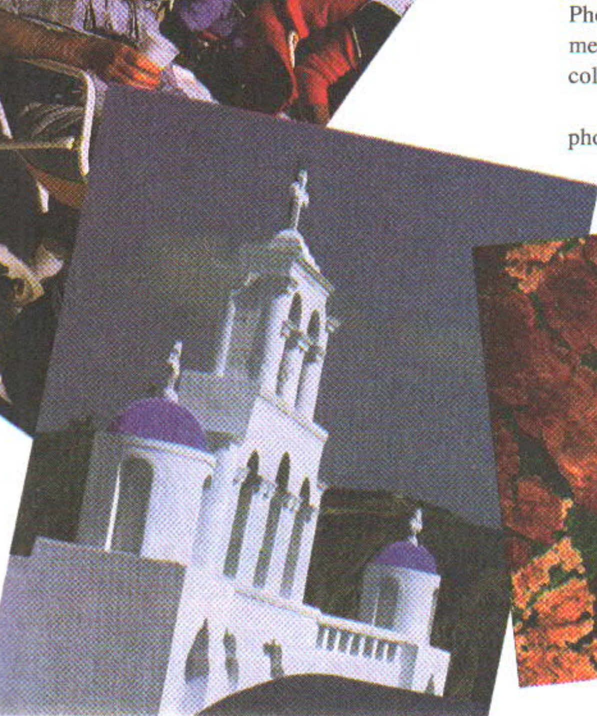
And when you're not viewing your photographs, you can also listen to your favourite CD audio discs, and get suberb sound from your stereo, thanks to Kodak's advanced bitsteam technology.

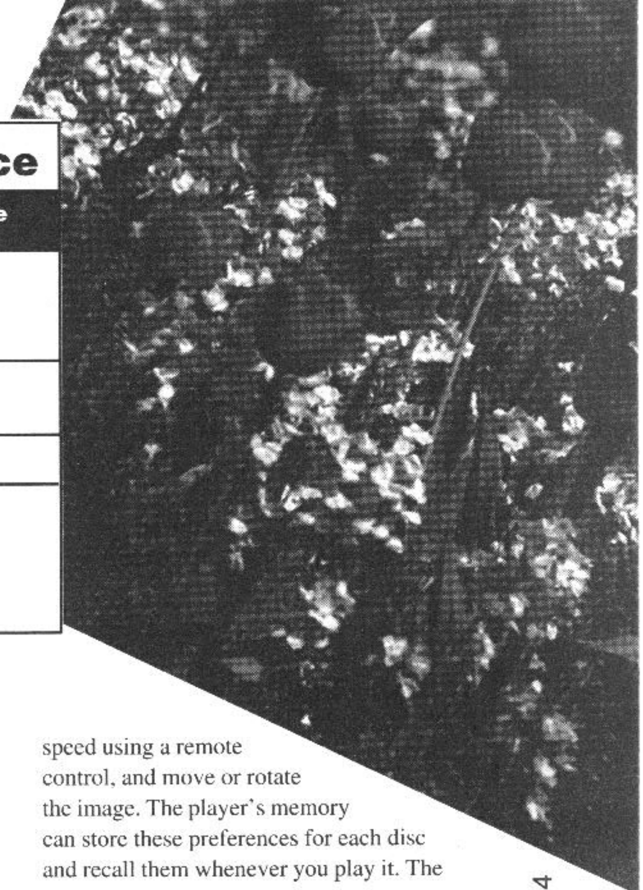
Your pictures have never been so powerful, and now they come with extra spending power.

The coupon on the opposite page allows Electronics In Action readers to save £4 when they buy a new Photo CD disc and transfer 30 or more images to it at any Boots store. Simply cut out the coupon and hand it in when you take your film for processing.

Your new CD will typically hold around 100 images, and you can take it back to add more any time until it's full.

Kodak has combined the best of traditional 35mm photography with digital image storage to create Photo





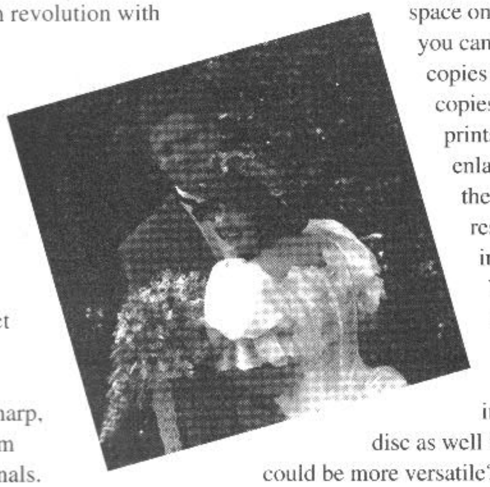
Kodak Photo CD Transfer Service

	135	Minimum Order	Retail Price	Service Time
Transfer of images from colour print film at time of processing (images will be transferred in frame number sequence)	✓		1-28 £12.99* 29+ £16.99* *(price includes full set of 6" x 4" prints)	7 days
Transfer of images from negatives/slides	✓	10	60p per image	7 days
Duplicate Photo CD	✓		£24.95 including disc	7 days
Thermal Prints				
10" x 8"	✓		£6.95	7 days
7" x 5"	✓		£4.95	7 days
6" x 4"	✓		£3.95	7 days

*Price does not include the Photo CD disc (£4.99)

CD. Your photo CD player plays audio CDs too - the best of both sound and vision just gets better.

Digital recording created a sound revolution with audio CD - now Kodak has created a vision revolution with CD and 35mm photography. Share your memories with friends and family on TV! Obviously the better the set, the better the image; but, as you'd expect from Kodak, the picture quality is outstanding with sharp, vibrant colours from well-exposed originals. Even less-than-perfect exposures can look better with Photo CD. And as the picture resolution from Kodak CD technology far outstrips the capabilities of current TVs, the picture will only get better as televisions continue to improve.



Once you have your favourite photos safely stored on Photo CD, you can take them back too add more images at any time while there is space on your disc, and you can order new prints, copies of the disc, copies of selected prints or high-quality enlargements, all to the highest resolutions possible in the medium.

You can take your old photos and negatives to have their images added to disc as well if you like. What could be more versatile? The choice is yours.

The Kodak PCD 265 Photo CD Player lets you view your pictures in any order, tell the player to skip any you'd rather not see again, advance the pictures manually or automatically at your own speed using a remote control, and move or rotate the image. The player's memory can store these preferences for each disc and recall them whenever you play it. The PCD 265 is also a superb audio CD player with the search, scan, programme and random play features you would expect on any high-quality audio CD player.

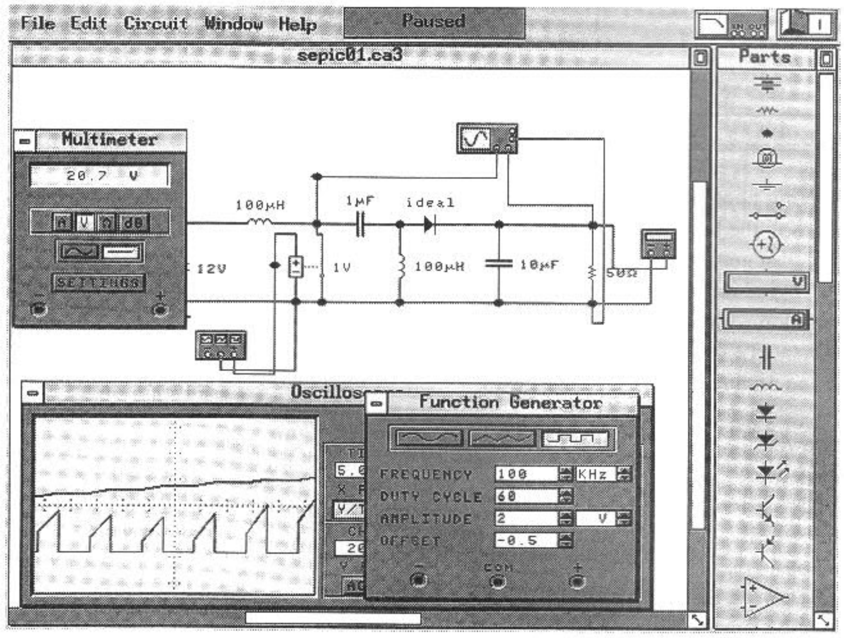
In addition to the features on the PCD 265, the Kodak CD Player PCD 865 gives you enlargement and cropping facilities for each picture on the disc, rotating, repositioning, zooming and even cropping the images to remove unwanted features and expand the portion you like best, all from the remote controller. The player's memory stores and recalls these for each disc. The CD audio functions also include additional Time Edit and favourite track selection features.

Take advantage now of this special Christmas/New Year offer from Boots the chemists' photo department.

Software Review

Electronics Workbench V.3

by Andrew Armstrong



Electronics Workbench is an electronics simulation package running under DOS, Windows3.1, or Macintosh. The review copy was the educational version running under DOS.

There are separate analogue and digital simulation programs. They have the same appearance and user interface, but they are different .EXE files run from the DOS prompt.

Installation is simple. The program is protected, which means that you have to install from the original disks, which cannot be write protected, and can only install the program once. If you want to run it on a new machine, you need to run a de-install program before it can be reinstalled. A faux pas with the disks could be expensive, since backups of the original disks will not work. I am concerned that the program may have written a hidden file on to my hard disk, and may not work again if I run a disk defragmentation program. I have not tried this!

The only other point to note is that a mouse is needed to use Electronic Workbench, but computer rodents are increasingly common so few people will find this a drawback.

In Use

In my view it is good if a program can be used without too much reading of the instruction book. The operation of Electronics Workbench is sufficiently clear that I could use it immediately. As you can see from the screen shots, there is a strip (referred to as the components bin) down the right containing components. To input a circuit diagram, you simply drag copies of components from the component bin and position them on the screen.

Holding down the mouse button and dragging from component end to component end makes a connection. The thing which fooled me briefly was the need to drag a junction point component to a wire before another wire can join it. I found this slightly irritating, and wished for automatic wire joining. Also, if components are not spaced far enough apart, a junction point placed on the wire between them will not join, and later on a cryptic error message such as "A capacitor is open circuit" will appear.

The program automatically routes the connection with conventional right angle bends, though sometimes it does not do so in the way one would expect.

It is not always possible to make straight lines between components straight. There tends to be a jag one way or the other because the components will not always line up. Also, though components can be rotated, they cannot be mirrored.

Overall, however, drawing a circuit is simple and quick.

The workbench analogy is carried forward into the circuit measurements. Various instrument icons can be positioned and connected to the circuit. The instrument can be zoomed to show the controls and display, though too many zoomed instruments clutter the display area. The DOS version did not seem able to use the full super VGA resolution available, which might have ameliorated this effect, though of course the Windows version would display in the normal Windows resolution.

Analogue instruments include an oscilloscope, multimeter, and a Bode plotter. This last displays a frequency response curve, with either log or linear axes. The screen shot of the low pass filter example shows the Bode plotter in use. The display has no scaling on the axes, but measurements of the cursor position are shown to the bottom right of the instrument.

These instruments can only be used once. That is a shame, as I would have liked to see four traces, for which two oscilloscopes would have been needed.

The two circuits shown so far are the examples supplied with the software. Naturally, I wanted to try some examples of my own devising as well. The screen shot on the left shows the principle of a sepic converter, a type of switched mode power supply whose output voltage can be above or below its input voltage. Only the basic principle is simulated, because it would be difficult to simulate the control loop. The results pictured, showing circuit operation before the output has settled are as expected, and show a possible resonance to be avoided by the control loop design.

Models

Very few device models are provided with this package, but it is possible to edit the models which are provided and then save them under different names. In this way, a useful library can be built up.

For educational purposes, circuits with faults can be produced, so that the student can have the task of deducing what is wrong. The faults can be hidden, and later displayed after entering a password. Other restrictions can be placed on the student, such as disallowing the use of any analogue instrument, or hiding the components bin so that only components already placed in the work area can be used.

The digital simulation program is limited in that it cannot simulate analogue effects. However, it contains some tools which have no equivalent on the real-world workbench. There is a converter which can turn a truth table into a Boolean equation, for example. One can derive a truth table from a circuit, convert it to a Boolean expression, simplify it, and then convert it then back into a circuit. This is certainly an easy way to optimise combinational logic, though it may not always conveniently use up the remaining gates from odd CMOS or TTL packages instead of using a new logic function on an extra chip.

A useful function of Electronics Workbench is its ability to capture any part or all of the screen as a PCX file. It is by using this screen capture function that the illustrations shown here were produced.

Other Remarks

When I tried to load the biggest example circuit, I received the error message "out of memory - circuit not loaded". After checking the documentation, I tried loading the program in the protected mode, on the theory that this should make more of my system's memory available to the program. Unfortunately, the memory extender provided with the system is only intended for a 286-based computer, and it crashed the keyboard driver of the 486 machine after I used the keyboard to change a component value. The program appeared to continue working, but the machine would not accept any further keyboard input (even at the DOS prompt) until after a hard reset.

The workaround I have found is to load the workbench program from a batch file which starts with the line:

KEYB US

and finishes with the line:

KEYB UK+ [DRDOS 6 syntax]

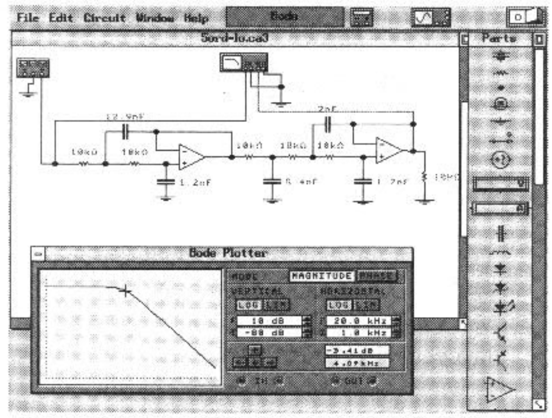
to reload the UK keyboard driver to make the £ sign work

One bugbear of computer simulation is that it can fail to converge on a solution. Sometimes a small change to a component value is all that is needed to make a simulation work. I only encountered this once, and changing an 11k resistor to 11.1k solved the problem.

Another common problem is that the simulation step size can be too large to give accurate results, and can require several attempts to make acceptable. This problem did not show itself at all while I was using Electronics Workbench, so it appears that the program is more than usually resistant to step-size snags.

The program was reviewed on a '486DX/33 machine with 8MB of RAM. Simulation worked at a reasonable speed, and I never found myself impatient, though I do not know how much it would slow down on a machine without a co-processor.

Subsequently a copy of Electronics



Workbench for Windows was supplied for evaluation. There was insufficient time to review it in detail, but it appeared to have exactly the same functions as Electronics Workbench for DOS.

It uses the full resolution of the Windows display drivers, so that more of a large circuit can be displayed on screen at once. Because it does not use the DOS memory extender, the clash with the keyboard driver did not occur.

The windows product seems to do the same job as the DOS version, but it is easier to use and can provide a better screen display, if you have a high resolution graphics card.

The simulation speed seems similar as well, so I can unequivocally say that I prefer the Windows product.

The software package is available from Robinson Marshall (Europe) Tel:0827 66212 for more details.

AMSTRAD DMP4000 Entire printer assemblies including printhead, platen, cables, stepper motors etc. Everything bar the electronics and case. Good stripper!! Clearance price just £5 REF: MAG5 or 2 for £8 REF: MAG8

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COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC operation. £8.00 REF: MAG8P2.

LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc in fact everything bar the case and electronics, a good stripper! £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

PHILIPS LASER 2MW helium neon tube. Brand new full spec £40 REF: MAG40. Mains power supply kit £20 REF: MAG20P2. Fully built and tested unit £75 REF: MAG 75.

SPEAKER WIRE Brown two core, 100 foot hank £2 REF: MAG2P1

LED PACK of 100 standard red 5mm leds £5 REF: MAG5P4

JUG KETTLE ELEMENTS good general purpose heating element (about 2kw) ideal for allsorts of heating projects etc. 2 for £3 REF: MAG3

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF:MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

OZONE FRIENDLY LATEX 250ml bottle of liquid rubber, sets in 2 hours. Ideal for mounting PCB's, fixing wires etc £2 each REF: MAG2P2

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***FM BUG BUILT AND TESTED** superior design to kit, as supplied to detective agencies etc. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert and ordinary phone into a payphone. The units we have generally have the locks missing and sometimes broken hinges. However they can be adapted for their original pupose or used for something else?? Price is just £3 REF: MAG3P1

100 WATT MOSFET PAIR Same spec as 2SK343 and 2SJ413(8A,140v,100w) 1 N channel and 1 P channel, £3 a pair REF: MAG3P2

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TWEETERS 2" diameter good quality tweeter 140R (would be good with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3 REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need just a small modification to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: MAG6P3

XT KEYBOARDS Mixed types, some returns, some good, some foreign etc but all good for spares! Price is £2 each REF:MAG2P6 or 4 for £6 REF: MAG6P4

PC CASES Again mixed types so you take a chance next one off the pile £12 REF:MAG12 or two identical ones for £20 REF: MAG20P4 component pack bargain 1,000 resistors +1,000 capacitors (all same value) £2.50 a pack. REF:MAG2P7

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COMMODORE MICRODRIVE SYSTEM mini storage device for C64's 4 times faster than disc drives, 10 times faster than tapes. Complete unit just £12 REF:MAG12P1

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HEADPHONES 15P These are ex Virgin Atlantic. You can have 8 pairs for £2 REF: MAG2P8

PROXIMITY SENSORS These are small PCB's with what look like a source and sensor LED on one end and lots of components on the rest of the PCB. Complete with fly leads. Pack of 5 £3 REF: MAG: 3P5 or 20 for £8 REF: MAG8P4

FIBRE OPTIC CABLE Made for Hewlett Packard so pretty good stuff! you can have any length you want (min5m) first 5m £7 REF: MAG7 thereafter £1 a metre (ie 20m is £22). REF: MAG1 Max length 250m.

SNOOPERS EAR? Originall made to clip over the earpiece of telephone to amplify the sound-it also works quite well on the cable running along the wall! Price is £5 REF: MAG5P7

DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: MAG5P8 Worth it just for the very comprehensive manual! 5.25" only.

DOS PACK Microsoft version 5 Original software but no manuals hence only £3 REF: MAG3P6 5.25" only.

FOREIGN DOS 3.3-German, French, italian etc £2 a pack with manual. 5.25" only. REF:MAG2P9

MONO VGA MONITOR Made by Amstrad, refurbished £49 REF:MAG49

CTM644 COLOUR MONITOR Made to work with the CPC464 home computer. Standard RGB input so will work with other machines. Refurbished £59.00 REF:MAG59

JUST A SMALL SELCTION of what we have- to see more get our 1994 catalogue (42p stamp) or call in Mon-Sat 9-5.30

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COMMODORE 64 Customer returns but ok for spares etc £12 REF: MAG12P2 Tested and working units are £69.00 REF: MAG69

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FIRE ALARM CONTROL PANEL High quality metal cased alarm panel 350x165x80mm. Comes with electronics but no information. £15 REF: MAG15P4

SUPER SIZE HEATSINK Superb quality aluminium heatsink. 365 x 183 x 61mm, 15 fins enamble high heat dissipation. No holes! £9.99 REF: MAG10P1P

REMOTE CONTROL PCB These are receiver boards for garage door opening systems. You may have another use? £4 ea REF: MAG4P5

LOPTX Line output transformers believed to be for hi res colour monitors but useful for getting high voltages from low ones! £2 each REF: MAG2P12 bumper pack of 10 for £12 REF: MAG12P3.

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REF: MAG50

Liquid Crystals Get Sharper and Faster

by Douglas Clarkson

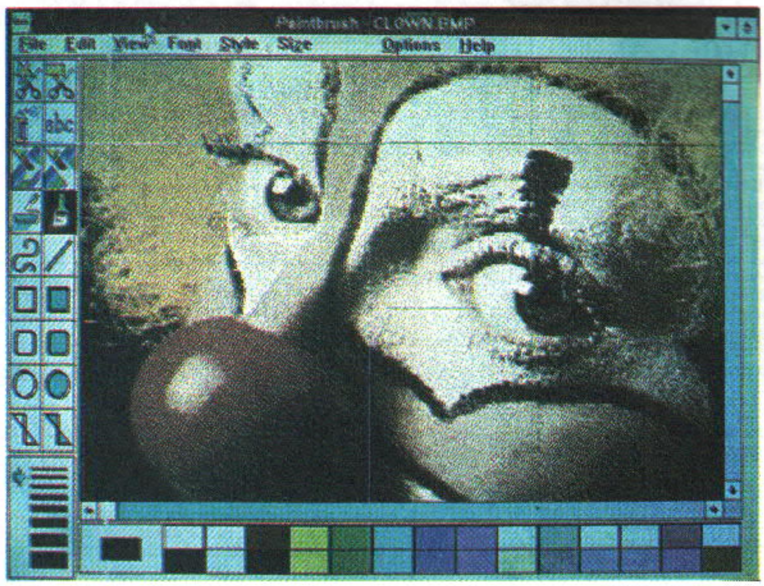
Liquid crystal technology, an overlap between the electronics and optics industry continues to be exploited for their speed and display quality.
Up until the mid 1960s liquid crystals were more of a scientific curiosity than the key technology which they are today. Such devices were initially developed at RCA where very basic effects were first demonstrated in 1968.

In normal liquids such as water and alcohol, the molecules tend to exist as independent units. With liquid crystals, however, the shape of the molecules can encourage them to orientate in preferred directions. Where liquid crystal molecules are 'thread like', for example, they can align so they all point in the same direction.

This preferred orientation can be influenced primarily by the direction of an electric (or magnetic) field and also by surfaces with which the liquid crystal is in contact. Treating the surface can make the molecules attach in a preferred direction. The direction in which the molecules tend to align is called the 'director'. Usually the electric field alters the orientation of the liquid crystal molecules. A typical electric field used to switch the liquid crystals is around 400 V/cm. In the case of a liquid film of 25 micron thickness, this corresponds to an applied voltage of 1V.

Basic Liquid Crystal Technology

Liquid crystals in display applications make extensive use of polarisation effects involving light. It is common for the upper surface of a liquid crystal display to include a linear polariser which transmits only light polarised in the axis of the polariser. In the popular 'twisted nematic' mode of liquid crystal this direction of light polarisation is



twisted by the configuration of the liquid crystals and reflected through a polarising layer on the base of the device. The reflected light from the base layer is again twisted so that it can pass through the upper polariser and the surface appears bright. In the 'on' state this twisting of light is inhibited and light will not be reflected from the lower layer - the device appears dark. The crystal operates by exploiting light polarisation, though during the 'ON' phase the applied electrical signal has to be present to maintain liquid crystal orientation.

New Ferro-Electric Liquid Crystals

The development of a new liquid crystals which can be switched more rapidly and 'remembers ' its optical state without the need to be refreshed is opening up a new range of applications for liquid crystal technology. So called ferro-electric liquid crystals have been shown to demonstrate very much faster switching rates. They are between 100 and 1000 times faster than conventional switching rates of around 0.02 ms. While the potential of ferro-electric liquid crystals has been known for some time, problems with their orientation stability has till now restricted their commercial development.

CRL (Central Research Laboratories) of Hayes, Middlesex, and part of the Thorn-EMI group have, however, succeeded in developing a stable ferro-electric liquid crystal which requires very little power to operate. Development work was undertaken as part of an ESPRIT collaborative programme. This FELICITA initiative demonstrated a 300 dots per inch (DPI) image bar operating at a print speed of 45 pages per minute in 1992.

The ferro-electric liquid crystal is switched between two states of molecule alignment by application of electric fields. The liquid crystal is behaving as if it exists in two distinct states and that it can be flipped between states by the superposition of appropriate electrical field across the crystal. It is also not necessary to maintain the electric field to keep the liquid crystal orientation. The liquid crystal is behaving like an electronically switched optical memory.

Their success at CRL relates to maintaining liquid crystal stability. The design of ferro-electric liquid crystal displays is generally similar to those of standard nemetic type. Usually, the upper and lower polarising layers have the same polarisation direction.

The most striking demonstration of a ferro-electric liquid crystal display is image retention even when electrical power is removed. This offers immediate advantages in display drive circuits of where a signal needs only to be applied to a display element if its display level needs to be changed. Also, this is exactly the technology required for lap and palm top PCs in order to minimise power supply requirements and complex drive circuits.

Applications

The achievement of significantly faster switching times has also significantly extended the use of such new liquid crystal technology. While such ferro-electric liquid crystals are being developed as display elements in PCs and have potential for TV displays. One new application area which is attracting considerable attention is as a high resolution linear type spatial light modulator. In this application each element within the array can be switched to transmit or not transmit light. Such spatial might modulators can switch at rates of around 200µs with a spot size of 20 microns and with a 10 micron 'indent'. Switch rates can be reduced to 100µs.

Such devices are being developed into light bars of width up to 13.5 inches and with a dot resolution of 2540 per inch. The principle of such a unit is shown in Figure 1. CRL are developing such products in association with the LASOR company. Products are being developed initially for high quality print applications in graphics design and publishing.

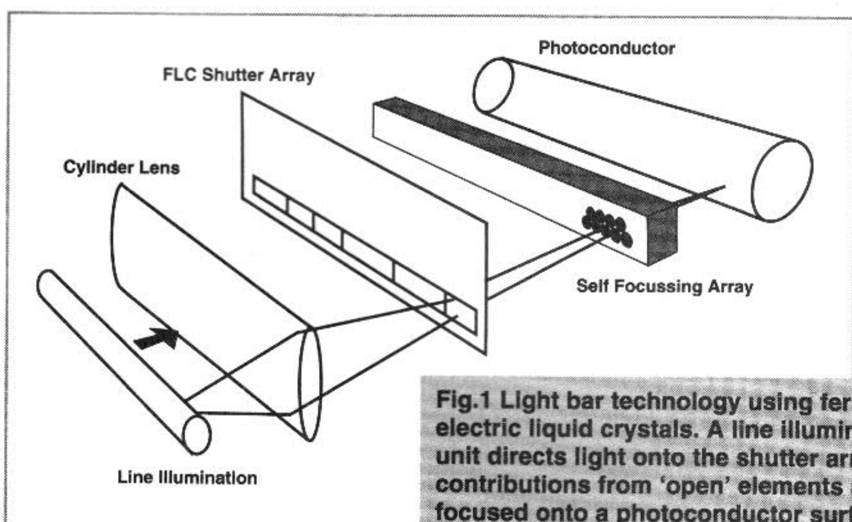


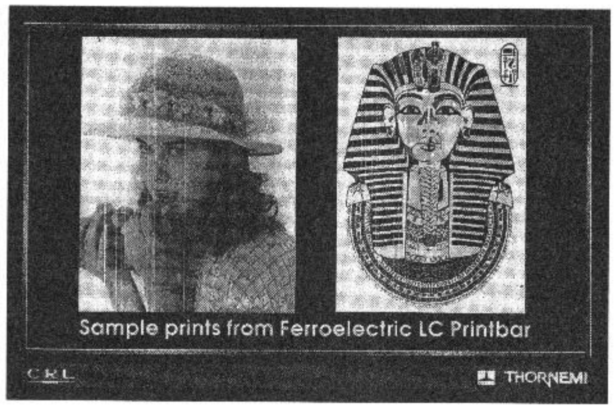
Fig.1 Light bar technology using ferro-electric liquid crystals. A line illumination unit directs light onto the shutter array and contributions from 'open' elements are focused onto a photoconductor surface mapping the corresponding charge density to an image. The photoconductor could be replaced with a self developing 'dry' film.

There is significant interest, also, in developing this technology as 'dry' film processors in a range of medical applications primarily relating to x-ray hard copy from digital radiology systems in hospitals. There is increased environmental pressure to replace existing chemical methods of film processing with such new technologies. The compact nature of the active head of such linear spatial light modulators is expected to make devices incorporating such units considerably more compact than present equivalent technology.

Once the technology is proven in the 'high' end of the printing market, then applications will be taken up across a broader range of print applications. In terms of printing speed however, the time to print a line across a linear spatial light modulator will not be limited by the process of switching the liquid crystal elements but by the processing time of mapping a graphical image to a series of line scans.

Thus on a print of 11" x 6" at 2540 dots per inch, there are approximately 400 million pixels to be mapped between graphical image held in memory and the output device. As device resolution increases this will tend to increase the need for faster graphics processing hardware and software.

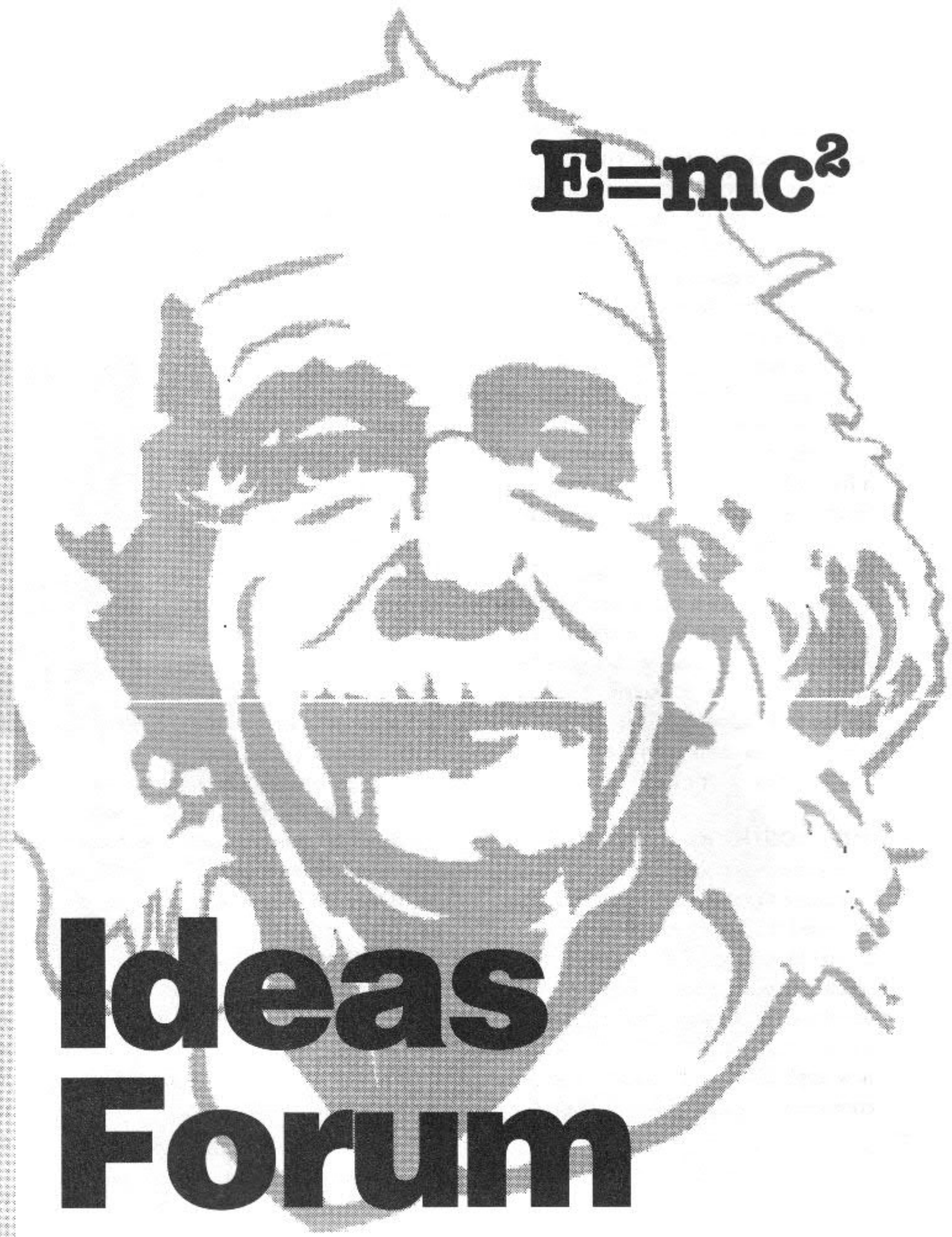
CRL are also developing spatial light modulators devices as arrays of liquid crystal elements which can be switched by computer control. One device, a 320 x 320 element spatial light modulator has been developed which can be interfaced to an IBM PC. Each element is 80 microns in size and with a 5 micron dead space between elements. Images from frame memory can typically be transferred to the display in 5ms. Such devices are becoming increasingly used in photonic switching in lightwave research and development. It is possible to couple the output of specific pixels to fibre optic cables. Such spatial light modulators can be used in elements of optical computing systems.



Spatial light modulators are in effect specialised shutters with no moving parts. There is considerable scope to use such technology in applications where highly accurate control of light exposure is required. Applications include, for example, light control for ultra fast photography where mechanical shutter speeds are either too slow or introduce timing errors or are expensive by virtue of their complex construction. There may be applications in conventional camera design where shutter mechanisms could be made from ring like sections of liquid crystal which could be selected both on an area basis for aperture setting and also for exposure timing.

Summary

For the first time fast response/low power liquid crystal technology has become available. While initial applications are likely to appear in high quality graphics reproduction systems, in time a much broader range of products will come to exploit the merits of such technology.



Ideas Forum

January

Some of your ideas

House/Car Security
This is a popular area of interest and now exploited by many companies. However, there are still many areas to be covered - like disabling the car engine and using combination locks.
Spectrum Analyser card for PCs.
Audio/Video compressor to give constant output level.
Indoor plant moisture measuring system. These are not new, but could the needs of a plant be combined with a room humidifier?

Photography
F stop timer
Watkins factor timer
Flash meter
Colour analysers, exposure meter/timer
Digital signal processor projects. These projects should be all the rage in years to come.
Charger for normal batteries. Watch out, there a few existing ideas patented already

Radio/TV computer link
Computer controlled audio - RS232 linked
Interfacing VDU to VHF/UHF receivers
More computer and computer software interfacing with radio and TV receivers. Could the software be a 'Window' on the world?
TV colour pattern test pattern generator -watch this space in the next six months.
Multi-media interfaces. These may be the gadgets of the 21st Century but does anybody have the project ideas for them?
Kirlian camera project. There must be an aura surrounding this one.
Digital voice recorder/player
Angle and pressure sensors

Technology for the garden
12V seed propagator
Outside LASER security beam
Proximity lighting switches for low voltage garden illumination. Not like PIR high power security lighting, these lights could provide the right mood to finalise the landscape.

You have replied with some of your project thoughts and ideas on what you would like to see in the magazine. Time to take out a pencil and paper and get designing.

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.

The ideas page 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 any of the suggestions here, try and get a working prototype together. We would like to see your efforts in print, so send in with the details to us here at: Electronics in Action, PO Box 600, Berkhamsted, Herts HP4 1NL. You will be rewarded for your efforts seen in print. The ideas presented 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 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 lower cost. Your thoughts 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.

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 magazine.

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December issue

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☐	QH1293-2	Switcher Main board	£10.00
☐	QH1293-3	Switcher Front panel	£6.00
☐	QH1293-4	Video Editing Unit	£8.00

November issue

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October issue

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☐	QH1093-6	Crossover unit	£3.00

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ADVERTISERS' INDEX

Technoshop

Electronics in Action in co-operation with The Technology Exchange Ltd, the international technology matchmaking service based in the UK, will be bringing you each month a selection of technology partnership opportunities 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).

For this issue of Electronics in Action, we are presenting a series of offers of licence, joint venture and patents rights for sale from organisations in 34 countries.

If you would like to have an introduction to any of the sources of the offers describes in these profiles, please write to the The Technology Exchange quoting the reference number at the head of the entry and giving full contact details for the contact person in your own organisation and your requirements for a new product or process development.

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 full contact details for the source of the offer and invite them to send you more detailed information about their offer.

The code letters at the head of each offer indicate the stage of development, type of offer and the type of organisation making the offer as indicated in the table

Each entry is preceded by a reference number and letters indicating STATUS, OFFER and SOURCE.

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KEY

Example: SPOLSU

Status — Offer — Source

Status: Indicates the stage of development.

P Patent or design only	M Laboratory model	W Working prototype
U Pre-production units available	F In current production	C Commercialised

Offer: Indicates the type of agreement sought.

L Manufacture under licence	S Design and/or patent for sale	J Joint venture offer

Source: Indicates the type of organisation making the offer.

C Limited Company	C Educational Institution	R Independant Research Organisation
G Government Research	P Private individual	

805020 P L U
Submersible television exploratory vehicle 'Steve'

This invention describes a remotely controlled device for exploring and mapping submerged geological cavities. It provides a means for exploring flooded underground cavities where the floor is silty or the passages are too narrow to use manual exploration. The device is sufficiently small and inexpensive.

505037 F S/L C
Multiplexing signal conditioners

For instrumentation, automatic test equipment and process control applications. Novel output multiplexing capability allows many transducers to be measured by few A to D convertors. Very small size, plastic moulded DIN rail mounted with finger proof terminals. 1000V isolated and low cost, non-isolated ranges cover temperature, pressure, voltage and current.

305077 G
Electromagnetic radiation transducer

Transducers transform invisible electromagnetic radiation into the visible one. They can be used in opto and micro electronics for the laser system and electron microscope tuning, for visual evaluation of light spot uniformity and as gamma-radiation dose meters. Luminescent composition, operating in clearance and reflection mode is the base of visualisers.

105136 F J G
Switching germanium tunnel diodes

Switching tunnel diodes are extremely fast, p-type germanium diodes with peak current of 50mA. These devices fabricated with KVARZ's new sandwich pellet and are housed in a sub-miniature epoxy package. Designed for use in ps switching circuits for voltage sharp change shaping with an edge of picosecond duration. They are key elements in wideband pulse-oscilloscopic radiomeasuring equipment.

805138 W L G
Magnetic valve-type reactor

This is a high power inductive reactance, smoothly regulated in its value by magnetic biasing of magnetic circuit with direct current. The reactor magnetic circuit is of a special transformer type design which cores operate in high saturation conditions. The cores incorporate mains, control and the converter transformer windings in one.

505158 W J G
Miniature fibre optic gyroscope

This includes a multiturn coil of the single mode, small diameter fibre is maintained polarisation; phase modulator; two fused tapered couplers; fibre crystal polariser; super luminescence diode; photo-diode and electronic circuit card. All optic elements are formed in series on a continuous strand of fibre. Fibre crystal polariser is fabricated under unique technology.

105469 P L
Printed circuit manufacturing process involving raised contacts

Enables electrodeposition of contacts at any desired location and provides simple protective coating operations. It can be applied to any rack including card carrying baskets. Advantages include reduced cost and higher reliability.

105483 W L/J C
Magnetic tape for unwinding device with intermediate storage

Enables a viewer to visualise recorded programmes from the beginning of retransmission with a slight time lag. Applcations include: professional and public video, industrial vision, storage of computer data, air traffic control, defence.

105484 W L C
Acoustical listening and recording aid for birdwatchers

A directional stereo microphone and amplifier combination with easy to use paraboloidal reflectors for efficient sound collection. It will be used by amateur and professional ornithologists and professional wild animal researchers.

105497 W L G
Self powered micro-miniature transmitter

The microtransmitter is a self-powered microminiature solid state transmission and telemetry device that transmits an electromagnetic pulse in excess of 1 kilometre. The current configuration employs a laser diode and is powered by solar cells; however, it can be configured to employ radio frequency and battery power. Applications currently envisioned include tracking, telemetry, surveillance and data acquisition and transmission applications.

105536 W L G
A process for manufacturing multilayer capacitors

Multilayer capacitors are currently constructed with metal electrodes of high palladium alloys. This process can be used to manufacture multilayer electronic devices having more silver rich metals in the construction process, enhancing the usefulness of the chips while lowering the value.

905605 W L U
Charge based multiplier circuit

Generates a charge packet proportional to the product of an input signal and a weight voltage. An exponential pulse is formed which is representative of the input signal. The circuit generates an output charge proportional to the product of the peak magnitude of the exponential pulse and the exponential decay time constant, which is represented by the weight voltage. The output charge can be generated as a charge onto an output bus for positive results, or the amount can be depleted from the bus for negative results.

5886 P S U
Minimum pulse width (MPW) power amplifier

The MPW power amplifier is a feedback controlled transconductance switching power amplifier intended for driving inductive loads. The primary intent of this invention is to achieve the high efficiency of a switching amplifier without some of the drawbacks such as high complexity, low bandwidth and short pulse fault susceptibility in prior designs.

905922 M J C
Electrical powerline signalling systems

A patented system allows for data transmission over considerable distances via electrical power distribution lines. The principle of the new system has been proved to work and investment is now required in order to develop and build a series of prototype systems. The technology will allow remote reading and tariff programming of domestic/business electricity meters through existing cables.

605926 L/J M C
Electronic network for connecting sensors to a computer or microprocessor

The sensors can measure a range of variables such as temperature, voltage, switch closures etc. and provide control of lights and motors etc. Many of these sensors can be connected together with a single two core cable and linked back to the computer to allow measurement and control. The sensors and computer interface electronics are very cheap to produce from easily available components, but have a very high functional specification. This opens up a wide range of potential applications.

905931 W J R
Sparkless 1-gang 1-way switch

No mechanical or moving parts. It can be operated by touch. The plastic plate is also available in a waterproof version.

406028 W L V
Class E AC-AC converter

This technology uses a single switch that operates only at low voltage or current, and at low time derivative of voltage or current, thereby achieving very high conversion efficiency. Variation and control of the output waveform requires less complex circuits.

706029 W L U
Electronic AC voltage controller

The electronic AC voltage controller detects lapses of AC power and slowly reapplies AC voltage to the load when power is restored. This invention may also be used as an AC regulator.

106066 M L G
Photorecording element and liquid crystal cell comprising the same

A photorecording element is disclosed which consists of a transparent substrate, a molecular layer of an organic compound with an ability to change structure reversibly by virtue of light and disposed in direct contact with the transparent substrate and a layer of liquid crystals disposed in direct contact with the molecular layer. A liquid crystal cell comprising the photorecording element is also disclosed.

6075 W L G
Induced base bipolar transistor

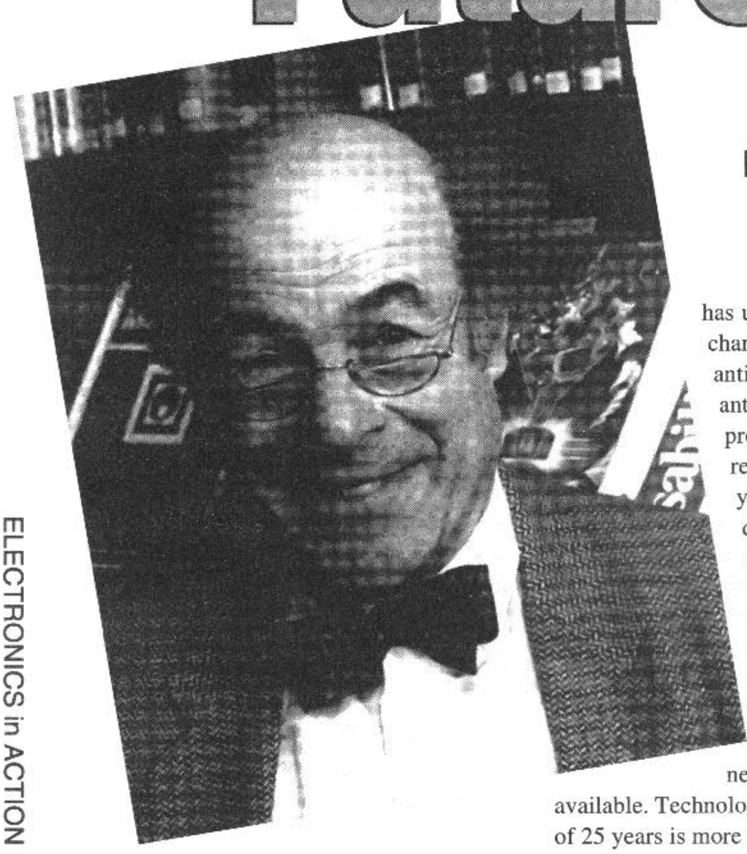
The base of the transistor is electrically induced and compatible with a channel of a field effect transistor. The transistor has compatibility with FET in the structure and fabrication steps. The induced base has the lowest thickness in principle compared with conventional bases made by impurity doping and this leads to high frequency, high speed operation.

106078 M L G
Josephson transmission line device

This Josephson transmission line device is a new digital or analogue superconducting electronic device which has the characteristics of ultra high speed operations and ultra low power dissipation.

MORE TECHNOSHOP NEXT MONTH

Future View



Professor Heinz Wolff talks to Paul Freeman-Sear about Life, the Universe and everything

***EIA**:In our October issue last year Future View looked at computer-linked videophones. How do you see visual telephony in the future?*

HW:The videophone may be something nobody desperately requires. It might avoid the need for face to face meetings, but in most countries shopping by television, for instance, hasn't really caught on. I suspect that meeting people is a fundamental social phenomenon which can only be imperfectly substituted by the videophone.

As for handwriting computers, a lot was made of keyboard phobia, but business people are used to keyboards now.

The qwerty keyboard was designed to slow people down!

But people can't think infinitely fast. This is the whole concept of what I call mental roughage! In 1983 I told journalists that technology rushing past us was not as true as people thought. I asked them to imagine going back to 1933, 50 years earlier. Home was likely to have central heating, certainly a maid - a very versatile domestic appliance - radio, telephones, cars and planes were there. Television wasn't there. Medicine has undergone large changes, there were no antibiotics or many antibacterials, but providing you were reasonably well off, you would have no difficulty acclimatising. In a later TV programme, 1948-1984, we discovered that in 1948 almost every everyday necessity was available. Technology over a generation of 25 years is more a question of being affordable than new. The Commodore Pet with a 4k memory 15 or 18 years ago cost me as much as a 486DX computer today.

Nearly everything worthwhile - railways, telephones, much of the heavy technology - was invented in the extraordinarily productive Victorian eras. Then there was a plateau and nothing changed dramatically for a long time. Then came all these advances in computing and technology.

So if I had to forecast for 2000 to 2030 it could be consolidation. Management skills must include limiting the speed at which people get information. People seem to become hypnotised by their screens, because information is appearing which seems to need a response. They no longer have time to think, but feel that everything has to be reactive.

I have also been impressed recently by the fact that the better communication becomes, the less governable a country becomes. It could be a principle of managing large numbers of people that if they all know equal amounts, however democratic this may be, they become unmanageable.

Will greater communication cause more global conflict, then?

A couple of wars - the Gulf war and Bosnia - have already been fought under the eyes of the cameras. There were British and American correspondents in Baghdad during the Gulf war. The danger of insult to one side, with a cry for immediate retaliation because it is known almost at once, may be disruptive. But the Hot Line clearly is a good thing - if the mad president could say "I'm terribly sorry, but we've accidentally let off a missile targeted on Minsk. We can tell you the trajectory, do your best to shoot it down!" And spy satellites have probably helped by preventing large secret arms build-ups.

Moving to another specialist area of yours, what do you feel about the habitation of space?

I don't think the colonisation of space will be an outlet for overpopulation. I think space is a symbol, a large-scale cultural activity, the next big challenge. Otherwise, it would be difficult to argue the need for a space colony other than a domestic one for communications satellites, but humanity has always required challenge. All stable civilisations have set themselves large-scale constructional programmes, whether the Incas or the Egyptians or Stonehenge, even tiny communities like the Easter Islanders with their figures. Whenever mankind has failed to set itself challenges it went into decline. When you have a problem, it's very much a necessity, for instance, the challenge of having a major highly technological enemy. In the arms race, there was a balance of terror to maintain, and what was cleverest and most versatile in technology and science was harnessed. This in a sense has fallen apart, nothing has taken its place. Perhaps what the Russians and the Americans are doing with the space station program is the beginning of other joint experiments, which is one way mankind sublimates this need for challenge.

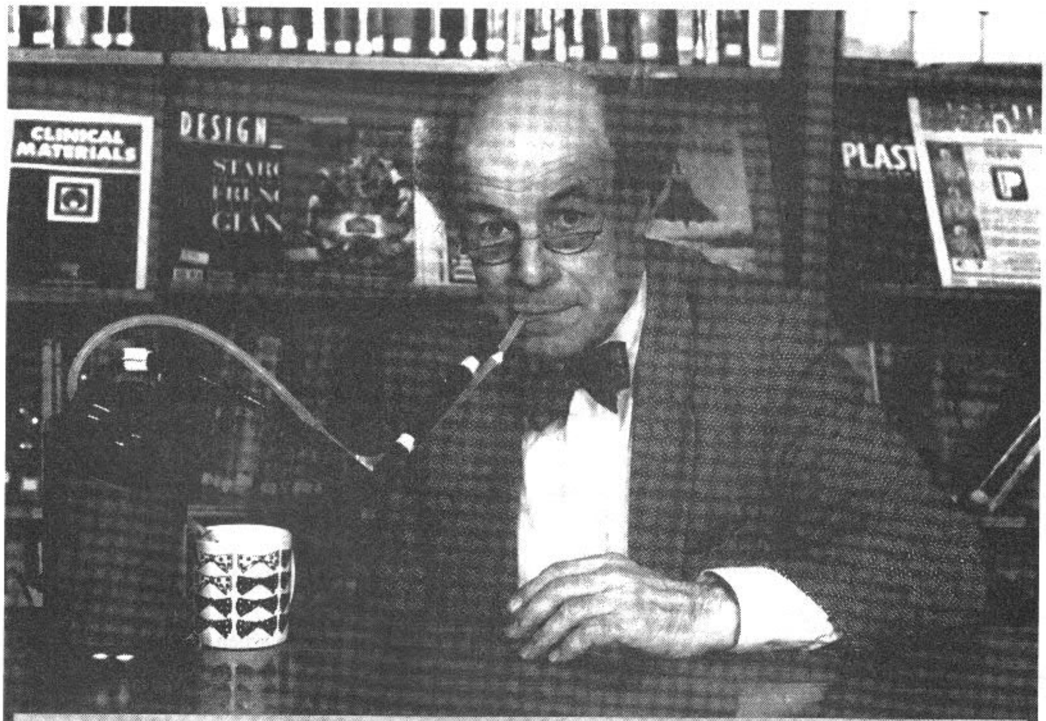
Where do you think is the best place to put a space station? What about the zero point between the earth and the moon if you are investigating microgravity?

Well, microgravity can be investigated in an earth orbit, and it's very much easier to get there, to resupply it. The only way a space station makes sense is as a base camp, a proving ground for technology to go further. How to work in microgravity is a problem we have to solve, but it's only as important as other branches of investigative science.

What puzzles me is the false economics of it: if a country has unemployment, and a project doesn't require a major proportion of the country's resources, the work will reduce unemployment and create a degree of social harmony. So I am sceptical when some European minister says there's something they can't afford to do. All that happens is that the money rotates more quickly. I would love some economist to explain it.

Do you think we doing enough in schools with new technology courses?

I now think it's a mistake to introduce technology into schools except as a vocational subject. Pupils should either come out of school able to perform at a practical level, or technology should be taught as a cultural subject, about what it does and can do for society. One of the problems in science and technology and mathematics is that people need to know it at two levels. There's what I call "Science for the Citizen", which is the title of a book written around 1939 with all the science which everybody ought to know. This is different from science for somebody who wants to use it professionally. It's difficult to teach pure physics to children without a certain mathematical ability, but everybody could have science or technology or mathematics for citizens, which allows them to cope with the television set and the mortgage, how baking powder works, how vaccines work. It would be taught differently, probably by different people. These two strands of education are becoming incompatible.



Autosip - Designed by "Tools for Living" team at Brunel Institute for Bioengineering

When GCSE first came along the intuitive element was introduced - put a set of bits and pieces in front of the child, a few basic questions, and ask them to put them together and come up with some results.

I now think the fashion for learning by experiment is a mistake. It would be wonderful if you had all the time in the world, but to solve problems without knowing about them is an extremely frustrating process, and it's only the brightest child who I think has the ability to garner the knowledge reasonably quickly. Children enjoy going through manipulative forms of education like doing sums, because once you learn them, you can get the right answer. To teach children practical skills with numbers and language, which is partly practice and partly didactic, is a good idea. Unless the child can read, most knowledge remains inaccessible. Yet there are 13-year-olds who cannot read with pleasure or confidence. And it seems to me to be almost criminal to operate an educational system which doesn't open the gates of competence and manipulation and numeracy and so on. Then I think you've got to have a bit of science, doing experiments or problem-solving, finding the density of mercury, or making an electronic oscillator and so on.

This gives pleasure and excitement. But schools now find things which used to be interesting are no longer permissible, because they are regarded as dangerous. Yet there is no statistically valid evidence that any appreciable number of children have been hurt learning science in schools. Bicycling to school is an infinitely more dangerous process.

So are we now overprotective, worried about the consequences?

Almost any human activity which is advantageous has a small overhead of risk. Take that very tragic accident with the van. If driving pupils to a concert is now inhibited, it would be a great pity. Every advantage you give your children does have a bit of risk attached - skateboarding, bicycling, climbing, and somehow society has to accept that if people take all reasonable care they should be absolved from blame. Otherwise society will strangle itself in its own health and safety regulations.

Certainly for young men and probably for all people risk is a bit like vitamins. If you prevent people from taking risks then they manufacture their own, and quite often these are anti-social. Risk-taking is absolutely fundamental to humanity and probably one of the things that drives us forward - some people take to the Stock Exchange, some people climb, some have extra-marital affairs. Humans go out of their way to take risks for thrills. Society will have to allow people to take risks if it wants to bring things like vandalism and crime under control. There have to be many dimensions of risk-taking to suit all tastes.

What about a lateral approach to design, with greater risks, and the possibility of a giant leap ahead?

I think this is only true of technology. It doesn't do society much good, because it's only a tiny proportion of society which is involved in this. The criminalising and vandalising classes by and large are not in the engineering or creative professions, but they have the same need for risk. I don't know whether virtual reality can satisfy some of this; I suspect not. I suspect there has to be a real risk, a bit of real danger, to satisfy the more extreme form. We are only a trivial number of generations away from a tribal hunting structure, where survival of a tribe was dependent on the young men, who were largely expendable, taking risks.

A creative person is also prepared to take risk. The apparent different success rates in creativity between man and women may be partly explained because, for very good biological reasons, women are probably more risk-averse than men, because the whole responsibility for the continuance of the tribe rests with them. You don't need many men for the race to continue. One the other hand, women can work on risk-averseness to overcome the apparently different success rate in the creative stakes between the sexes. Lack of opportunity should be a decreasing factor.

What about your interest in designing systems for the disabled?

It is the proportion of over-80s which will increase. It is an important humanitarian problem that society hasn't the mechanisms yet for a world where it is possible to compensate for physical wearing-out, but not for the mental part. I do believe that mankind has become what it is through the cooperation of hand, eye and brain, and if it hadn't been for these magnificent hands we've got, we wouldn't have developed the brain. We are throughout our lives dependent on tools of all kinds. In early human civilisation, the elderly did not play much part because there weren't many of them. Now we require a toolkit for this section of the population. We've called these Tools for Living. The real reason for founding the Institute, ten years ago was to put myself in the Tools for Living business, to see whether it's possible to mobilise technology for this section of the population, to make it easier for them to care for themselves, and for other people to care for them. Possibly even - this is highly controversial - to allow people to have a better assessment of themselves if they feel that enough's enough. Even 50 years ago I lectured about how it would become respectable to make a decision while in your right mind, as distinct from appointing an executioner by having somebody writing on your hospital notes 'do not resuscitate', that you really feel that 75 or 78 or 85 years are enough and you want a way out. These are all implications of technology.

I'm always rude to green ecologists unless they have a definite policy on population

You mentioned health checks. Do you think that we will all be 'called in' every so often by the turn of the century?

I think it would all be voluntary. People already have medicals even though the preventative effect of regular medicals is not proven. People might be educated to be more aware of the signals their bodies send them. We still have more sensitive transducers inside ourselves to tell us that we are not well than are easily available diagnostically.

It would be intolerable to be compulsorily health-checked. The authority could say, well, you are no longer roadworthy, I'm afraid you've only got another six months! But I think there would be a withdrawal of the State from whole areas of human acitivity, a rather tough time for people who either aren't able, or haven't the means, to look after themselves or their future.

Do you think that charities should take a greater involvement?

They already do. I work with a number of charities, and if I was to show my political colours I would say that none of us has nay rights but we all have obligations, which means looking after the people worse off than yourself. And I think we have now seen that a society which stands on its rights is probably not a very effective society. It's a very disputable point, and it used to be one of the big divisions between political opinions. Personally I believe that charities are a very important force in society, both for the people who give, and who take.

The human race has astonishing powers of survival and adaptability. Think what humanity can survive, from solitary confinement in Siberia for thirty years, to space flight. I have no fears about the survival of mankind, because mankind will simply adapt. Even if we made a mistake which wiped out 99% of us, 100 years later we'd be back. However, this might be not a good prospect for the individual.

Do you think global pollution has been blown out of proportion?

This is what the Gaia Hypothesis is about. The earth is quite capable of looking after itself. But it's probably not a good idea to pour mercury or cadmium into the sea. I wouldn't necessarily take the same view about the greenhouse effect, because it is swings and roundabouts ...

Maybe its just a blip in history. We think that there's an excess of CO_2 at the moment, but ...

Long before oxygen, there was almost certainly a lot more CO_2. Perhaps also the use of solar and nuclear energy may make it unnecessary to burn fossil fuels, so the problem may only be there for a few years.

What about population growth?

I'm always rude to green ecologists unless they have a definite policy on population. If the population grows unchecked the world will become a less pleasant place. I would like to show that - not by coercion, as the Chinese are apt to do, but by demonstrating to people that they will be looked after in old age, they don't have to have lots of children just as an old age provision. I spent a summer in Norway, a particularly empty country, and it is a less stressful society. I think mankind is a relatively solitary animal, living in family groups ... not like an ant.

If the population of Britain was cut by 10% to about 40 million, the road and rail system would be big enough, there wouldn't be a housing problem. I don't think that this can be contemplated, but in most developed countries populations are barely being maintained. Certainly in a place like Russia, populations are now dropping.