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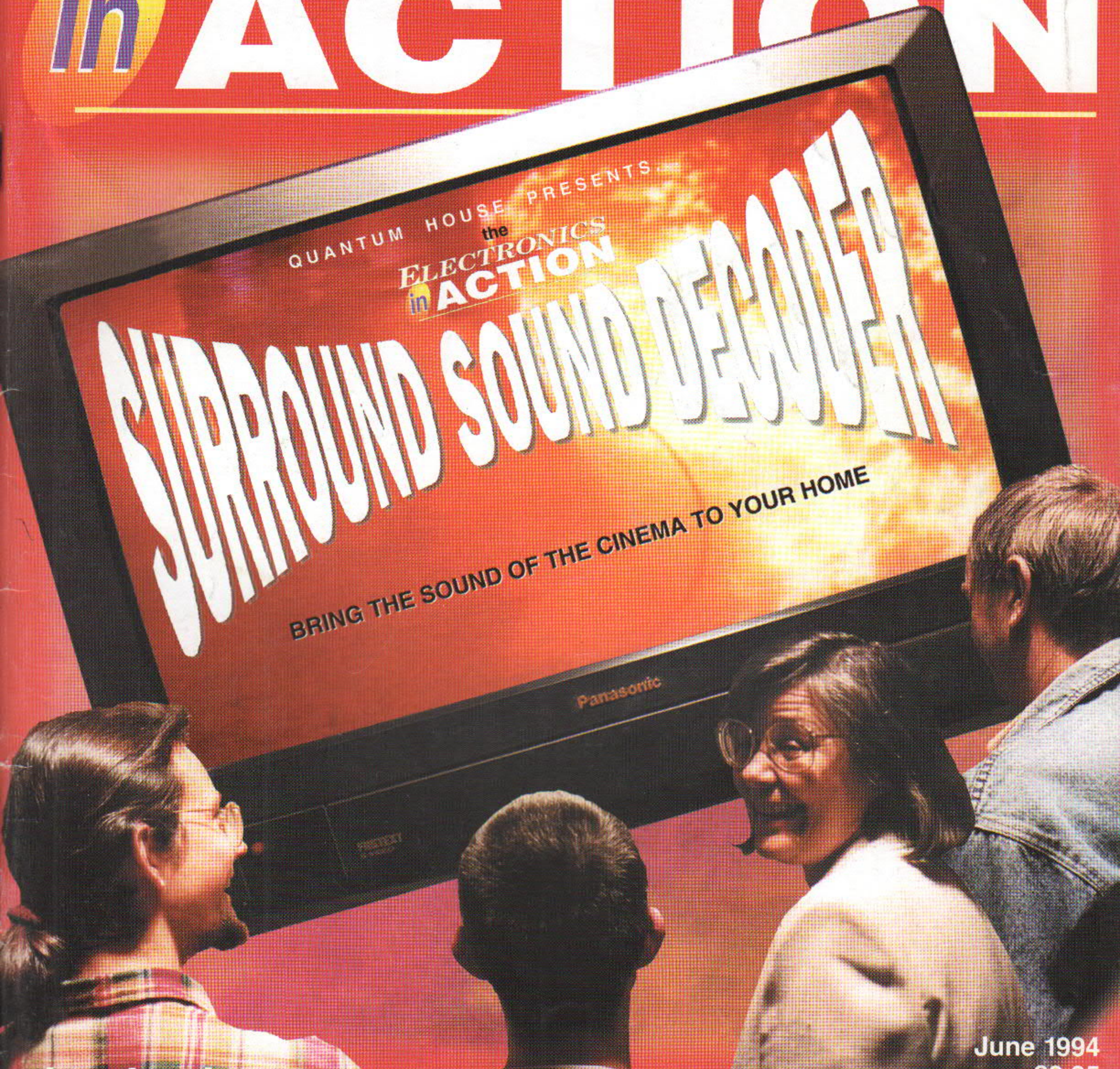
ELECTRONICS in ACTION



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ELECTRONICS in ACTION

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EDITOR
Paul Freeman-Sear

NEWS EDITOR
Geoff Martin

DESIGN and TECHNICAL ILLUSTRATION
Iain Houston

CONTRIBUTORS
Dr. Pei An
Douglas Clarkson
John Linsley-Hood
Mike Meechan
Brian Padgett
Peter Roberts
Paul Springate
Paul Stenning

ADVERTISING SALES
Gilly Martin
☎ 0442 842069

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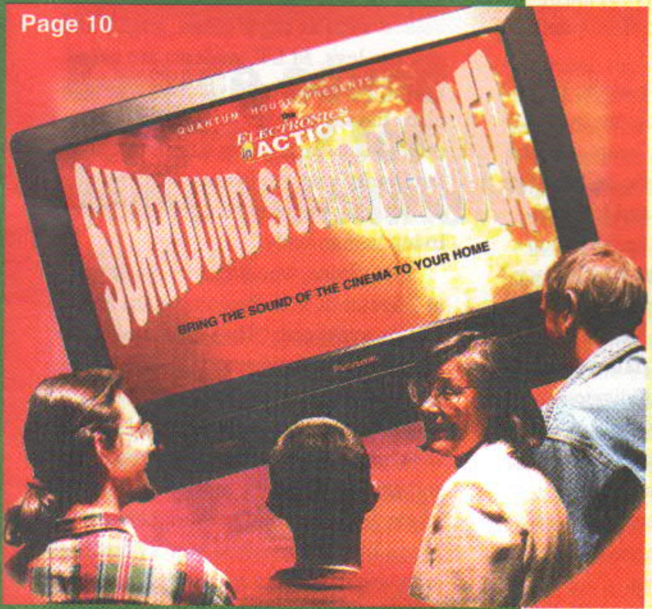

Quantum House Publishing Ltd.

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

Realising Aims

It is pleasing to see some of our aims and objectives materialising. Ideas suggested within these pages have been adopted, developed and working prototypes have been produced.

Also there has been a keen interest in some of our projects for commercial development. These will go ahead with agreement from both parties.

Benefits for all

A fair and open society will bring benefits to all. The scientific community in the past has been justifiably proud of letting the world know of its discoveries through publication. To a large extent this is still the case. However, state underfunding of science in certain countries and therefore a push towards commercial sponsorship, has led to a tendency to be more secretive with any scientific discovery. The resulting competitive element in some quarters has changed the race for publication to a race for a patent. The paranoia can extend even further if there is a mistrust of the patents system and the idea or formula remains in the head of an individual. A huge amount of money might be expected from an inventor before the secrets of the wonder cure/drug/material/machine are given up. If nobody can agree terms, owing to a mistrust, all possible benefits can be lost.

In an open and considerate society everybody gains. We hope this magazine is providing that service of an open exchange of ideas.

Paul Freeman-Sear

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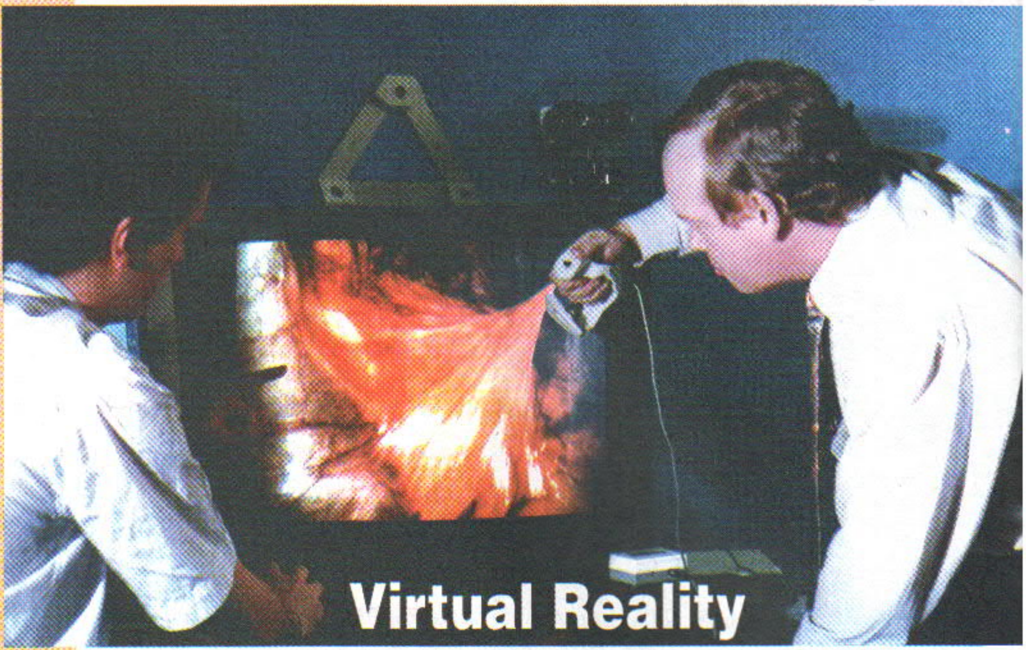
NEWS



Virtual Reality for keyhole surgery

A joint initiative between The Department of Health and The North of England Wolfson Centre has set up a satellite research centre based at Manchester Royal Infirmary to resolve many of the training problems associated with Minimally Invasive Therapy (M.I.T.) or keyhole surgery. The technological input for this project will come from Professor Bob Stone and his team at Advanced Robotic Research Limited, based in Salford.

M.I.T. is seen by many as the biggest revolution in surgery since the introduction of anaesthetics. Four years ago, the country's first Laparoscopic gall bladder removal was performed, and it is estimated that four fifths of the fifty thousand Cholesystectomies that take place every year will use laparoscopic techniques in 1994. Naturally, such a high take-up rate has produced training problems. These problems are mitigated slightly because the operation is monitored by the whole surgical team as a miniature camera inside the abdomen displays progress on a 24inch screen. However, a series of recent critical articles in the press has highlighted the problem.

Rory McCloy, the Clinical Director (North West) of the North of England Wolfson Centre for M.I.T. will be in charge of the satellite centre. He commented: "M.I.T. calls for a range of skills completely different from those of ordinary surgery. Instead of using our hands, we do everything remotely with instruments whose movement is the reverse of a corresponding hand movement. Also, the screen shows the operation in 2D and you can't easily see what is behind the operation site. I went to the United States for my M.I.T. training, but this is simply not feasible on a large scale. We currently rely on an apprentice system called proctoring, videos and laparoscopic simulators. The simulators are not replicas of the human body. They are boxes filled with small, fiddly objects such as sugar cubes, grapes and chicken legs. M.I.T. students are asked to peel the grapes and chicken legs and place the sugar cubes on top of one another. Such tests improve dexterity and familiarity with the instruments, but they do not fully prepare them for M.I.T. on a living human body."

Prof. Stone, who will take on the role of Director of V.R. Research at the M.I.T. Centre, explained: "The virtual reality programme is designed to fill the gap between the simulator and a real body. Using a simulator, students of M.I.T. will see virtual internal organs on the monitor and their actual instruments will move inside the virtual body just as they would in real life. There will be sensory feedback to the instruments in real time. Surgeons will be able to practise different operations many times. It will even be possible to programme in differing degrees of difficulty by covering organs in fat or scar tissue and moving organs around, thus placing the surgeon in an emergency situation without placing a patient in any danger. This application is believed to be the first actual use of virtual reality in British surgical practise."

Longer telephone life

Mitsubishi is announcing the introduction of a new package deal for its MT7 cellphone which is now available complete with one standard and one extended battery.

The analogue ETACS hand-held cellphone, one of the first products to comply with the new TACS-2 specification, measures just 156x5x18mm. This award winning design is packed with high performance, high quality operation features.

As well as the new battery specifications, the phone comes complete with a rapid charger that incorporates a battery conditioning facility. The standard Ni-Cad battery provides typically one hour of talk time or eight hours on standby. The extended battery typically provides 110 minutes of talk time or 20 hours on standby.

The ergonomically designed cellphone is easy to use and programme and just slips into the pocket when not in use. A fully handsfree car kit is available for continuous in-car use, with an optional 3W booster to increase radio power to Class 2.

For occasional mobile applications, a cradle and cigarette lighter power connection can be supplied.

Up to 99 telephone numbers can be stored and fast recalled from memory and a one touch fast dialling key is provided. Additionally the cellphone features memory scrolling for fast number search and the Mitsubishi MT7 will also automatically retry network engaged telephone calls.

Resettable functions include a received call number display to identify unanswered incoming calls. Automatic answering for hands free operation is also available. The last three numbers dialled can be fast recalled and talk time logging is provided for received and transmitted calls individually and as running totals.

Status indication is provided for Power On, Signal Strength, Battery Condition, No Service, Roam and Function. The keypad features slow acting Power, Send, End and one touch dial memory keys. The clear display provides up to three lines of ten characters and the LCD viewing angle 5 user adjustable to individual requirements.

Volume control is incorporated and the volume can be automatically escalated as a call continues to be unanswered. An audible warning is provided for low battery, and a mute function and silent scratchpad are also provided. A resettable lock prevents unauthorised use of the phone.

8-voice sound generator for game machine market

A new 8 voice ADPCM sound generator IC offering highly flexible sound effects features has been introduced by Yamaha for the games machine market, and is solely available in the UK from Polar. Alongside the device, Polar is offering a low-cost 16-bit Yamaha DAC, plus an effects processor IC if required to generate a complete, cost-effective and highly integrated system for generating an audio environment in games applications.

Key features of the YMZ280 ADPCM sound generator are its ability to generate 8-channels simultaneously from an input which can be 4-bit ADPCM, or 8/16-bit linear PCM for high quality applications. The device offers the capability to sample at frequencies of up to 44.1kHz, enabling CD-quality sound reproduction to be provided, but also offers a minimum sample rate of 172Hz. An external address space of 16Mbytes is available for wave data, stored in ROM or SRAM. Other features include the ability to loop voices, pan them, change the sample rate - and digital attenuators are provided for each channel. Wave data can be rewritten during sound playback.

Alongside the YMZ280, Polar is offering the Yamaha YAC513 as a low-cost, yet high performance DIA converter. For systems requiring the introduction of advanced sound effects, a YSS-225 effect processor can be added between the output of the YMZ280, and the input of the DAC. The YSS-225 offers the designer effects such as reverberation, delay, flange, distortion and auto-panning. Each effect is applied to each input channel independently and simultaneously by transferring set up data to the YSS225. The device offers a maximum delay time of 1.5s, and has sampling frequencies of 32KHz to 48KHz.

For further details please contact Gary Spinks, Polar Electronics, Cherrycourt Way, Leighton Buzzard, Bedfordshire, LU7 8YY.

ROMANSE in Hants

Hampshire County Council's ROad MANagement System for Europe (ROMANSE) project will be increasing its visibility among Southampton's motorists this summer.

Contracts have been awarded to Siemens Plessey Controls Ltd. (SPCL) for two innovative systems. On the street, moving messages will appear on signs to provide up-to-date information to drivers. Additionally, Southampton will also see the first urban application of the Automatic Road Traffic Event Monitoring Information System - ARTEMIS - in the traffic information centre (TTIC) on Town Quay.

Variable message signs have previously been used in the UK to support traffic management measures and more recently to reinforce speed limits at motorway roadworks.

Moving messages will advise motorists in Southampton of accidents, congestion or other disruptions affecting the road network within the City. This will allow drivers to take avoiding action, to prevent increased congestion and disruption.

In addition to the mobile units, Route Guidance variable message signs in the central area of the city will provide information enabling motorists to modify their journey out of the city if congestion or other factors affect their usual route. The signs are unique to the project and will provide specific traffic information rather than just general directions.

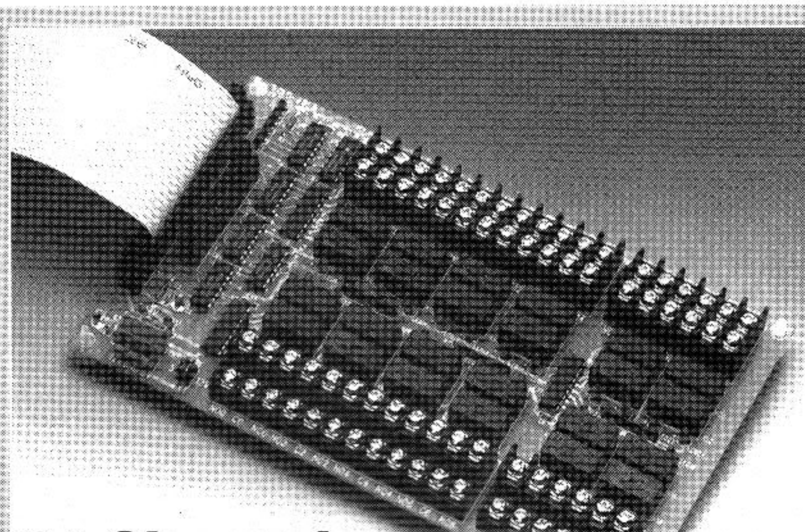
Car parking messages will give motorists information about the availability of spaces in city centre car parks. The signs indicate which area of the city the car park is in using a novel colour coding system. Drivers will be able to see the actual number of spaces available in each car park as they approach and thus target those with spare capacity.

ARTEMIS

The system works by comparing the relative speeds of moving and stationary traffic through a complex computer analysis of images from the project's closed circuit television cameras. Having identified stationary vehicles which may be indicative of congestion, breakdowns or accidents, ARTEMIS alerts the road network controller by flashing an 'alert message' onto his or her display screen.

ARTEMIS will accumulate on computer, statistics on traffic flow and volume. These will then be used to assist in the prediction of future traffic flows and aid long term planning for specific events.

ROMANSE is partially funded by the EC's DRIVE II programme, it is one of the leading urban traffic management projects in the country.



24 Channel Relay Switching

Integrated Measuring Systems has announced the PCLD-785B board as a new addition to the PC-LAB range. The 785B offers 24 channels of SPDT electromechanical relay switching, while maintaining compatibility with 16-channel applications with dual host connectors. A 50-pin Opto-22 compatible connector accesses all 24 channels, whilst a 20-pin flat cable connector accesses 16 channels. The board automatically switches control logic to match the connector-negative logic for the 50-pin connector and positive logic for the 20-pin connector.

Each relay has three contacts: common, normally open and normally closed. Convenient screw connector strips on the card sides facilitates wiring, and LED indicators on each channel indicate its On/Off status.

The PCLD-785B is an economical solution for applications which control a large number of outputs, such as signal switching, On/Off control, alarm activation and test automation.

For further information contact Max Toti on 0703 704301.

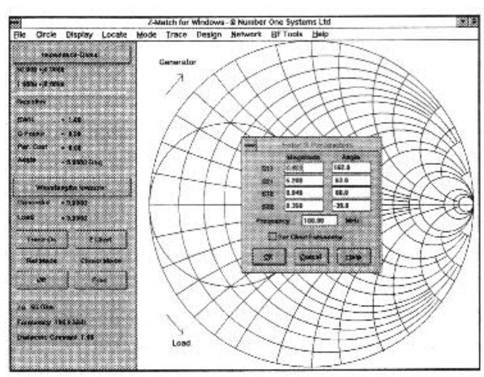
WINDOWS based CAD Toolkit for RF Engineers

The paper Smith Chart, invented over 50 years ago, provides a graphical method for solving impedance matching and transmission line problems.

The new Z-MATCH for Windows program from Number one Systems greatly increases the usefulness and accuracy of Smith Chart techniques, and adds a wide range of valuable Radio Frequency Engineering utilities.

It provides RF and Communications engineers with a comprehensive set of circuit and system design tools in a remarkably easy to use, low cost package.

It works directly with actual lengths of transmission line, and actual resistance and reactance values, eliminating the need for normalisation. The engineer can also switch instantly between impedance and admittance charts.



Direct readout from the chart gives immediate measurement of impedance or admittance parameters, equivalent component values, SWR, Q factor and reflection coefficient, and for transmission lines, distances towards generator and load.

Circles of constant SWR, resistance, conductance, reactance and susceptance can be drawn automatically and the cursor locked to these at will to provide rapid solutions to matching problems.

Also provided is a Receiver and System Design tool for calculating overall values of gain, noise figure and third order input intercept point for a series of interconnected stages made up from filters, amplifiers, mixers and attenuators. For RF amplifier designers, Z-MATCH for Windows' ability to work directly with S-Parameters greatly simplifies many design tasks. Options include plotting stability circles, the calculation of stability factor, transducer gain, maximum available gain and the source and load impedances needed to achieve it, and even the determination of the component values to provide source and load matches for specified Q.

Also included is a collection of valuable time-saving utilities for performing conversions between many of the common units used in RF engineering, for calculating reactance and resonant frequency values, for finding the characteristic impedance and length of quarter wave and other transmission line transformers, and for calculating parameters associated with Standing Wave Ratio (SWR) and losses along a transmission line.

It includes a library of over 600 sets of S-Parameter data for the popular Motorola range of RF devices.

The program requires a minimum of an AT286 running Microsoft Windows 3.0 or later, and is available now direct from Number One Systems for £245.

IBMs Infobase in Notts

IBM UK has teamed up with Nottinghamshire County Council to develop Infobase, a unique information system for young people across the county.

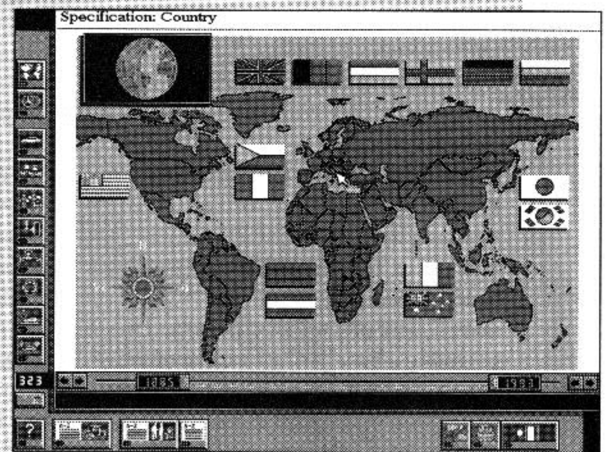
Infobase is an interactive touch screen computer, housed in a small kiosk about the size of an automatic cash dispenser. Developed by IBM, specifically to meet the requirements of the National Youth Agency's (NYA) National Youth Agency Focused Access Information system (NYAFAIS). INFOBASE uses state of the art multimedia technology to provide instant access to an extensive database of information.

The project has been developed to support and strengthen an NYA initiative to Open Information Shops across the country. INFOBASE enables its users to access a comprehensive bank of information, relating to issues that affect young people. Categories include Education, employment, housing, money, leisure and relationships. The effectiveness of INFOBASE was tested by local youth before the design was finalised.

The IBM technology, fronted by colourful computer graphics, allows users to obtain information at the touch of a screen, by responding to simple prompts. The prompts guide the user to the precise information they require. The 'user friendly' technology means that the system can be operated without assistance from others - giving instant privacy to those who require information of a sensitive nature. Leaflets and brochures held within the Information Shops offer additional back-up to the information displayed on screen.

First ever Moving Picture Library on disk

On March 2nd 1994, Software Partners launched their Infoware range, the UK's first ever interactive, multimedia reference books on disk; a dramatic breakthrough in PC software technology. An initial selection of 6 titles, each priced around £29.99, are now available from Boots, WHS, and other major high street retailers in addition to computer specialists including Byte, Staples, Icon and PC World.



Each 'book' has a distinctively entertaining character of its own, imaginatively combining text with colour photographs, live video action and ingenious moving explanatory graphics. There are even sound effects for those with multimedia equipment.

Paul Ward, Sales and Marketing Manager of Software Partners explained; The emphasis is on fun, 'edutainment' if you like. Even the controls have been designed with a splash of humour. My staff have been amazingly keen to take their work home!"

The first 6 titles cover a diversity of subjects. For those planning a break, 'Summer Sun' and 'Ski Europe' offer refreshingly painless, foolproof holiday planning. The fussiest traveller's precise requirements from budgetary restrictions to the date of travel are analysed against climatic conditions and facilities in literally thousands of resorts. Upon returning from holiday excesses 'Fitness Studio' may be called for; the ultimate programme for devising, demonstrating and monitoring a personal workout schedule. 'Classic Car and 'History in Motion' (land, space, air and sea) require less active participation, but they do contain an exhaustive catalogue of detail. Equipped with a ready answer for every question, these 'books' can even identify a machines' inventor or offer a peek at the engine. 'Exploring Animals'; a fingertip zoo completes the range.

Paul continued; 'This software actually follows your train of thought. You ask a question and Infoware produces a precise, relevant answer in an instant. You can even print out a copy on paper! Subject specialists can home in on complex material immediately while beginners and young people can start with the basics."

In order to complete the library effect, Infoware include a software package that simulates a shelf of books. As each Infoware book is loaded on to the PC a star appears by the title on the spine of that book, to indicate that it is now available for use. If a user seeks to open any book which has not been installed by clicking on the relevant spine, a synopsis of the book is provided.

Research World

Technical Advances from around the Globe

Development in neural network

Research workers at the Georgia Institute of Technology are developing neural networks to aid in the manufacture of integrated circuits. By providing a better understanding of the process variables, the networks can help designers produce higher-quality chips at lower costs. The networks can also improve other manufacturing processes that require control of multiple non-linear variables.

Georgia Tech already uses neural nets to model complex semiconductor processes such as plasma etching and chemical vapour deposition. The university hopes to expand the use of neural nets to other IC processes and to provide real-time process control that will identify and help correct equipment malfunctions.

"Manufacturers typically don't catch production problems until long after they occur," explains Gary S. May, assistant professor. "The parts processed in the meantime must be discarded." Bay claims that neural nets can help catch production problems sooner, thereby increasing yields. The network would use information from sensors and other data sources on the factory floor.

Neural nets also promise to simplify design for manufacturing. They can show how design parameters translate into quality variations during production. A clearer picture of production tolerances will allow engineers to be more aggressive with their designs, says May. Circuits will not have to be slower than absolutely necessary, for example, and structural components can be made even lighter.

Manufacturing engineers, on the other hand, will benefit by knowing how process variations affect the final product. This will help them fine-tune production equipment. Such optimization now depends on trial and error and less accurate statistical methods.

Although neural nets are said to be 30 to 50% more accurate than conventional modelling techniques, May believes both methods must play a role in improving manufacturing.

New sensor interface

A new sensor-interface chip converts, scales, linearizes, and outputs data in engineering units over two industry-standard serial interfaces. In addition, it also provides excitation signals and compensation for a variety of sensors, including thermocouples, RTDs, and volt and milli-volt sources.

The API 360 is actually a computer that is configurable in software. Besides a micro-controller, the chip features a high-resolution A/D converter, input multiplexer, programmable-gain amplifier, reference, and EEPROM. Selectable input ranges include seven NIST-standard thermocouple ranges, two platinum RTD ranges, and ten voltage ranges. For non-standard sensors, two software programmable custom ranges can be stored in memory.

The input multiplexer has four channels for low-level signals and one channel for signals up to +/-10V. A precision amplifiers matches the output to the input range of the A/D converter.

Up to 32 chips can be connected in a network and addressed individually over a single interface. Using the asynchronous bus, a central controller can configure each device as needed.

Also available is an evaluation board to facilitate design. The board includes a buffered RS-232 port, clock crystal, voltage reference, cold junction compensation thermistor, and configuration switches.

New design technique for chips

The first working chips developed using a new design technique called behavioural synthesis recently went into production at the Pelco Electronics IC Design Centre in Kokomo, Indiana. With help from parent company General Motors, engineers at Pelco designed the two integrated circuits in just four months. One chip is a fast Fourier transform IC containing 177,000 transistors, the other a decoder comprising 65,000 transistors.

Behavioural synthesis tools generate IC schematics directly from C-like algorithms describing the operation of the chip. In contrast, logic synthesis makes designers work at a lower level, defining and optimizing blocks of logic. Instead of writing behavioural algorithm, designers must enter Boolean equations and other low-level commands.

Chipmakers have been developing behavioural design methods for many years, but Pelco claims to be the first to produce commercial ICs using the new technology. The final hurdle, says Pelco, was getting its behavioural software to share data with commercial design automation tools.

Pelco engineers created two DSP algorithms using a language called Verilog. They then used a proprietary behavioural design tool called AutoCircuit to convert the algorithm into a netlist of circuit modules, including adders, substractors, state machines, memory blocks, and control logic. The netlist was fed directly into a physical design package from Cascade Design Automation, Bellevue, Washington, and automatically compiled into a circuit layout verified for timing.

AutoCircuit was developed at General Motors Research and Development Centre, Warren, Michigan. Without AutoCircuit, designers would have spent several months just entering schematics. Pelco plans to use behavioural synthesis for all fast-turn datapath-based ICs.

Dry sodium injection for fluegas desulphurization

With completion of the first of its two dry-sodium injection systems for fluegas desulphurization, NaTec Resources Inc. of Rouston, claims to have proved the commercial viability of technology to reduce SO_2 emissions by up to 90%. A system was placed in service recently for Wisconsin Electric Power Co.'s plant, to be followed by completion of a second system next year. Advantages of the technology include its ability to adjust to various levels of SO_2 reduction.

Paul Stenning ushers us into the cinematic world of surround sound at home, with his complete decoder.

Get Surround,

Like many owners of stereo satellite receivers or NICAM stereo equipment, I have connected the audio output to my hi-fi system. This gives a vast improvement in realism, particularly with films. However, by comparison to the cinema, there is still something missing! One thing that really makes a visit to the cinema memorable is the Dolby Stereo surround sound system.

Nearly all new films are made with Dolby Stereo sound. The surround sound information will often remain encoded into the stereo soundtrack when the film is transmitted by satellite or in NICAM stereo, or released on video. The Sky Television film channels have a "Dolby Surround" caption at the beginning of these films. These are also indicated in some television listing guides by the letters "SS", but this does not seem to be too accurate in the magazine I use.

There are some excellent Dolby licensed decoders available for home use, however these tend to be rather expensive. The unit presented here is a "sound-alike" circuit which, while not performing quite as well as the real thing, gives superb results for a more affordable price. An 8-watt power amplifier is included to drive the rear speakers.

Construction is straightforward, probably the most difficult part is drilling and preparing the case. The completed unit needs no setting up or alignment.

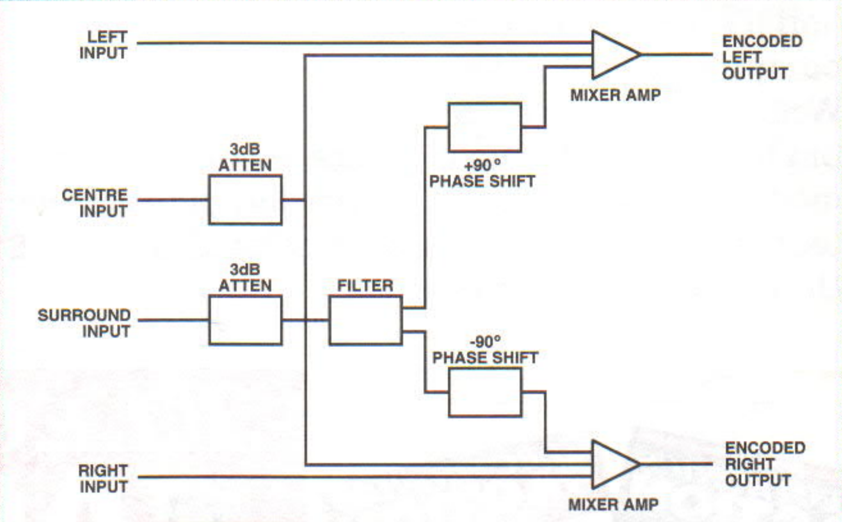


Fig.1 Surround sound encoding

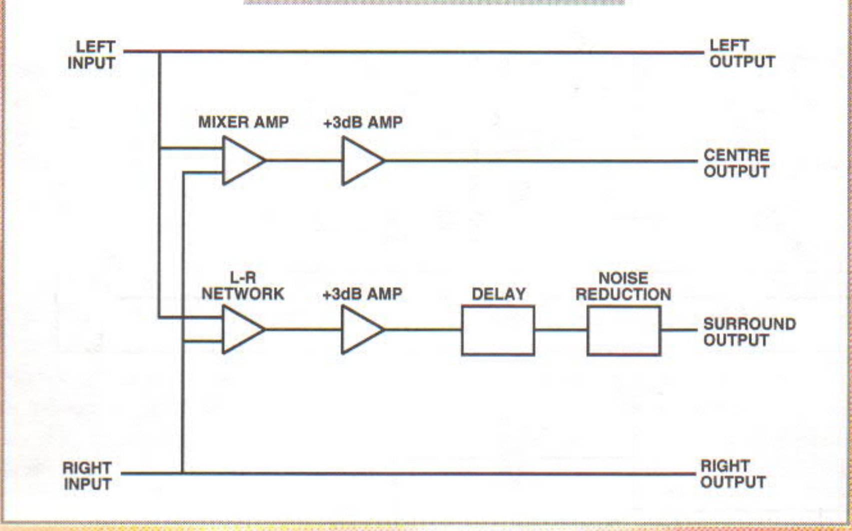
Surround Sound Operation

The professional system used in cinemas has four channels, Left, Right, Centre and Surround. The Centre channel is necessary in a cinema, to ensure that people sitting to one side of the auditorium do not miss the effect. It also fills the gap caused by the Left and Right speakers being so far apart. A Centre channel has not been included on this more basic home system, since the effect does not have to cover such a wide area.

When the system was developed, the most common cinema film format was 35mm, which has provision for only two sound channels (the 70mm format now commonly used in larger cinemas has four sound channels). This presented Dolby with the problem of encoding four channels into two, in a way that could be replayed successfully on a two-channel stereo system without a suitable decoder.

A basic form of the encoding system is shown in Figure 1. The Centre channel is attenuated by 3dB and added equally to both the Left and Right channels. The Surround channel is attenuated by 3dB before passing through a filter circuit having a pass band of 100Hz to 8kHz. The signal then passes through a pair of phase shift circuits, before being added to

Fig.2 Surround sound decoding



round, round

the Left and Right channels, as shown.

If this is replayed on a stereo system without a decoder (like the cinema in the author's home town, until last year), it will sound fine. The Centre channel sounds will come from the Left and Right speakers equally, and will therefore appear in the Centre. The Surround signals will also come from both speakers. However, the 180 degree phase shift between the two channels will give this a very wide effect. A basic decoding system is shown in Figure 2. This is based on the original Dolby Surround system, used in older cinemas and this project. Most modern cinemas, and the more expensive commercial home decoders, use the Dolby Pro-Logic system.

The Left and Right signals pass unaffected through the decoder. The presence of the Centre and Surround information on these causes no problems, for the reasons described above. The Centre channel is extracted by summing the Left and Right signals. The resulting signal is amplified by 3dB to counter the attenuation in the decoding system.

The Surround channel is extracted by a subtraction (Left minus Right) network. In this design an op-amp circuit is used. The resulting signal is then amplified by 3dB. The signal then passes through an audio delay circuit, with a delay of between 10 and 30ms. On this unit the delay may be switched to either 12 or 24ms. If sounds come from both the front and surround speakers, those from the rear will be regarded by the brain as echoes and ignored. The delay also gives the sound field greater depth. Following this is a noise reduction circuit. This will reduce any stray low level high frequency sounds, while allowing louder sounds to pass unhindered. The delay and noise reduction circuits may also contain filtering components, to limit the bandwidth to the 100Hz to 8KHz specification.

This system is relatively simple, and the limitations are apparent. The delay and noise reduction systems are present to remove stray signals from the Surround channel, caused by slight imbalances and phase shifts in the replay system. The more advanced Dolby Pro-Logic system uses active signal channelling technology to ensure that any particular sound comes from one speaker only. This uses DSP (Digital Signal Processing) or similar technology, which is inevitably protected by copyrights and patents. This cannot be simulated in a form that is cost effective for home construction.

Other Uses

In this design the noise reduction and delay circuits may be independently switched out of the signal path. This may be useful for appreciating the effect and limitations of these sections.

With both sections switched out, the unit may be used to add surround effects to music. The sound is similar to that obtained from 1970s "quadraphonic" music centres, with the rear speakers connected in series between the positive terminals of the front speakers. This effect may not be to everyone's taste!

The unit can even be used to record Karaoke tapes, by adjusting the balance to cancel out the vocals. Again the delay and noise reduction should be switched off. Some bass may also be lost, but this probably won't matter too much if everyone is getting drunk!

PCB Construction

The circuit is constructed on a single sided PCB, which is available from Electronics in Action. The component overlay is shown in figure 6.

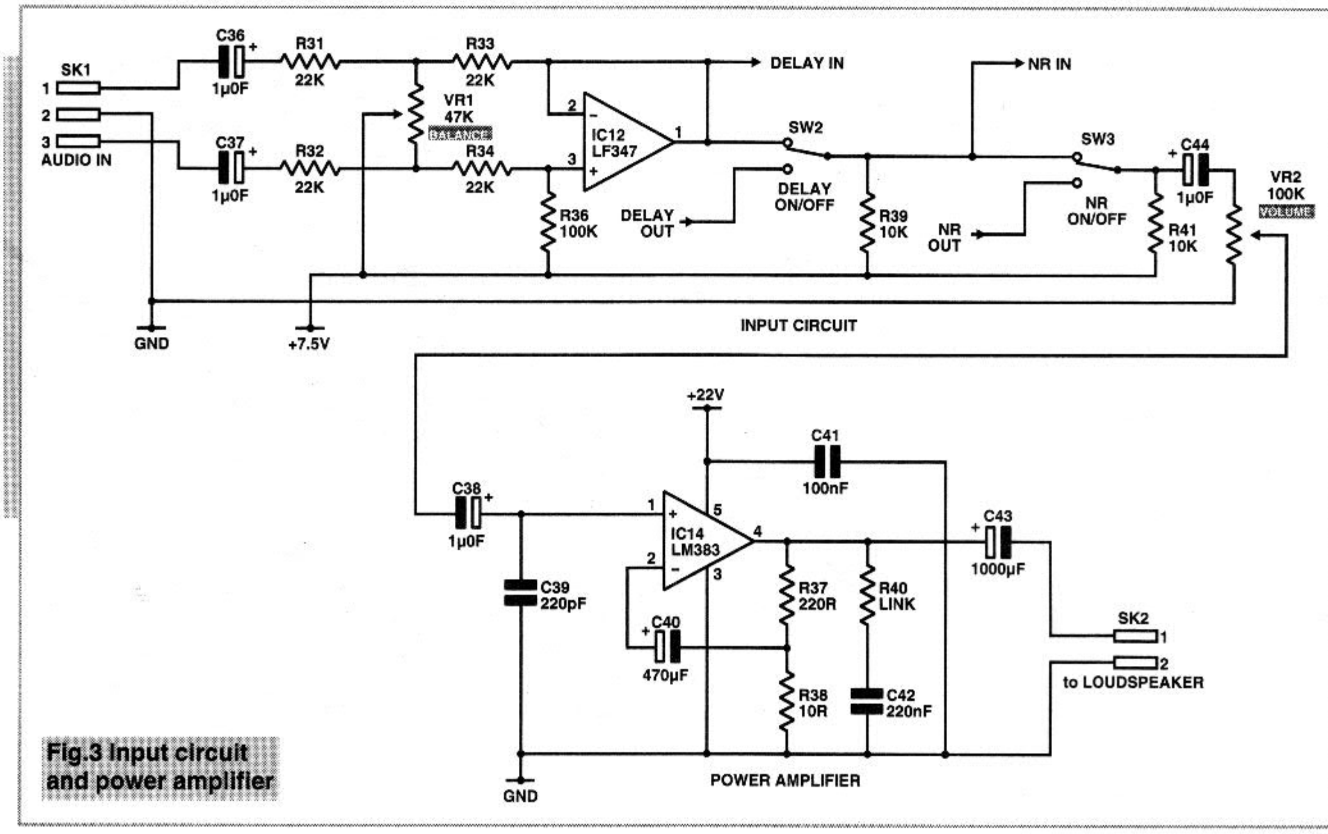


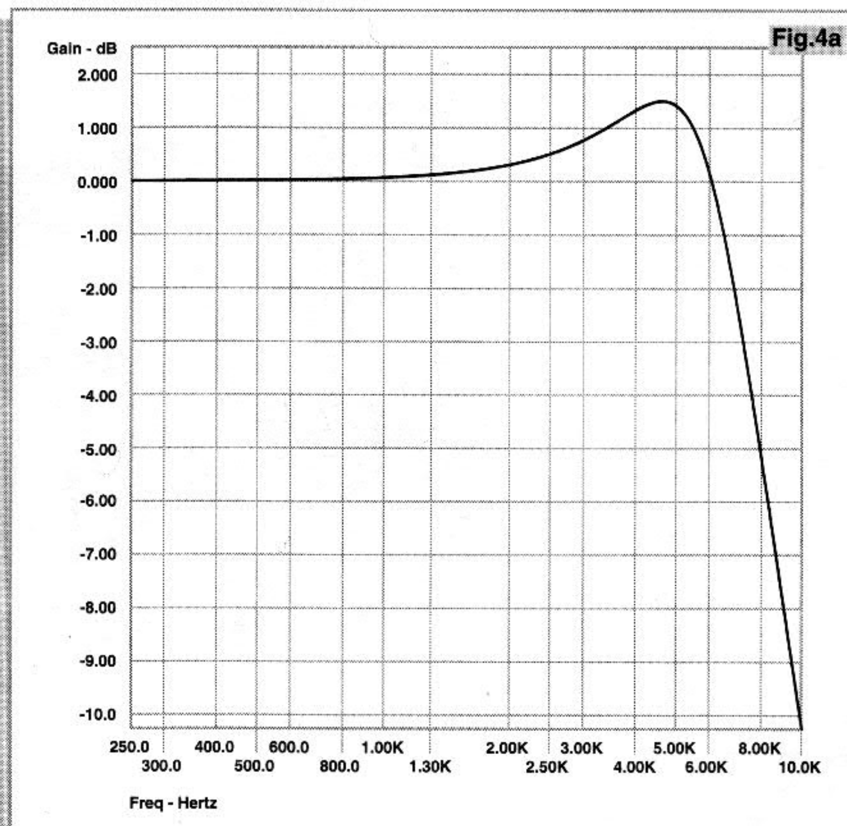
Fig.3 Input circuit and power amplifier

The Works

The delay circuit is shown in Figure 4b (logic) (A-D and D-A converters). This is similar to the delay section of the Digital Echo project, featured in last month's edition of EIA. IC1 is the clock generator, which runs at four times the sampling frequency. This unusual configuration gives an output with an approximately equal mark-space ratio. The A-D converter IC10, requires a negative bias on pin five. Since the current required in small, this negative voltage is obtained by rectifying the clock signal from IC1, giving approximately -4V.

The ZN448E (IC10) is an 8 bit successive approximation A-D converter. Nine clock cycles are required for each conversion. The eight data lines are tri-state, and controlled by the OE- pin.

The device contains a built-in clock circuit, the frequency of which is set by C26. The data sheet gives the maximum clock frequency as 1MHz, and a graph shows that a capacitor value of 100pF will give this. However tests with several devices showed that 100pF gave a frequency of only about 500KHz. To achieve 1MHz a 47pF capacitor is required. It is possible that some ZN448E devices will fail to operate with a 47pF clock capacitor. In which case, replace C26 with a 100pF component, or the lowest value that gives correct operation. R12 is the biasing resistor for the internal voltage reference, which is decoupled by C25. The ZN428E (IC11) is an 8 bit D-A converter, which uses an R-2R resistor network driven by an accurate voltage reference. This reference is biased by R15 and decoupled by C27. A latch circuit on the data lines is controlled by the EN- pin. When EN- is inactive, the previous output voltage remains.



The audio signals to the A-D converter and from the D-A converter pass through identical low pass filter circuits. These have a slope of 18dB per octave and a -3dB point at about 8KHz. The frequency response of these filter circuits is shown in figure 4a. The 1dB

The Works

The audio section of the circuit diagram is shown in Figure 3. Input signals should be within the range 0.5 to 1.0 volts RMS, this is the usual level from the audio output (NOT Speaker) connectors on audio equipment.

The first section of IC12 is the Left minus Right amplifier circuit, with a gain in differential mode of about five. This gain will overcome the loss caused by the balance control and the 3dB encoding attenuation, and will give the correct level to drive subsequent stages.

The Balance control (VR1) is used to offset any difference in the level of the two channels.

This section is followed by the Delay and Noise Reduction switches (SW2 and SW3), and the Volume control (VR2). IC14 is the power amplifier circuit. The LM383 was chosen because it will drive two 4R speakers in parallel. The minimum load impedance in 1R6, and the power output is 8 Watts RMS into 8R. This device also has output short circuit and over temperature protection.

peak before the cut-off point is not important in this application.

The filter on the input to the A-D prevents frequencies too high to be accurately sampled, from reaching the converter. Allowing these signals through would result in severe aliasing distortion, leading to a poor quality output. The filter on the D-A output removes noise due to the sampling frequency, and smoothes the stepped output.

Fit the 22 link wires first, using thin (approx. 26SWG) tinned copper wire. The components may then be fitted in the usual size order. The non-polarised capacitors should have a lead pitch of 0.2", to match the holes in the PCB. Low cost ceramic or polyester devices are ideal. Use terminal pins for the off-board connections, since this will simplify the interwiring.

IC sockets may be used for the DIL devices if you wish. Opinion on this issue is varied, I feel sockets are unnecessary on single sided PCB's, because soldered IC's can be readily removed with a decent de-soldering tool. However, I would always use sockets in a PCB with plated through holes.

The voltage regulators and power amplifier IC's will become warm in operation, and should be mounted on a suitable heatsink or bracket. An 85mm length of aluminium angle was used on the prototype, as shown in the photographs, to transfer the heat to the rear panel of the case. The closest readily available bracket is the Maplin "15W Amplifier Heatsink Bracket" (order code YQ36P), although you will need to drill two extra holes.

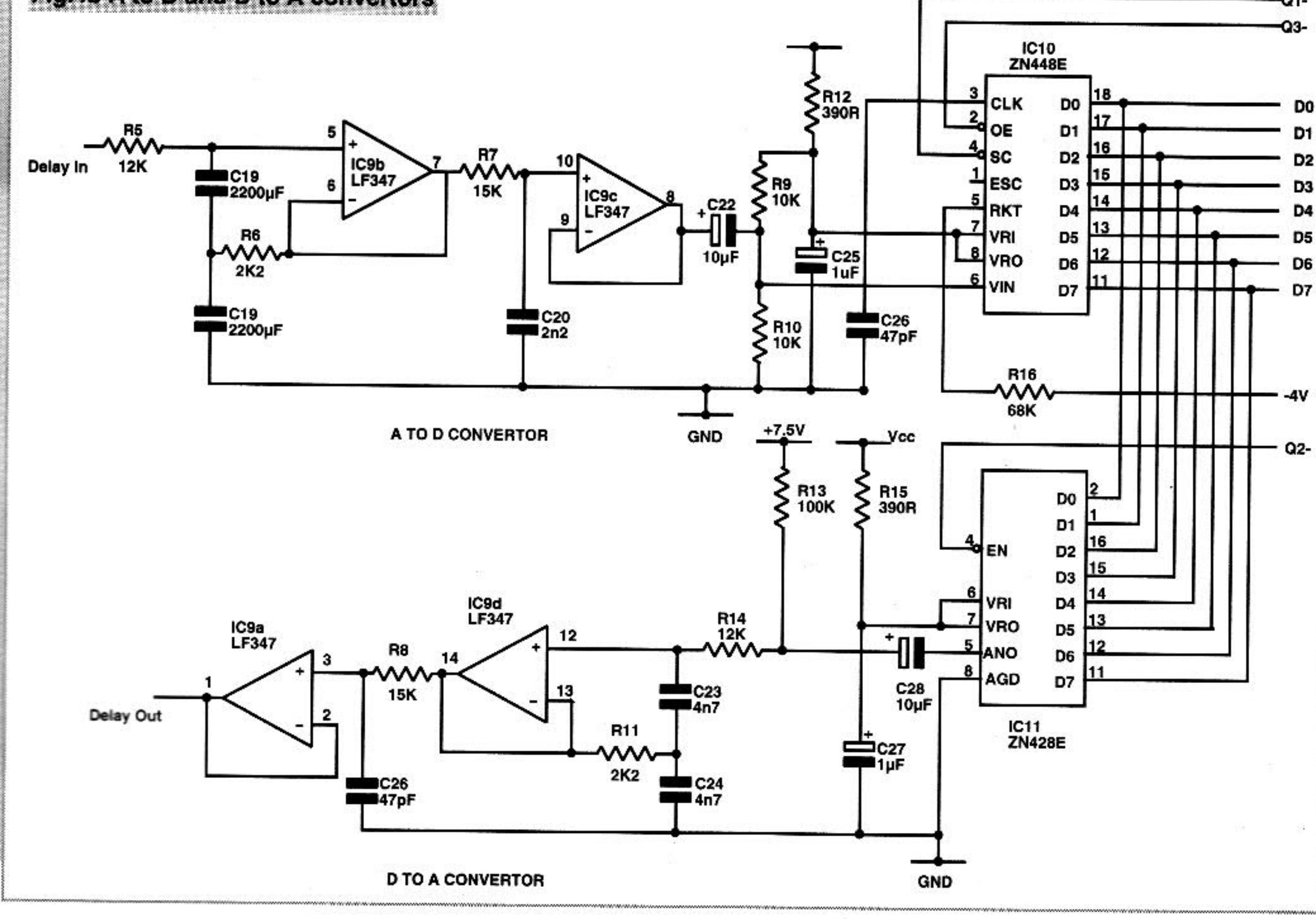
The mounting tabs of all three devices are internally connected to 0V, so insulation washers are unnecessary. This should be the only point where the 0V rail connects to mains earth.

Case

The prototype was constructed in an aluminium case, 280mm × 155mm × 75mm. This is often listed as type WB5. Before removing the protective film, check the panels are not scratched (Maplin, please take note). Once you have removed this film, you may not be able to return a damaged case for replacement.

A suitable front panel overlay is shown in figure 9. This may be photocopied (enlarge to 278mm × 75mm) onto transparent film, and fixed to the front of the box with clear self adhesive vinyl. A second paper copy can be used as a drilling template.

Fig.4b A to D and D to A convertors



The Works

IC2 produces the four timing pulses required, three of which are inverted by gates in IC3. When Q1 goes high, the A-D converter IC10 starts a conversion. When Q2 is high, the data in the RAM IC7 is sent to the D-A converter IC11, which produces the appropriate voltage. When Q3 is high, the data from the A-D is stored in RAM. Finally when Q4 pulses high, the address counter IC4 is incremented.

SW1 sets the amount of the RAM chip to be used to either 512 or 1024 bytes. This sets the delay to either 12mS or 24mS. I chose a 2K RAM chip because it is the cheapest readily available device. Observant readers may notice that the address line functions on IC7 are different to those shown in the 6116 data sheet. This was done to ease the PCB track layout. Static RAM address and data lines may normally be connected in any order, providing they are the same in the read and write circuits.

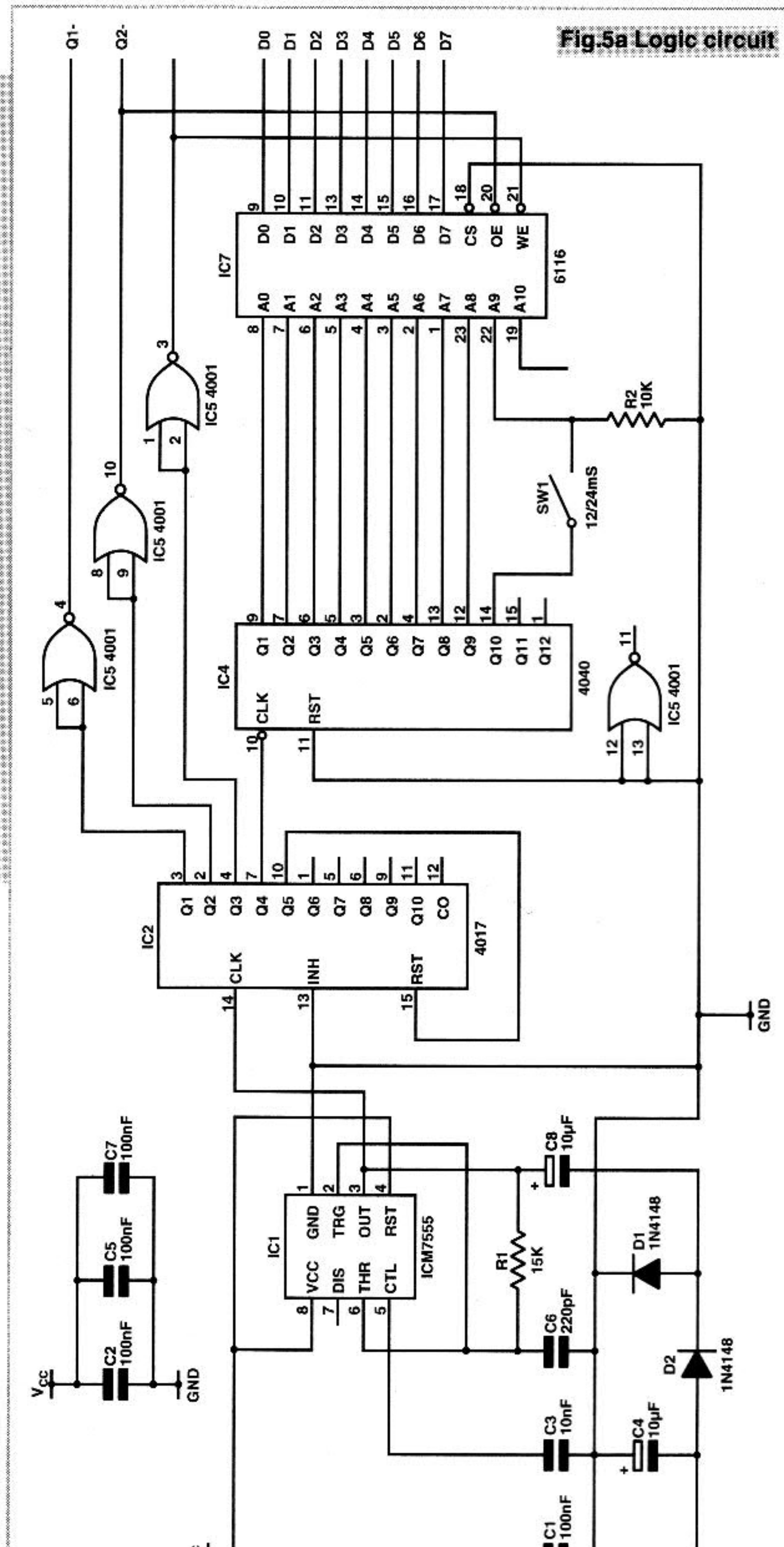


Fig.5a Logic circuit

When copying onto clear film, please make sure the film you use is suitable for photocopiers. The correct material is normally sold as photocopier overhead transparency film, and has a sheet of thin paper behind it, attached by one edge. Other types of clear plastic will probably melt in the copier, which won't make you very popular with whoever has to pay the repair bills! If in doubt, get the job done at a local photocopying and printing firm.

Five holes are required in the front panel for the pots and switches, these should be 10mm in diameter. The stops on the Power and NR switches should be set to give two positions, and the stop on the Delay switch should be set for three positions. Please use a proper double pole mains rated component for the Power switch, and not the type fitted into the prototype! The knobs used on the prototype are black plastic with chrome inserts, and are often listed as types M3 (small) and M4 (large). Mount the transformer in the base of the case, towards the left side. Check that the case lid fixing screw will not foul on it. I used a 60VA torroidal transformer on the prototype because it was to hand, however any torroidal or conventional transformer rated at 20VA (1.3A at 15V) or greater will be suitable.

Mount the PCB to the right of the case on 10mm spacers, with the heatsink bracket secured to the rear panel. Again check that the lid fixing screw does not cause any problems. The internal photograph of the prototype should make all this clear!

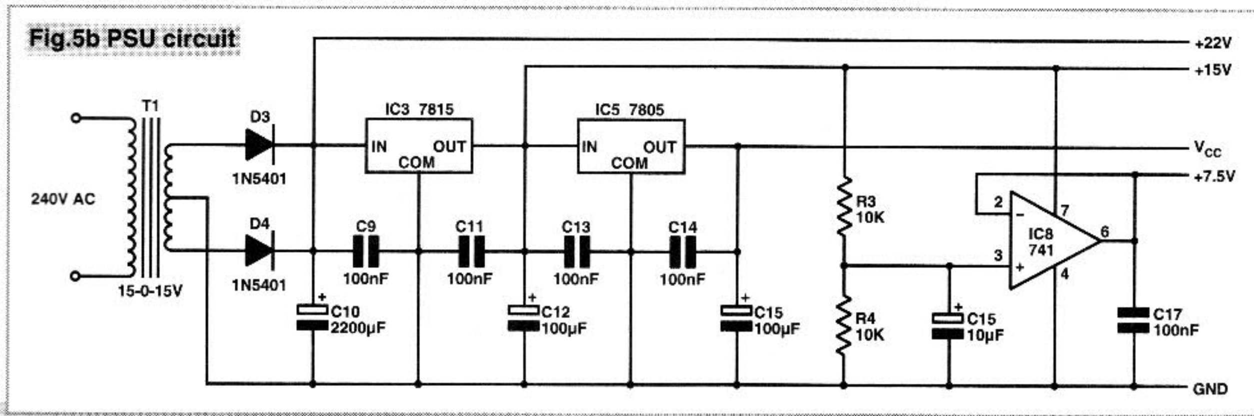
The rear panel can now be prepared, with a hole for the mains cable clamp, and appropriate holes for the audio connectors. Remove the PCB and transformer when drilling the holes.

Phone connectors were used for the audio inputs on the prototype. Use insulated sockets to prevent earth loops, the cheap phono sockets mounted on insulated paxolin panels are ideal. To simplify installing the unit into your home entertainment system, it may be useful to fit two pairs of sockets, connected in parallel. I used a pair of terminal posts for the loudspeaker connections on the prototype, again you could use whatever suits your installation.

Wiring

The internal wiring is shown in figure 8. The terminals on the PCB and controls are identified with letters, simply connect 'A' to 'A', 'B' to 'B', etc. If you intend to form all the wiring into a tidy

Fig.5b PSU circuit



The Works

The power supply circuit is shown in figure 5a. An unregulated 22V rail is used to drive the power amplifier, while regulated 15V and 5V rails power the remainder of the circuit. IC8 gives a mid-rail for the op-amp circuits. The transformer should have a rating of at least 20VA. A 10nF Class X capacitor is connected across the primary on the prototype, to remove the crackle sound from the speakers when the unit is being switched off.

loom, you may need to use screened cable for the signal connections, due to the extra length and the nearness of the cables. No problems were experienced using ribbon cable for the short point to point on the prototype.

If a torroidal transformer is used, the two primary windings must be wired in series for 240V operation. The mains input should be connected between the brown and blue transformer tails, and the grey and mauve wires should be connected together (check the label on the transformer first). On the prototype this was done on a pin of an unused section of the power switch. However since you will be using the correct type of switch (please), you will need to solder the two tails together and cover the joint with insulation sleeves.

C45 must be a Class X rated component, suitable for direct connection across the mains. If you use any other type of capacitor, it will probably explode sooner rather than later. Mount the capacitor on the switch terminals, in parallel with the transformer primary.

Connect the earth core of the mains flex securely to the metal case. No mains fuse was used on the prototype, a 3A fuse was fitted in the 13A mains plug. There is space on the rear panel to fit a fuse holder you wish. I would suggest a 250mA anti-surge fuse (T-250mA), since the initial current surge of a torroidal transformer will blow a fast-blow fuse.

The transformer used in the prototype had four tails for the secondary windings. Connect both the red and orange wires to the centre pin on the PCB (0V). The yellow wire is then connected to one of the outer pins, and the black wire to the other. Again, check the label on the transformer first.

Initial Testing

If you have a test meter, it would be a good idea to check the following voltages, before finally installing and

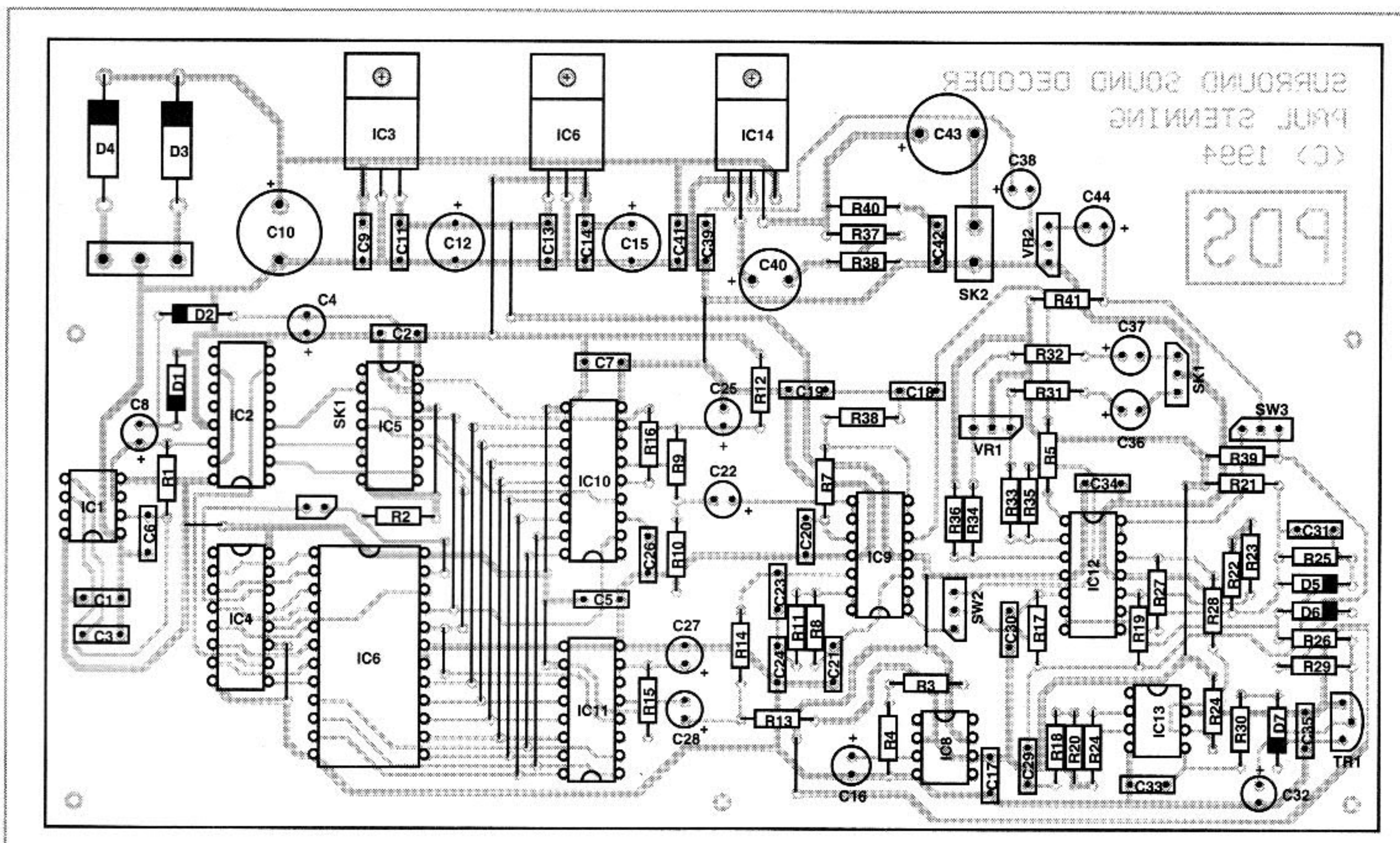


Fig.6 Component positioning

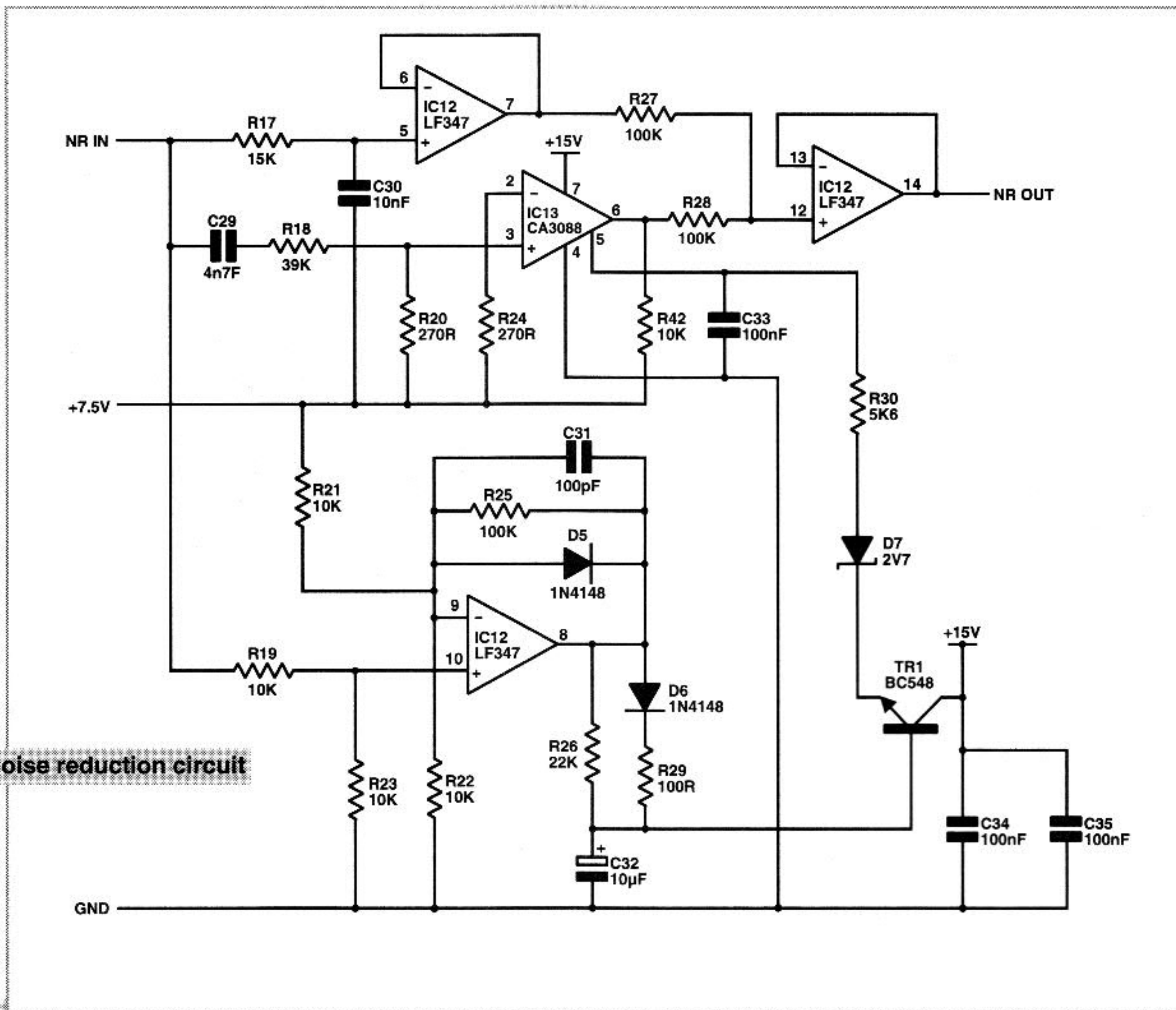


Fig.7 Noise reduction circuit

The Works

Figure 7 is the circuit diagram of the noise reduction system. A Dolby licensed decoder would use a modified Dolby B Noise Reduction system in this position. However, genuine Dolby noise reduction IC's are not readily available, and the data sheet is almost impossible to obtain legitimately. I have therefore designed a simple noise reduction circuit using readily available parts, which gives very good performance in this application.

The principle of operation of many noise reduction circuits, including Dolby B and this circuit, is to filter out more of the higher frequencies as the sound level reduces. Noise is only really a problem at lower signal levels, since it is masked by louder sounds. With systems that operate on recording as well as playback, the treble is boosted at lower levels for recording. The input signal is split into two bands. R17 and C30 set the lower frequency band. This is buffered by one part of IC12, and then passes to the output mixer formed by a second part of IC12. The higher frequency band is set by C29, R18 and R20. IC13 is a transconductance op-amp, the output current being controlled by the current into the control input on pin five. The output of this also passes to the output mixer circuit.

Thus the lower frequencies pass through unhindered, while the treble frequencies are controllable. Note that the filtering circuits are simple 6dB per octave networks, giving a gentle response.

D5 is in the feedback path of an amplifier within IC12. This causes the circuit to have unity gain on negative half cycles, and a gain of 20 on positive half cycles. Thus, the circuit acts as a half wave rectifier. The biasing gives an output voltage of about 4V with no signal. C32 stores the peak output level, this is buffered by TR1, which is configured as an emitter follower.

The voltage on the emitter of TR1 will be about 3.4V with no signal. About 2.6V is dropped by D7, leaving 0.8V on R30. Pin five of IC13 is internally connected to the base of a transistor, and should be at least 0.6V for the device to operate. As the input signal increases, the voltage on the emitter of TR1 and therefore the control current to IC13 also increases.

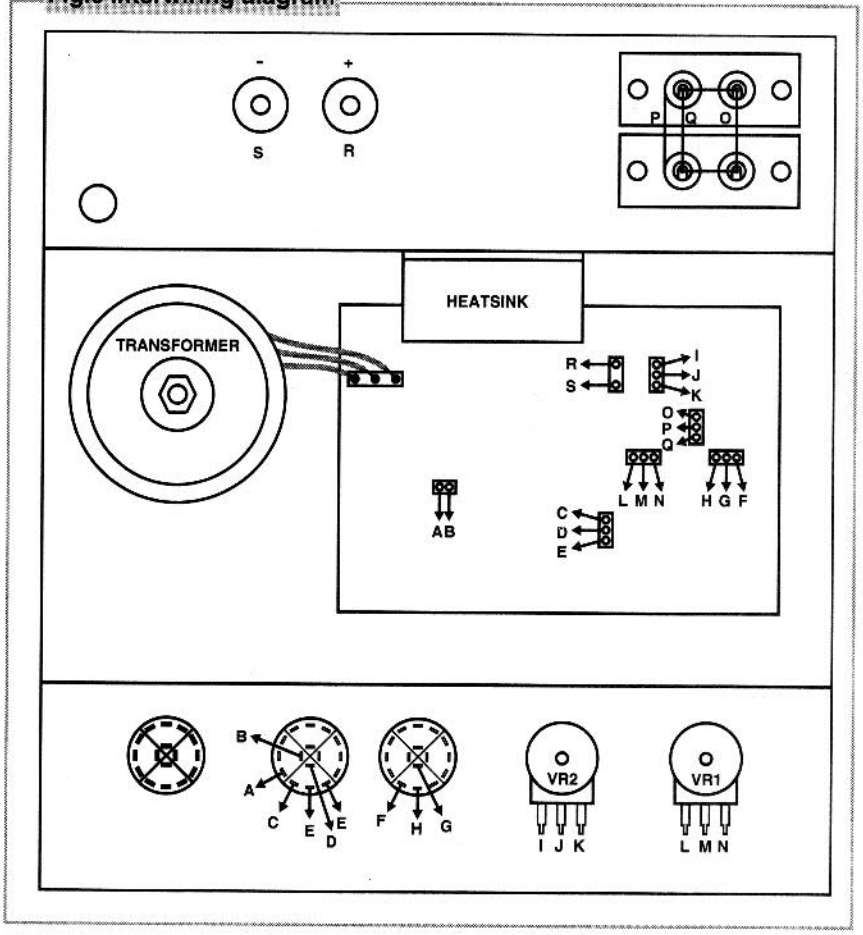
If you are experimenting with this circuit, please note that the maximum recommended current into pin five of the CA3088 is 2mA. I learned, from bitter experience, that 5mA is enough to destroy the device.

testing the unit. Connect the negative terminal of the meter to the case of the unit, and check the following voltages with the positive probe. Don't worry if any of the readings are a little outside the tolerance given, however if a reading is a long way out it should be investigated. The values were measured with a digital test meter, and some may be a little lower if an analogue meter is used.

Cathode of D3 or D4	22V +/- 2V
Pin 3 of IC3 (7815)	15V +/- 0.5V
Pin 3 of IC6 (7805)	5V +/- 0.25V
Pin 4 of IC14 (LM383)	11V +/- 1V
Pin 6 of IC8 (741)	7.5V +/- 0.5V
Pin 7 of IC10 (ZN448)	2.56V +/- 0.05V
Pin 7 of IC11 (ZN428)	2.56V +/- 0.05V
Pins 1, 7, 8 and 14 of IC9 (LF347)	7.5V +/- 0.5V
Pins 1, 7 and 14 of IC12 (LF347)	7.5V +/- 0.5V
Pin 8 of IC12 (LF347)	3.75V +/- 0.5V
Pin 6 of IC13 (CA3088)	7.5V +/- 0.5V
Pin 5 of IC13 (CA3088)	0.65V +/- 0.1V
Cathode of D7 (2V7 Zener)	3.1V +/- 0.5V
Upper pin of R16 (68K)	-3.8V +/- 0.5V

If all these voltages are correct you can be confident that most of the unit is working correctly. The digital section

Fig.8 Interwiring diagram



cannot be checked easily, but you will know soon enough if any of this is faulty.

Check that the heatsink is not getting too hot - it should be barely warm. A hot LM383 is a sign of instability - this is very unlikely but worth checking. If it is unstable, replace C41 and C42 with polyester capacitors, and thicken the tracks between C39, C41, C42 and the LM383 by soldering tinned copper wire along them.

You can now install the unit and test it, as detailed below.

Installation and Use

To set-up your viewing area, place one speaker either side of your television and two speakers behind your head, towards the rear corners of the room (if only one speaker is used its position will be heard). The effect may be a little better if the rear speaker(s) are further from the viewer than the front speakers.

The rear speakers do not have to be of hi-fi quality, since the rear channel bandwidth is only 100Hz to 8kHz. On the other hand though, don't use the nasty plastic or hardboard cased offerings that are supplied with many cheaper stereo systems. I am using a pair of solid wooden cased speakers that came with a defunct Ferguson stereo music centre from a local car boot sale, and these sound superb.

A similar comment applies to the cable for the rear speakers. The unit certainly does not need specialist hi-fi speaker cable, costing several pounds per metre. However since the cable run is likely to be fairly long it would be a good idea to choose something heavier than doorbell wire. 5A twin mains flex is a sensible choice, and was used successfully with the prototype. Connect the audio input to your home entertainment equipment. Note that the Audio Out from the satellite receiver or VCR needs to connect to both the decoder and your main amplifier, this is the reason for the suggestion of paired sockets. Alternatively the unit could be connected to the Tape Out connections on the amplifier, and the tape deck connected to the second pair of sockets.

Set the Balance control to the centre position and the Volume control to minimum. The Delay and NR switches should be in the off positions. Set the main amplifier volume to minimum for now, and switch on the surround sound decoder and the satellite receiver or stereo video recorder.

Choose a mono program (if you have satellite try Sky News or CNN), and advance the volume control to about the 10 O'clock position. If you adjust the balance control towards either end, you should hear the sound from the rear speakers. When the balance control is adjusted towards the centre there should be virtually no sound from the rear speakers.

Leave the balance control at this position, and select a stereo film channel (Sky Movies or The Movie Channel). If the film is in Dolby Stereo, you should get a significant amount of sound (but not speech) from the rear channel. If you can't get this to work, check your satellite receiver is set to the main stereo audio channel (AU1 on Amstrad receivers), and check the film is really in Dolby Stereo.

Now switch the NR on. You should notice a significant drop in the treble on quieter sounds, while louder sounds will be unaffected.

Switch the Delay to 12ms. You may notice a slight drop in the treble response, due to the filter circuits. Switching to 24ms should cause no noticeable effects. The full effect of the delay will not be evident until the front amplifier is turned up.

Set the volume on the main amplifier to your usual listening level. Now adjust the level of the rear channel to a level where the rear sounds contribute to the complete sound, without intruding.

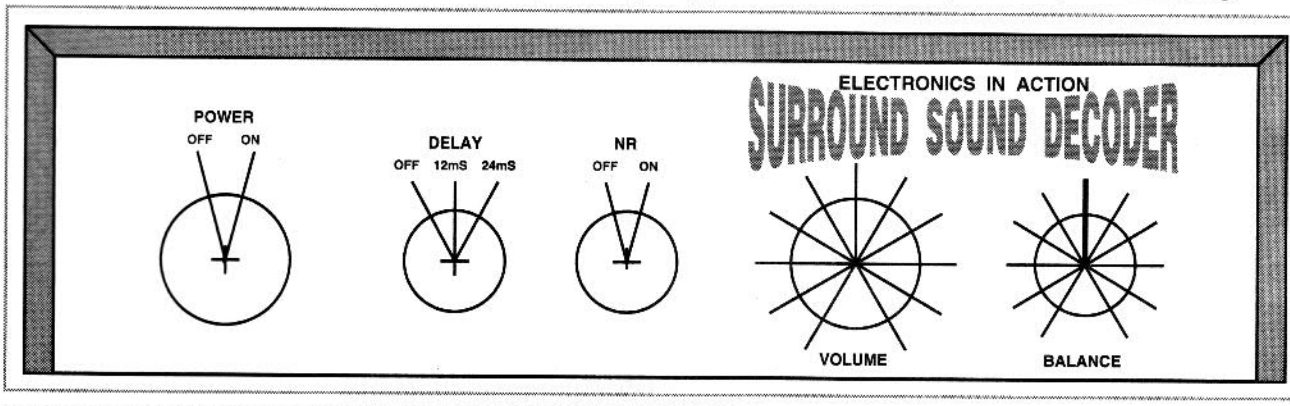


Fig.9 Front panel layout (enlarge this by 166% on a photocopier)

Parts

Resistors

(all 0.25W 5% or better)

R1,7,8,17	15K
R2,3,4,9 R10,19,21 R22,23 R39,41,42	10K
R5,14	12K
R6,11	2K2
R12,15	390R
R13,25,27 R28,35,36	100K
R16	68K
R18	39K
R20,24	270R
R26,31,32 R33,34	22K
R29	100R
R30	5K6
R37	220R
R38	10R
R40	LINK
VR1	47K Lin Pot
VR2	100K Log Pot

Capacitors

C1,2,5,7,9 C11,13,14 C17,33,34 C35,41	100n
C3,30	10n
C4,8,16 C22,28,32	10µ 25V
C6,C39	220p
C10	2200µ 35V
C12,15	100µ 25V
C18,19,23 C24,29	4n7
C20,21	2n2
C25,27,36 C37,38,44	1µ0
C26	47p
C31	100p
C40	470µ 16V
C42	220n
C43	1000µ 16V
C45	10n 250V AC Class X

Semiconductors

IC1	ICM7555 (CMOS 555)
IC2	4017
IC3	7815
IC4	4040
IC5	4001
IC6	7805
IC7	6116
IC8	741
IC9,12	LF347
IC10	ZN448
IC11	ZN428
IC13	CA3088
IC14	LM383
TR1	BC548
D1,2,5,6	1N4148
D3,4	1N5401
D7	2V7 Zener

Additional Items

- Two 4 Pole 3 Way Rotary Switches (one for SW1 & SW2, one for SW3)
- One Double Pole Rotary Mains Switch
- Four Phono Sockets (SK1)
- Two Terminal Post Connectors (SK2)
- 15-0-15V 20VA Torroidal (or Conventional) Transformer (X1)
- PCB
- Case
- Knobs
- Material for Heatsink Bracket
- Cable Clamp
- 3 Core 3A Mains Flex
- 13A Plug with 3A Fuse

Speech should still appear to come from the front, while crowds, music and dramatic sound effects should fill the room.

The effect of the delay switch will now be more apparent. With no delay the sound will seem a bit flat, and the rear channel may be distracting. Switching to 12ms will give the sound more depth, and you may want to turn the surround volume up a bit more! Switching to 24ms will add more depth - this will probably give a slight distracting echo effect unless you have a large lounge.

In most normal sized modern sitting rooms, the 12ms setting will be appropriate. However if your room is larger than average or has a high ceiling you may prefer the added depth of the 24ms setting.

You may need some practice to get the best results from the unit, it's really a matter of trial and error, but it's worth the effort! The results from this unit can be stunning. It really does add a new dimension to home entertainment, the effect on some modern films is dramatic. It almost makes the Sky film channel subscription charges seem good value!

Legal Acknowledgement

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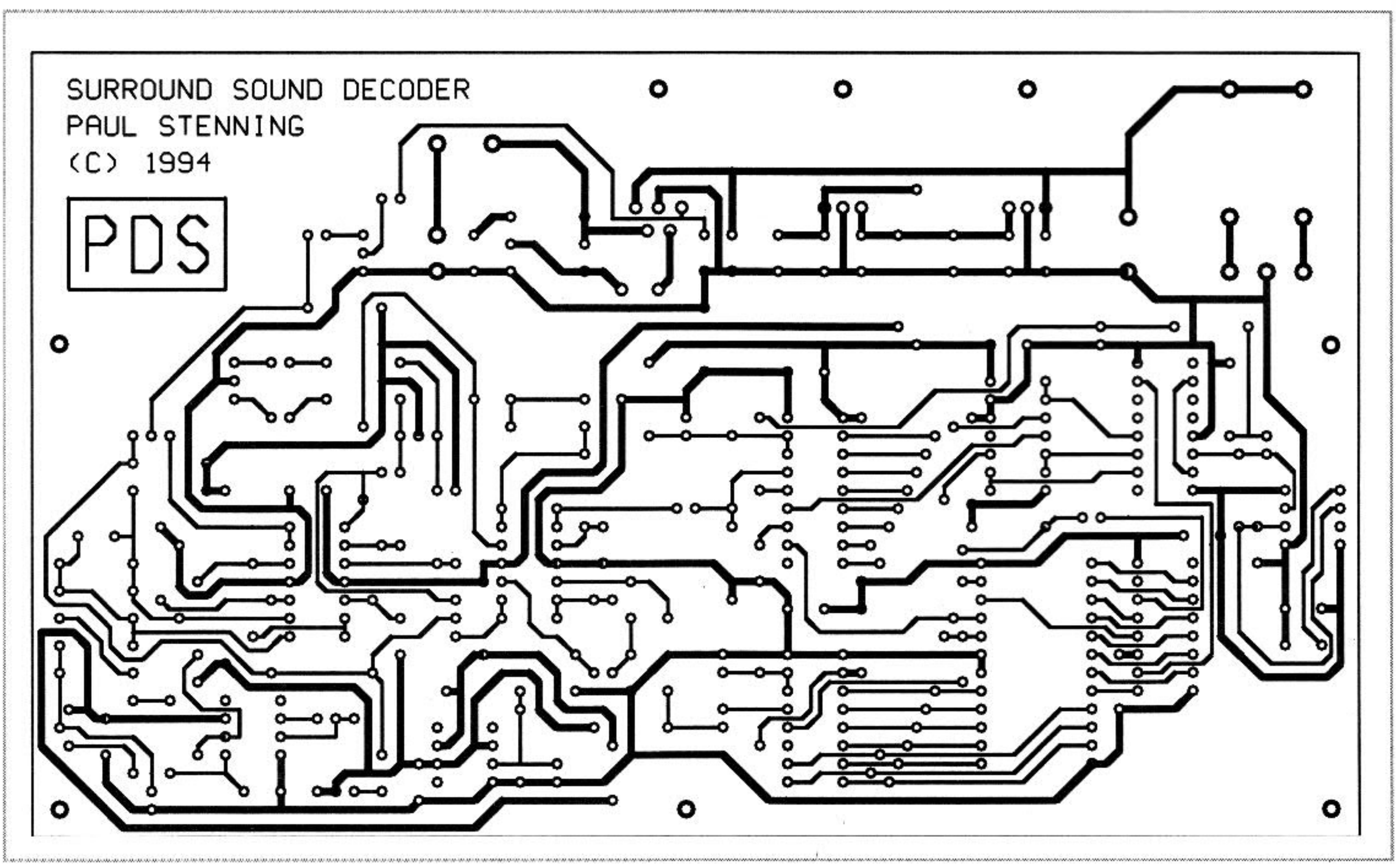
This project is based on readily available published information. Consequently we believe that none of Dolby's patents have been infringed.



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BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.12
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.11
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.17
BC182	£0.08
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207C	£0.72
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC237B	£0.09
BC238C	£0.09
BC239C	£0.10
BC251	£0.13
BC252	£0.13
BC261B	£0.24
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC327	£0.10
BC328	£0.10
BC337	£0.10
BC338	£0.10
BC414C	£0.10
BC441	£0.40
BC461	£0.40
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC490	£0.30
BC516	£0.22
BC517	£0.20
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546C	£0.08
BC547C	£0.08
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
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BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.21
BCY70	£0.21
BCY71	£0.20
BCY72	£0.20
BD135	£0.20
BD136	£0.21
BD137	£0.22
BD138	£0.22
BD139	£0.23
BD140	£0.24
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2.2	–	–	£0.05	£0.06	£0.18
4.7	–	–	£0.05	£0.08	–
10	£0.05	£0.05	£0.06	£0.08	£0.48
22	£0.05	£0.05	£0.09	–	–
47	£0.06	£0.06	£0.11	–	–
100	£0.06	£0.09	£0.11	–	–
220	£0.09	£0.12	£0.31	–	–
470	£0.15	£0.19	£0.57	–	–
1000	£0.22	£0.29	–	–	–
2200	£0.37	£0.57	–	–	–
4700	–	£1.11	–	–	–

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0.47	–	–	–	£0.15	–
1.0	–	–	£0.10	£0.10	£0.19
2.2	–	–	£0.10	£0.10	£0.22
4.7	–	£0.09	£0.10	£0.10	£0.34
10	–	£0.12	£0.12	£0.12	–
22	–	£0.09	£0.13	£0.17	–
47	£0.10	£0.11	£0.16	£0.20	–
100	£0.10	£0.13	£0.21	–	–
220	£0.13	£0.18	£0.42	–	–
470	£0.21	£0.24	£0.69	–	–
1000	£0.33	£0.40	£1.05	–	–
2200	£0.52	£0.64	–	–	–
4700	£0.90	–	–	–	–

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John Linsley-Hood looks at Modern solid-state designs

The Evolution of Audio Amplifier Design Part 5

In the previous part of this article, I looked at some of the circuit design techniques which the engineer could use to increase the gain and reduce the distortion introduced by solid-state voltage amplifier stages. As it happens, these two things are interrelated, since if the transfer characteristics of a gain stage have some degree of curvature - as, in practice they will always do - then, as I have shown in Figure 1, the higher the stage gain, the smaller the input voltage swing which will be needed to produce a given output voltage. This is a good thing since the smaller the portion of a curved characteristic which is used, the more closely this will approximate to a straight line (and will therefore be distortion-free).

A further consideration of the same kind applies to the input voltage vs. output current characteristics of the various amplifying devices at our disposal, the thermionic valve, the junction FET, the bipolar transistor and the MOSFET, whose characteristics I have shown in Figure 2, where there are differences in the intrinsic linearity of the transfer slopes. Obviously, the junction transistor has a much more curved transfer characteristic than any of the other devices, and though it also has a much higher gain (due to its steeper slope), this isn't enough to make up for its less linear characteristics. For the record, g_m values for small signal bipolar junction transistors are typically in the range 40-80mA/V, depending on collector current, compared with, say, 5mA/V for either a low-power valve or an FET or a MOSFET.

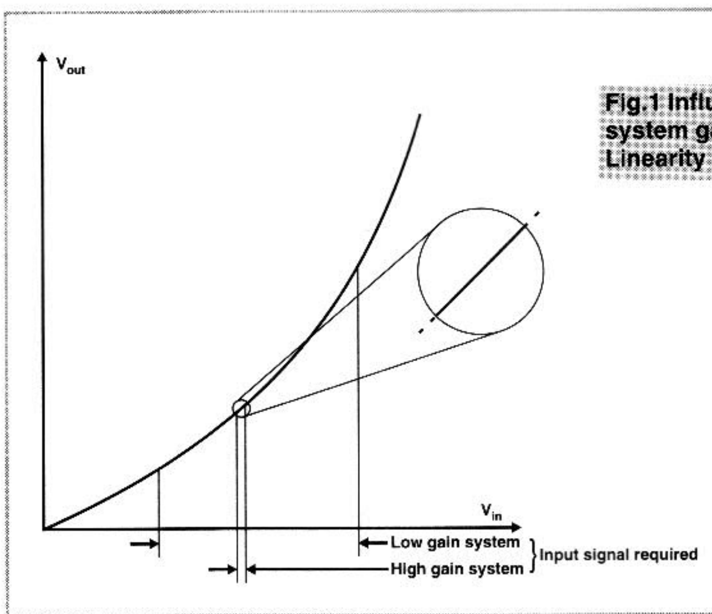


Fig.1 Influence of system gain on Linearity

FET input stages.

A good design recipe for a highly linear solid-state input stage would therefore seem to be to use an input long-tailed pair of junction FETs (these would be preferable to MOSFETs as input devices because they would not be vulnerable to breakdown as a result of an inadvertent application of too high an input voltage) in cascode connection, and with a high impedance current-mirror load.

I have shown a typical input circuit of this type in Figure 3. Although cascode connection is usually a good thing, as it improves the gain and reduces the distortion, in this case the cascode buffer devices, TR2/TR4, happen to be essential since matched dual-FETs of this type have drain/gate breakdown voltages in the 20V region, which would not allow very high supply rail voltages. However, ordinary junction transistors are available with collector/emitter breakdown voltages up to 150V or more, and can isolate the input FETs from these supply rail potentials.

The circuit of Figure 3 could, and in a modern Hi-Fi amplifier probably would, be doubled-up with another, identical circuit layout using PNP transistors and P-channel FETs to make a completely symmetrical layout, which would avoid any suggestion of asymmetrical slew-rate limiting. The input devices shown (TR1 and TR3) are a matched pair in a single envelope, and modern FETs of this type offer a sufficiently low noise figure that this circuit could even be used as a direct moving coil PU input stage.

A trend in ultra-Fi systems - yes, I do know that 'ultra' means 'beyond' - is to delete all capacitors in the signal line, on the grounds that capacitors are rather complex components, and can have some queer types of dysfunction which may sometimes degrade the sound quality. In

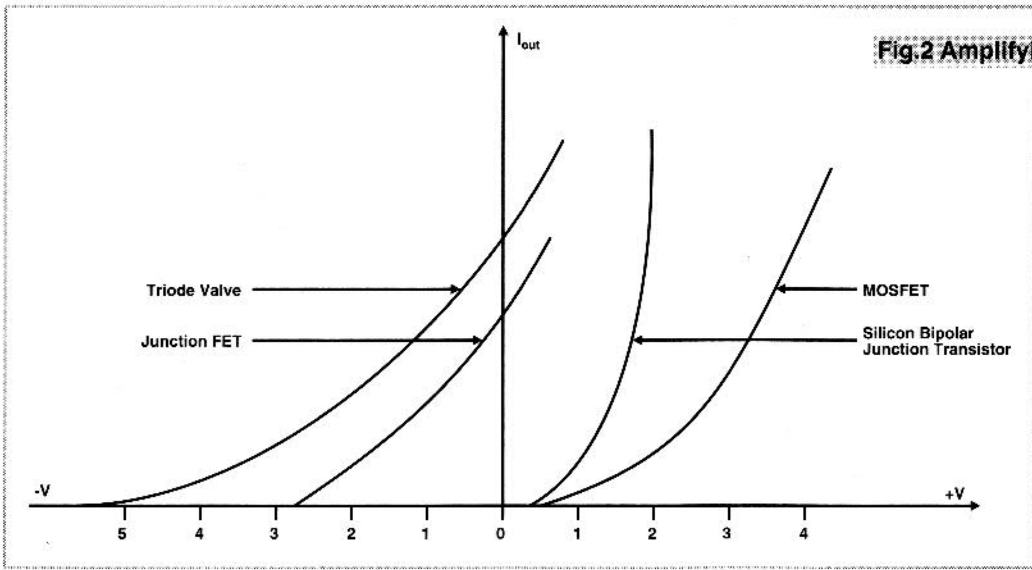


Fig.2 Amplifying device

the case of Figure 3, deleting C1 will cause the circuit to have full gain right down to DC, and this will magnify any drifts in the DC offset at its output. With well matched devices, accurately balanced by suitable offset adjusting means, this may be OK in the short term, and should give an improvement in deep bass.

However, deleting C2, which is also done in some purist designs, will impose a similar demand for the absence of any DC offset in the input signal source - and this cannot always be guaranteed with discrete component circuitry, though it is easy enough to do with IC op. amps.

FET noise figures.

For a long time, the ultimate low-noise input device has been the 'super match' bipolar transistor pair, such as the LM394 or the SSM 2220. These are devices made like an IC, with a whole raft of tiny individual transistors distributed across the chip, and arranged in two parallel connected groups. This reduces the noise output and increases the current gain (compared with any single transistor) by a factor of n, where n is the number of parallel connected devices. In practical terms, if 100 devices are parallel connected in each half, the noise figure and current gain would both be improved by a factor of 10.

The same thing can be done with junction FETs, and the Hitachi 2SK389 devices shown in Figure 3, which are made like this, have a slope (g_{fs} or mutual conductance) of about 20mA/volt at an I_d of 2mA. Since the thermal noise resistance R_N of the channel in a junction FET is

$$R_N \quad 0.67/g_{fs} \text{ (ohms)},$$

the noise figure for the 2SK389 works out at 330 ohms - a very respectable value indeed. (The SSM2220 has a noise resistance of about 100 ohms).

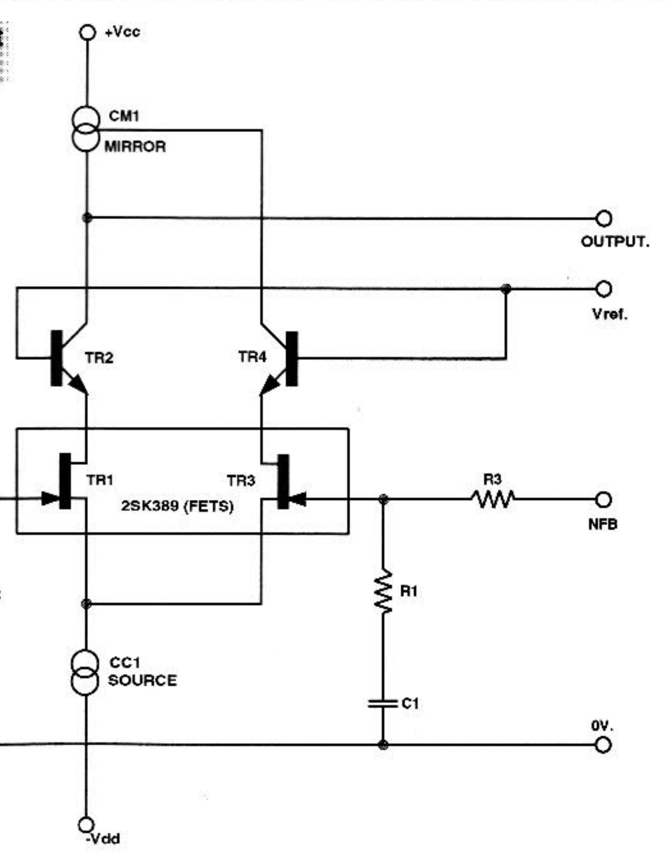
Discrete components vs. op amp ICs

All of the circuits which can be used by the audio design engineer are available to, and probably have already been used by the IC designers - among whom are some pretty smart guys. It is a sensible question to ask, therefore, why anyone should go to the trouble of putting together his own circuitry when he can buy an op.amp. with as good (or better) performance, ready made and tested. So, please forgive me if I digress for a moment.

During the years in which I have been interested in audio, I have spent quite a lot of time on listening trials aimed at relating faults in sound quality to the types of electrical defect which are shown up by tests made with instruments. As an (initially) unexpected result of these trials I have found that there are often small audible differences between circuits which are, so far as I can tell, virtually identical in electrical performance. So, as a general rule with new circuit layouts, I try to supplement the results of instrument tests with comparative listening trials.

Admittedly, this mostly just tells me how things sound to me, but, when the possibility occurs for me to get other people's views on these tests, I don't

Fig.3 FET input Cascode stage



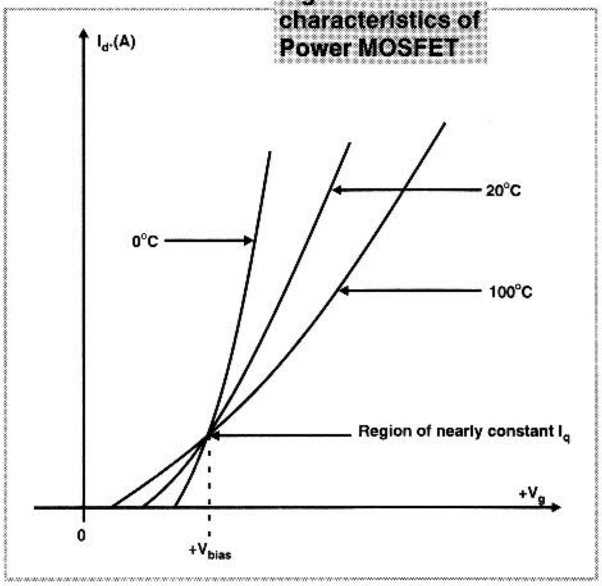


Fig.4 Thermal characteristics of Power MOSFET

usually find that they differ greatly from my own. The outcome of trials on the performance of high quality op. amps. vs. comparable quality discrete component circuits has left me with the opinion that at low stage gains (say 1× to 5×) there are no differences in sound that I can detect, but at higher gain levels, dissimilarities in sound quality begin to emerge and these usually favour the discrete component circuitry.

Of course, in many cases - especially in the design of high power amplifier systems, where some very large peak-to-peak voltage swings are likely - the IC. op. amp. just cannot do the job, and one has to use discrete component systems, but one should not ignore ICs where they are usable, especially when one is not striving for the ultimate in sound quality. (On a similar tack, I think there are small differences between the sound of unsymmetrical and completely symmetrical audio gain block layouts - with the symmetrical layouts usually sounding somewhat 'brighter', and the single-ended layouts usually sounding a bit 'smoother'. Mostly I prefer the unsymmetrical circuit layouts, since these are simpler to make and also need only about half the number of components. Also, other things being equal, I think that the less complicated the circuit the better it will sound).

Audio power amplifiers.

Most commercial solid-state audio power amplifiers still follow the basic 'Lin' scheme of a high gain voltage amplifier driving the LS output via a pair of emitter followers connected in push-pull, as I had shown in Figure 1 of last month's article. Negative feedback is then connected from the LS output back to the input of

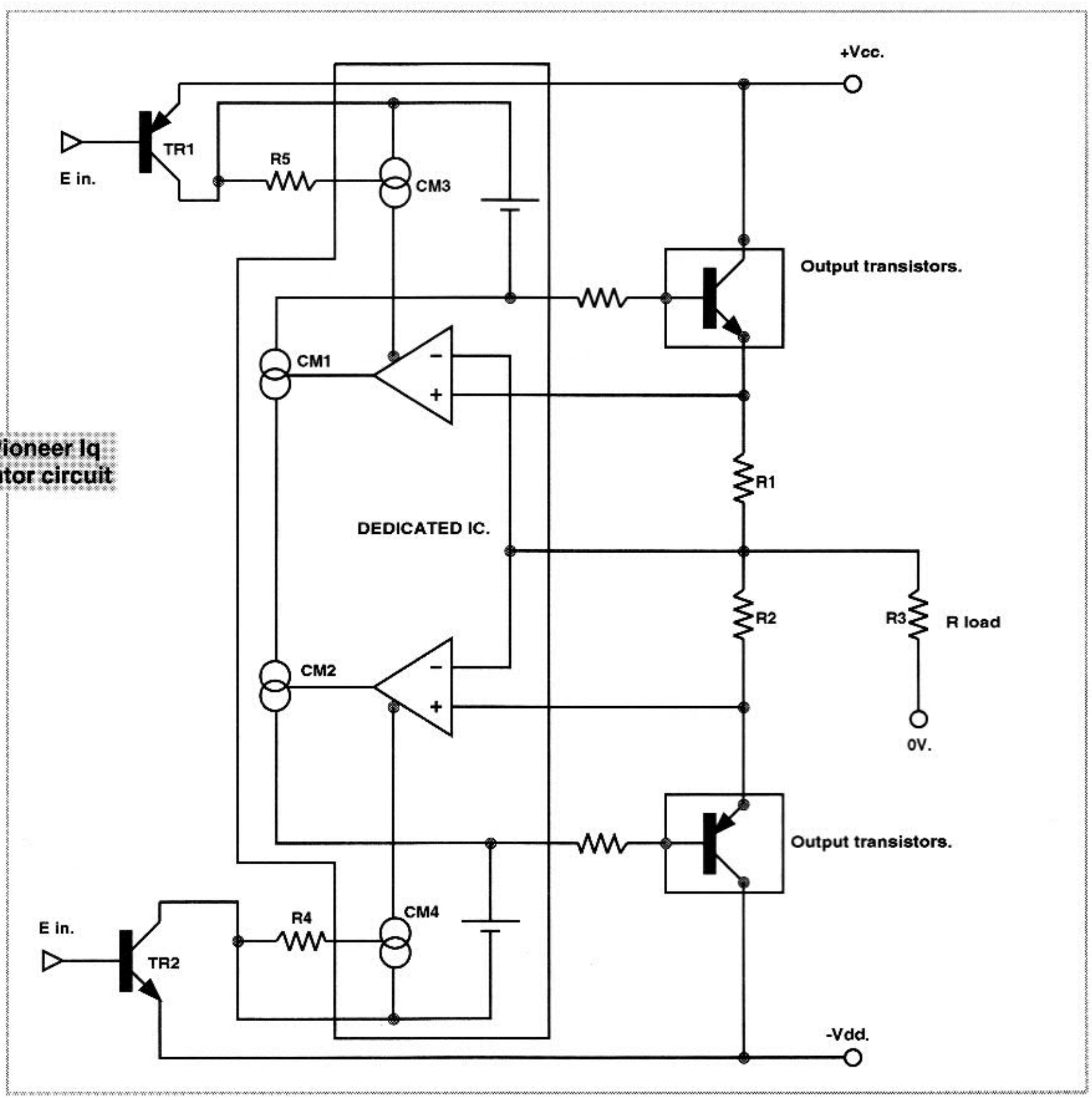


Fig.5 Pioneer Iq Regulator circuit

the voltage amplifier to reduce the distortion and improve the bandwidth.

The success of this scheme depends entirely on the performance of the output emitter followers, and this, in any push-pull system, depends on the correct setting of the quiescent current of the output transistors, since minimum distortion is only given at some precise current value. This value, and the precision with which it must be set, depends in turn, on the steepness of the turn-on characteristics of the output devices, and, as can be seen from Figure 2, bipolar junction transistors have the most abrupt input voltage vs. output current characteristics of all the devices available to the designer. They are therefore the most difficult to set to the correct value initially, and to keep at that value throughout their working life.

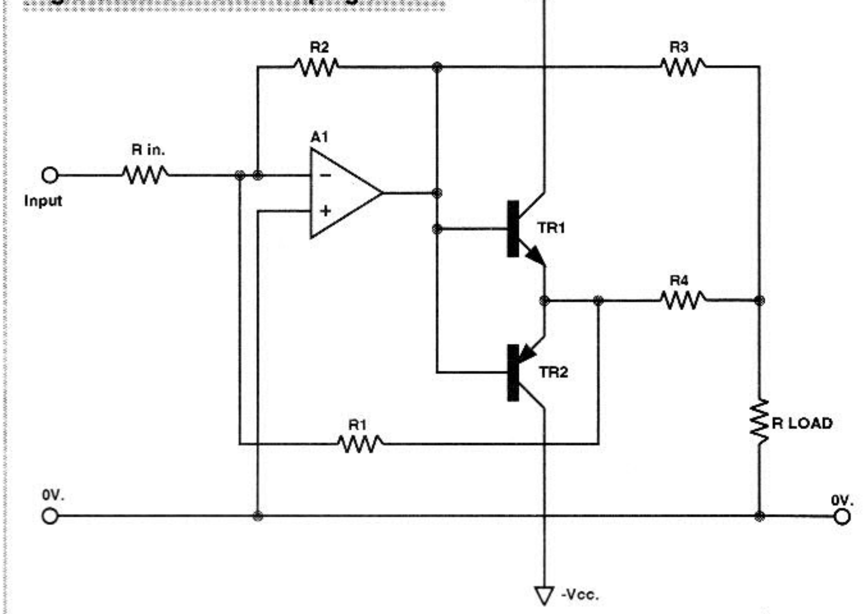
Power MOSFETs have a much more gradual, and much more linear turn-on curve, and are, consequently, much easier to use as output impedance conversion devices. On the other hand, the output impedance of an emitter- or source-follower is related to the slope of the device, so a power transistor with a g_m value of perhaps 45A/V will have an output impedance which is 15× lower than a power MOSFET with a slope of 3A/V, so, for the same LS drive characteristics more negative feedback (NFB) would need to be used.

There are several techniques which can be used to control the forward bias applied to the output transistors, and hence the output quiescent current setting. These endeavour, with varying degrees of success, to compensate both for the ambient temperature of the equipment and for the actual working temperature of the output devices, since this will affect the required forward bias level.

The problem is that any sudden high power demand on the amplifier, due, say, to a loud musical passage, will cause the output transistors chips to heat up, and it will then take 10-20 seconds for this change in temperature to diffuse through the mounting hardware to any external sensor, to allow a compensatory change in bias setting. During this time the bias setting will be incorrect. The same problem exists, in reverse, when any high power passages come to an end. MOSFETs avoid this problem, in part, because there is a value of quiescent current setting - usually in the 80-200mA range, depending on the device - at which the setting is independent of temperature, as I have shown in Figure 4.

Pioneer, in their M-90(BK) amplifier, which has bipolar transistors in its output, use a custom designed IC, shown in schematic form in Figure 5, to anticipate, and to control, variations in quiescent current setting, an approach which is an improvement on the simple forward bias control circuitry usually adopted. However, designers recognise this weakness in the system, and a number of attempts have been made over the years to design a push-pull output layout which didn't need accurate control of the quiescent current. Of these attempts, two useful circuits have emerged which allow the output transistors to be operated at any arbitrary I_q level chosen, without a crossover distortion penalty.

Fig.6 Quad Current Dumping circuit



The Quad 'current dumping' system.

This circuit was introduced by the Acoustical Manufacturing Co. in 1975, for their '405' power amplifier. The basic circuit layout of this is shown schematically in Figure 6. The idea behind this is that when the output transistors (TR1 and TR2) are non-conducting, the amount of NFB to the input of A1 (via R2, in parallel with that through R3, R4 and R1) is much less than when TR1 and TR2 are conducting, and consequently the gain is greater. When the output transistors conduct, the amount of NFB is increased, and if the values of R1 - R4 are chosen correctly the amount by which the extra NFB will reduce the gain is just enough to compensate for the increase in gain due to TR1 and TR2. So, the point of handover from the low-distortion class 'A' amplifier (A1) to the unbiased output transistors is 'glitch' free.

The Sandman 'Class-S' circuit.

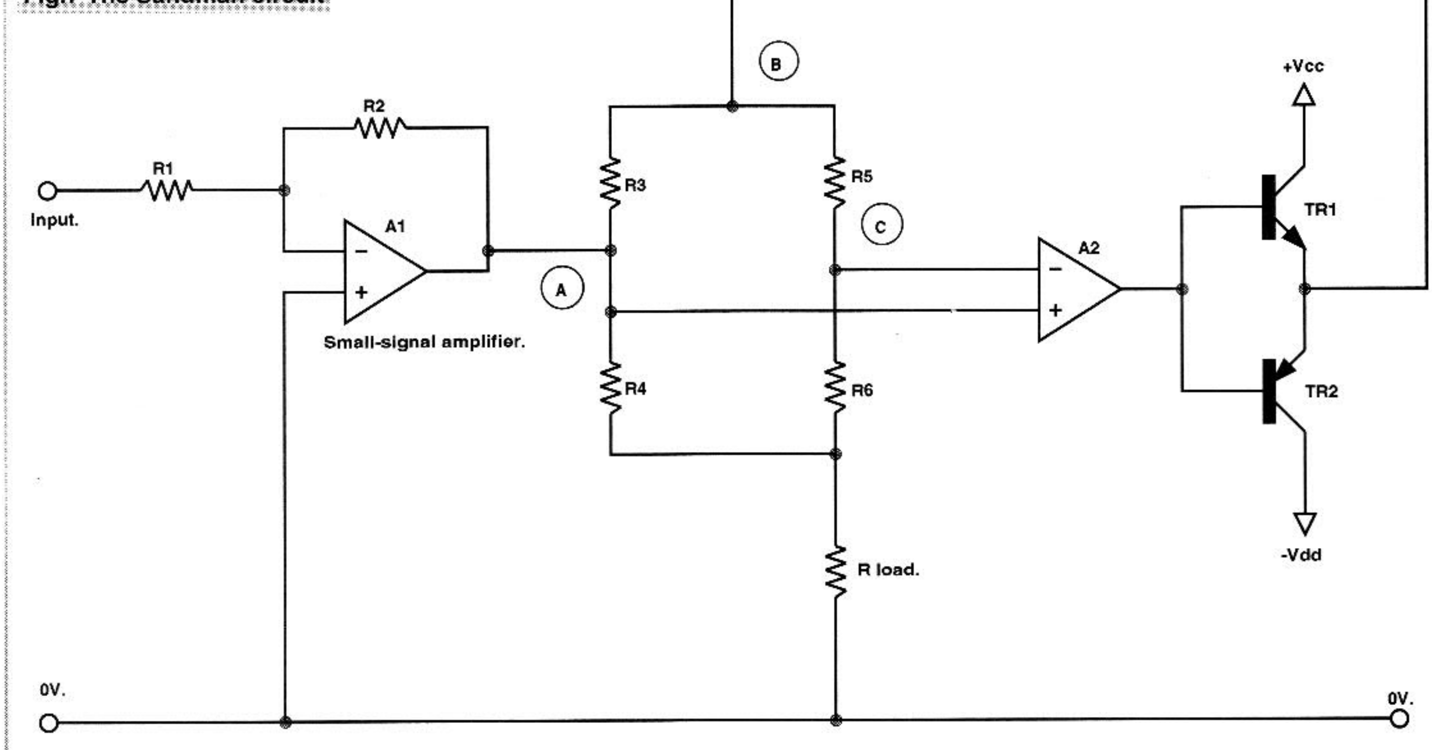
I have shown this, schematically, in Figure 7, and it is based on the observation that almost any amplifier will work better if it is only required to operate into a high impedance output load. This is achieved if A2 has a high enough gain, and if the ratio of R5:R6 is the same as that of R3:R4. Since these resistors can have a high value they will present a high impedance load to A1. The amplifier A2 acts to try to produce at point 'B' a voltage which will make the voltages at points 'A' and 'C' identical to one another.

As the output passes through the 'crossover' point, the output transistors will be driven rapidly from conduction in one direction to conduction in the other, and, since this can't occur instantaneously, there will be some small residual 'crossover-type' glitch. For distortion free operation, this must be filled in by current from A1 through R4. This sets an upper limit, in practice, to the resistor values which can be used for R3/R4. Also, in practice, R4 will probably need to be a little lower than the theoretical value.

I have promised myself that sometime, when I have completed the other jobs in the queue, I will do a 'Hi-Fi' amplifier based on the Sandman circuit (with Dr. Sandman's blessing), using high speed power MOSFETs as the output devices.

Of course, when one gets down to it, one will find a lot of small snags which will need to be smoothed out - mostly in

Fig.7 The Sandman circuit



the area of sorting out the transient response, and in ensuring adequate HF stability and tolerance towards awkward LS loads. Certainly, also, the supply voltages involved will be too high for op. amps. to be used for the two amplifier stages, and these will need to be one or other of the types of gain block I have looked at in the earlier articles.

Power supplies.

This is the other area in which there has been a change in 'Hi-Fi' thinking over the years. Initially, in almost any audio amplifier design, the power supply had a 'Cinderella' status. Valve amplifiers tended to be fairly tolerant in this respect because the currents involved, in the output valve anode lines, were fairly low. However, with all audio amp. designs, the power supply is effectively in series with the output circuit, and it must have a constant, low impedance.

This impedance is composed of the equivalent series resistance (ESR) of the capacitors across the supply lines, the conducting resistance of the rectifier diodes, the impedance of the secondary windings of the transformer, and the impedance presented by the power supply electrical connections - which may not be negligible. In earlier times, almost any old transformer would be used, so long as it had the correct output voltage/current rating.

In modern designs a toroidal construction is nearly always used, since it has a lower external magnetic (hum) field, and a much lower dynamic impedance. This is important with contemporary amplifiers because, for good reproduction of the string bass of much 'pop' music, very large peak output currents are needed, and this entails the use of large value, low ESR power supply capacitors, high current rating rectifiers, and low impedance power supply transformers (as well as low impedance LS cables).

Watch out for John's latest amplifier project in a future issue of ELECTRONICS in ACTION

Signal to NOISE

The postbag breaks and the letters spill out

The contributors right to reply

As a regular contributor to Electronics in Action, I would firstly like to respond to the comments made by Andrew Chadwick on the Signal to Noise page of the May edition.

In particular, Mr. Chadwick criticised inelegant design, due to authors not using currently available ICs.

As a contributor I try to ensure that the components used in my designs are readily available to home constructors through the usual mail order companies serving this market. There have been a few occasions when I have had to refrain from using a particular device which may have been ideal for a particular application, simply because it was only available from a specialist semiconductor distributor who is only interested in supplying large quantities to industry customers.

It normally seems to take two or three years for interesting new ICs to find their way into hobbiest market. Only then is it viable to use them in magazine projects. However I agree with Mr. Chadwicks suggestion of a column in the magazine, describing some of the latest devices - as long as this does not consist of merely reprinting manufacturers publicity material.

I often like to design with logic chips and op-amps, instead of more complex devices, because this makes the working of the design easier to understand. Also constructors are more likely to have the required devices (or something similar) already.

Designs using complex ICs can sometimes become little more that reprints of the application circuits on the data sheets. Although this black-box engineering is often considered good practice in industry, it makes boring reading in a magazine!

I cannot respond to the comments about specific projects, since I did not design them. However I would like to counter one criticism of Daniel Coggins' guitar switching box. The 4066 device only costs forty pence, so if using two instead of one gives any improvement in performance at all it must be worth this minimal extra cost.

I assume Mr. Chadwick works in the electronics industry, where reducing cost and component count is a high priority. I also work in the electronics industry, so I can see the situation from both sides. In the amateur/hobbiest market we can be more flexible as I have mentioned above.

I agree to some extent with Mr. Chadwicks comments on repetitive construction details, and will bear them in mind when writing future articles. I do not see the need for a separate section in the magazine on project construction, since this is generally fairly straightforward. There are a number of good books available detailing project assembly for absolute beginners, as well as many tedious articles in other magazines which 99% of us never read!

Magazine contributors are paid by the page area their article occupies. There is obviously a temptation to pad out projects with some unnecessary detail, to take up more space. Fortunately the editor of this magazine is very good at cutting out the surplus waffle - I know this from experience!

I will also endeavour to provide more information on the workings of my projects, and why particular design decisions were made.

The subject of construction details has been argued for many months on the letters page of a competing magazine (Electronics - The Maplin Magazine) without conclusion. I suppose it was inevitable that someone would bring it to this magazine sooner or later.

Now onto a completely different subject. M Coutts was asking in his letter where he might obtain a 1537A VCA chip. 'Semiconductor Archives' stock or can obtain an extremely wide range of obsolete ICs. Their address is

Semiconductor Archives, 48 Deptford Broadway, Deptford, London SE8 4PH Tel:081 691 7908 Fax:081 692 3185

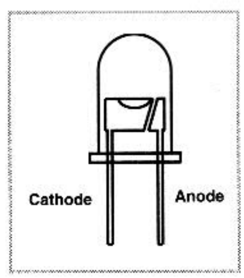
However I must point out that they are not cheap - the company I work for recently purchased an obsolete UART chip from them, at a cost of over £40!

Maybe it would be better to redesign the offending part of the circuit to use a current device.

Finally, Andrew Armstrong mentioned the problem establishing the leadouts of the IR LEDs in his Cordless Audio article.

LED lead identifications do seem to vary from one manufacturer to another. Often they rely on differing lead lengths, which is meaningless if the device has already been used! However there is a foolproof way of establishing the leadouts of all conventional LEDs, including IR, high intensity and shaped devices.

Take a look at the innards of the device through the translucent casing. One lead will be connected to a larger piece of metal, which has a cupped section on top where the piece of silicon is mounted. This lead is the Cathode.



The other (Anode) lead connects to a smaller section to one side of the other piece. There is in fact an extremely thin piece of wire connecting from this to the piece of silicon, but this will probably not be visible.

This is shown in the accompanying diagram, which should make my description clear! If you think of 'Cup' for 'Cathode' and 'Arm' for 'Anode' (note the initial letters), it should be easy to remember. I have used this method for many years and it has not failed me yet!

Paul Stenning
Hereford

Audiophile components

In reply to A G Crane's letter in signal to Noise April issue, top quality audio phile components are available in small and large quantities from RATA Ltd, Edgebank House, Skelsmergh, Kendal, Westmorland, LA8 9AS. Tel:0539 823247. A free Audiophile catalogue is available on request

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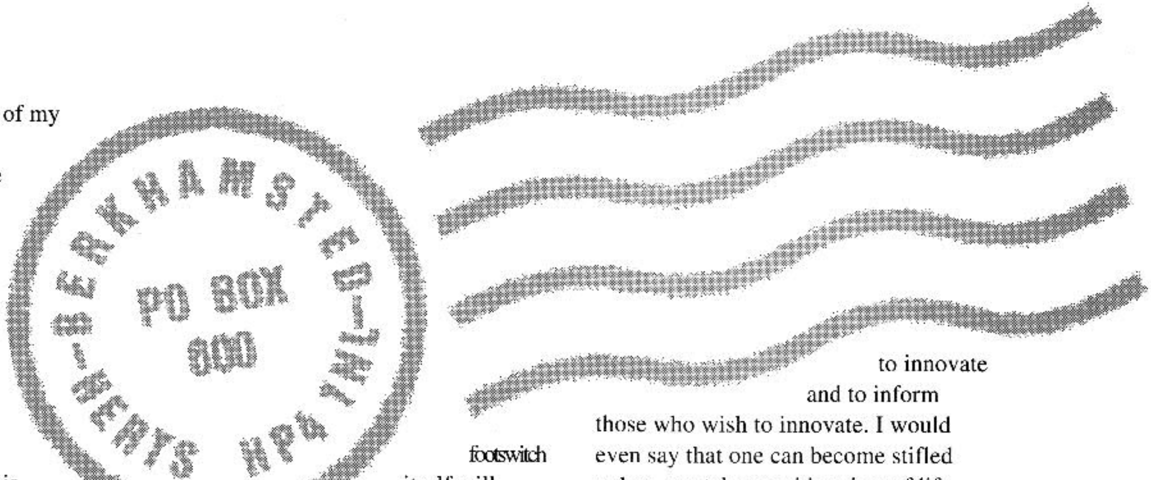


In reply to the criticisms made of my 'Guitar AB Box' design in the May issue of EIA. I would like to first acknowledge Mr. Chadwicks' judgements (yes, you could use just one 4066, and the circuit can be DC coupled, and using switches in parallel is of questionable merit).

The point is that my design works - very well, and I would suggest that the reason for this is that I used my ears to judge the end result.

My design works; surely that is what matters, even though it might appear to the purists as a Heath Robinson creation. Certainly, some hobby magazines have published circuits that appear to have overlooked this fundamental belief. My circuit features 'inelegant' quirks and foibles for good reason. Using a gate to switch an LED is important in THAT circuit because we want to keep noise and pops to an absolute minimum. Switching LED current through the footswitch itself will cause a 'pop' to be heard at the output. As for 'negative supply' - we are working between 0 and +9 volts - no negative supply! Paralleling switches effectively reduces series resistance, minimising RC losses due to cable capacitance. I preferred to use these switches, rather than tie them to ground.

I would like to say that my designs do not claim to be totally original; how can you re-invent the wheel? How many designs pretend to be entirely original, without even the slightest element of plagiarism? I gather that the sideswipe about 'rehashing tired old circuits' was in my direction - guitar technology is not renowned for being advanced, but I feel that my designs will be useful to those who do not wish to spend a fortune on commercial devices, as my circuits give comparable, even favourable results.

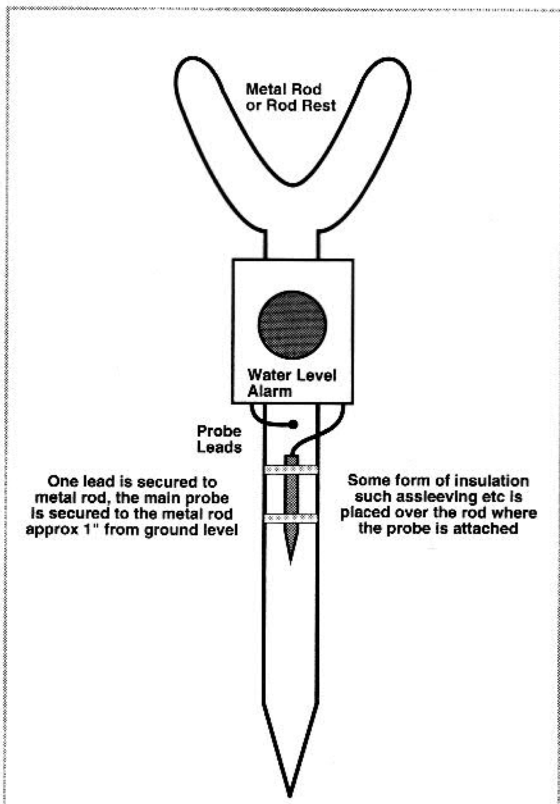
I believe that I have given insight into the design approach in my articles, emphasising the importance of experimentation, rather than being blinkered by a 'classical' approach. This is the way to innovate and to inform those who wish to innovate. I would even say that one can become stifled unless one takes a wider view of life, emerging occasionally from the backwater of a scientific discipline like electronics.

I look forward to seeing your own designs Mr. Chadwick.

Daniel Coggins
Henley on Thames
Oxon.

This brings up the dualistic argument once again on how we discover things in life. On the one hand, the slow conservative developmental approach produces more reliable products but with a low degree of innovation (the internal combustion engine is good example) and the other is the more radical, lateral thinking sidestep approach. This produces totally new innovative ways of achieving the goal but at much higher risk. The financial rewards are however much higher. The decision is yours.
*Back to the storyline, guitar effects boxes are indeed popular with some of our readers and it is the required effect that is important. -**Ed**.*

Discussion is what it's all about. Keep your views flooding in to the address shown above.



Fishing to what level

After reading the Ideas Forum in the May issue and after chatting with my friend who had just returned from fishing, rather annoyed at losing some of his equipment to the fast incoming tide, my mind was cast back to last months issue i.e. the water level detector. Do lots of other fishermen want to hear about it and would they benefit from it - my friend certainly would have! Is there a market for it? I think so if it were built on the same lines as the useful Bite detectors which are incorporated or fitted by some means to the rod rest.

One can be caught unaware whilst sitting and chatting on the beach, to the fast rising tide. In some places where I have been fishing, the tide can actually creep around you cutting you off from the shore. I have been using rain alarms attached to an appropriate metal rod and I usually place three of these around the selected spots and now feel quite safe when beach fishing, especially at when there's no one around to help should trouble occur. Flashing LEDs can also be incorporated and are most visible at night, and need to be as it usually very dark on the beach. I have never seen anyone using these simple devices when fishing on the beach or tidal rivers and sometimes get few funny looks myself, but I must admit they have saved me on more than one occasion when my attention has beam on my torch lit rod top and not the tide.

Harry Layne
Plumstead
London

Clang

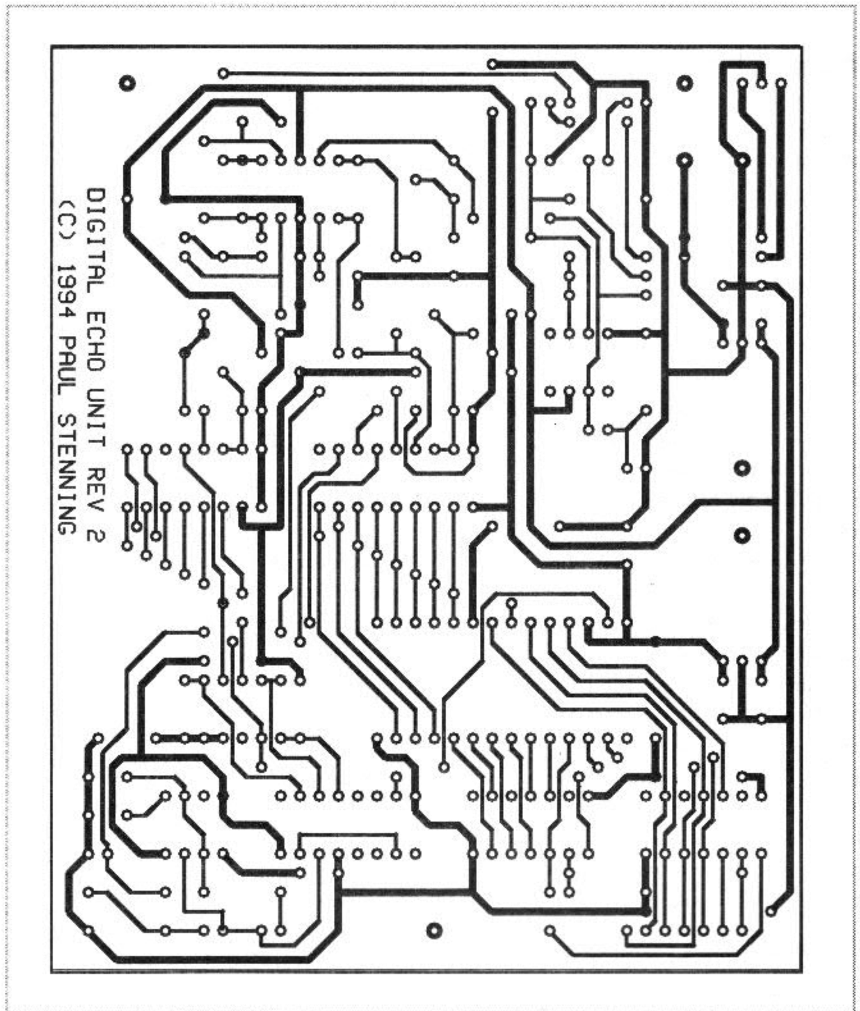
Sometimes errors get past the most stringent tests. So here are a few remedies to previous clangers.

Intercommunications April '94

In the circuit diagram of Figure 1, TR8 should be shown as a PNP device with its emitter connected to R19. The numbering and component positions are correct.

Echo Base May '94

Apologies to those who wanted to make their own PCB for Paul Stenning's echo unit, as we neglected to include it. We reproduce here.



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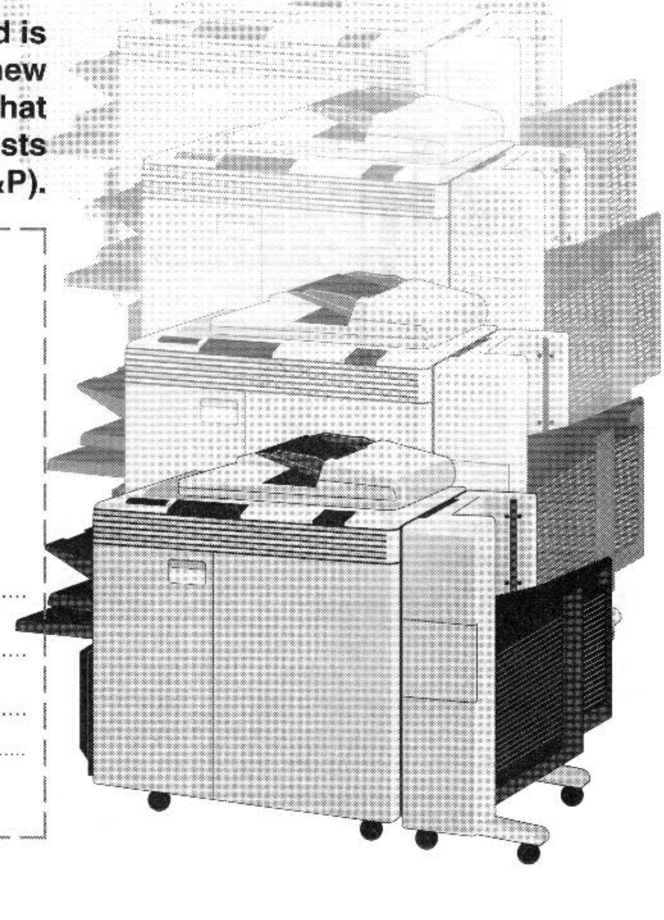

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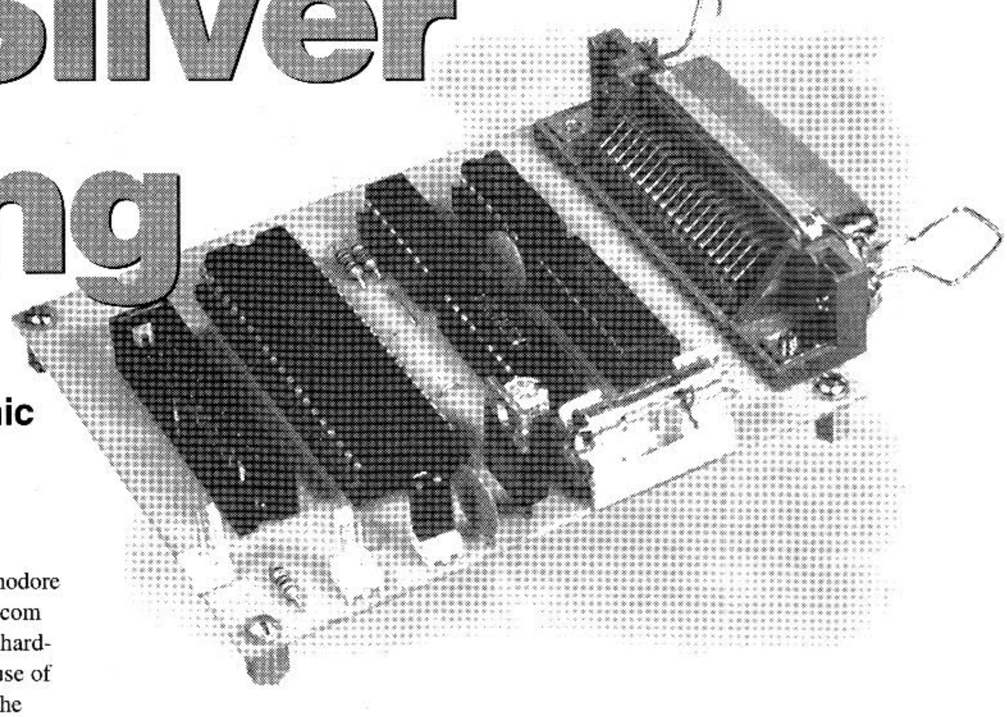


A Versatile Centronic 24-line I/O Port by Dr Pei An

There were days when Commodore C64, Acorn Atom or ZX81 com puters were used to control hardware intelligently. Nowadays the use of IBM-PCs and clones has become the most popular and, undoubtedly, the most powerful way. A modern PC runs at an ultra high speed and is supported by almost all available computer languages such as BASIC, PASCAL, C and ASSEMBLER. These make it the best candidate for controlling external devices. As a result, various I/O cards have been developed for this purpose.

This article introduces a general purpose I/O card for IBM-PC computers. This card is based on an industry standard programmable peripheral interface chip which is able to offer 24 I/O lines. Unlike conventional cards which are normally inserted into the PC's expansion slots, this card is connected directly to the Centronic port (printer port) of PCs. The 24 lines are organized into 4 groups which can be independently configured either as inputs or outputs under software control via the Centronic port. Figure 1 shows how the I/O card is connected to a PC computer and gives the pin-out functions of the 26-way DIL expansion socket from which external circuitry is connected.

The Works

The I/O card is controlled by the Centronic port of the computer, therefore it is suggested that readers should be familiar with the functions and control of the Centronic port. A detailed

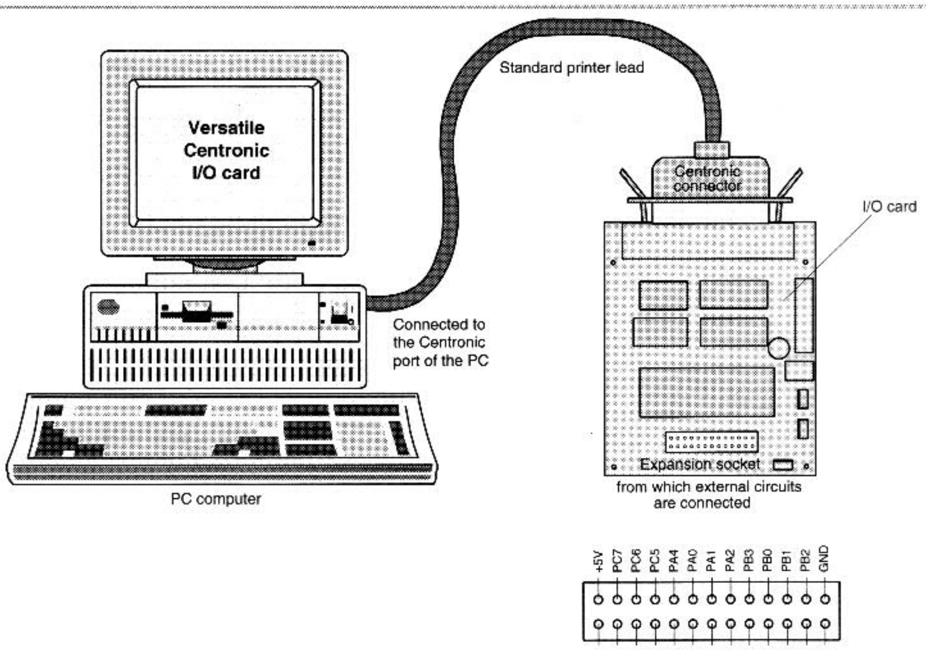


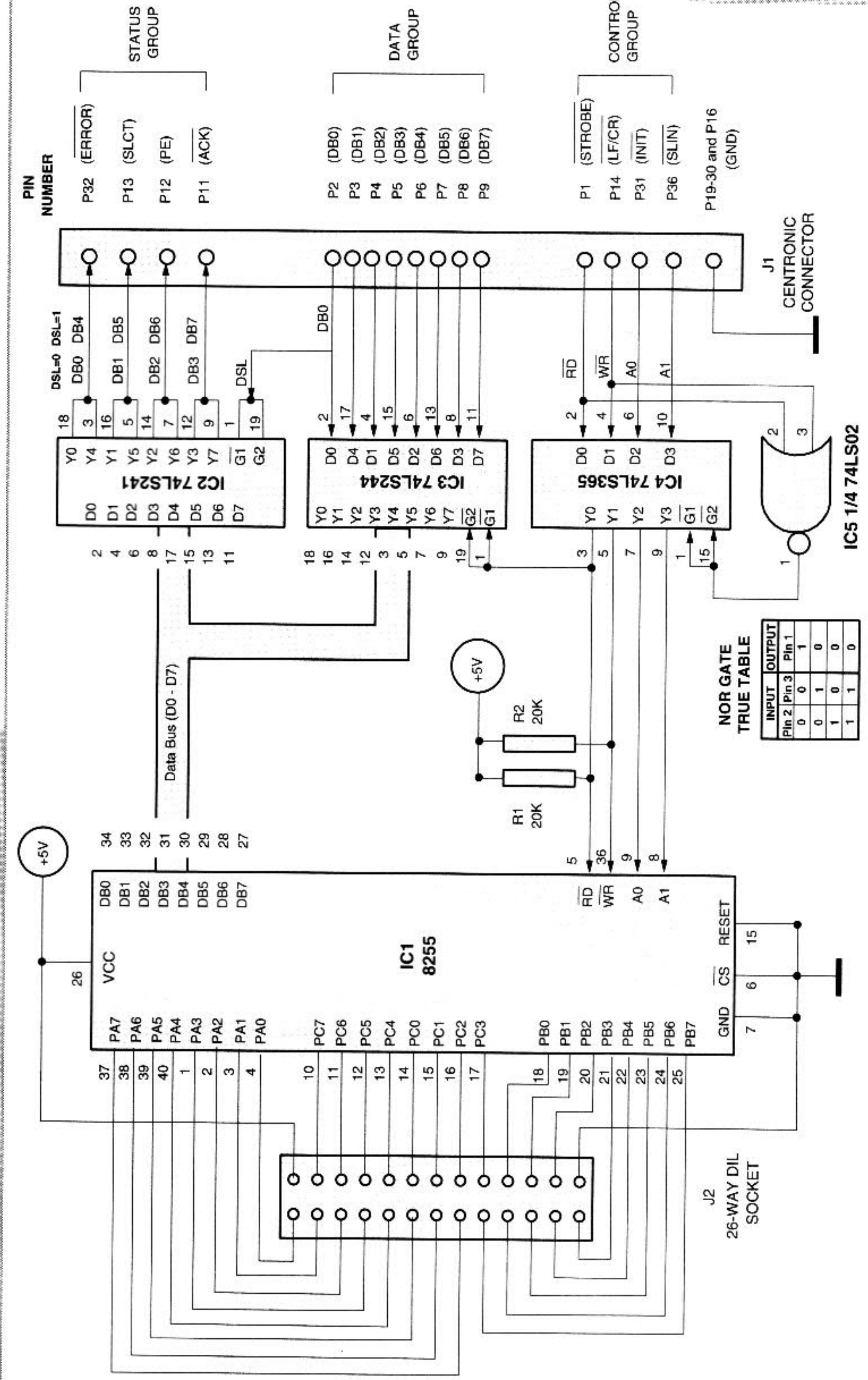
Fig.1 Centronic I/O card arrangement

The Works
I/O card operation

Before reading this part, readers are recommended to read the article suggested earlier and be familiar with the fundamentals of the Centronic port. Briefly, the Centronic port consists of three independent ports, namely, the Data port (output), the Control port (output) and the Status port (input). In the present application, the Data port is used to send data from the Centronic port to the card and the Status port is used to read data from the IC. The Control port is used to control reading/ writing operations of the 8255 PPI.

Data transfer is facilitated by IC2 and IC3 (74LS241 and 74LS244 tri-state buffers) and the control over the 8255 is made by IC4 and IC5 (74LS365 tri-stage buffers and 74LS02 NOR IC). It can be seen from Figure 2 that two lines of the Control port (Pins 31 and 36) are connected to the address lines A0 and A1 of the 8255 PPI via IC4 which is a tri-state Hex buffer IC. Other two lines of the Control port (Pins 1 and 14) are connected to -RD and -WR of IC1 via IC4. A slight problem may occur when these two lines are both at low state, as for the 8255 PPI chip, -RD and -WR can not be set low at the same time, otherwise internal damage may be caused as a result of internal bus contention. To prevent this, a NOR gate (a quarter of the 74LS02 IC) is used. Its two inputs are connected

Fig.2a Circuit diagram



directly to the two control lines from the Centronic port (Pins 1 and 14) and its output is connected to the ENABLEs of IC4 (Pins 1 and 15 of the 74LS365 IC). When the two lines from the Control port are both low, the output of the NOR gate will go high. This will disable all the buffers on the 74LS365 IC and set all the outputs at high impedance state and the two resistors R1 and R2 pull up -RD and -WR lines high.

To write data to an 8255 register, firstly the required data is written to the Data port and an address to the Control port, then a high-to-low-then-high pulse is issued from -WR line of the Control port. This will enable buffers on IC3 and the data on the inputs of IC3 will be transferred to the 8255 data bus. The -WR low-going pulse will also write the data into the selected register. Reading data from the 8255 is slightly complicated, since the Centronic port only has five input lines and in order to read an 8-bit data into the computer, the computer at least has to read twice. This is accomplished by IC2 (74LS241). 74LS241 is a tri-state octal buffer IC (Figure 3(b)) and its pin-out function is shown in Figure 3(b). It can be seen that when pin 1 (the 1st enable) is low, the 4 left hand side buffers work (i.e. the outputs follow the inputs). When pin 19 (the 2nd enable) goes high the 4 right hand side buffers will work. IF Pin 1 and Pin 19 are connected together to form a Data Selection Line (DSL) and by putting the line low and then high, the Status port can read the 4 bits connected to the left hand buffers and the other 4 bits connected to the right hand buffers in turns (Figure 2). These two reading are then bit-manipulated and combined to form a single 8-bit byte. Operating in such a manner, the 8-bit data appearing on the input lines of IC1 can be read into the Centronic port. Referring to Figure 2, the DSL line is controlled by the first LSB bit of the Data port of the Centronic port (DB0). When reading data from an 8255 register, firstly an address (A0 and A1) is written to the Control port and -RD line is held low. This will make the 8255 PPI to output data onto its data bus DB0 to DB7. Then the DSL line is set low and the Status port reads the first reading. The Status port reads the second reading with the DSL line held high. Those two readings are then combined to reproduce the original data.

The card incorporates a 7085 1A 5V regulator. An external 8-12V DC supply is required. The card consumes a current of about 100mA. The regulated 5V power supply is also supplied to the expansion socket which can be used by other external circuits. An 800mA on-board fuse is used to limit the total consumed current.

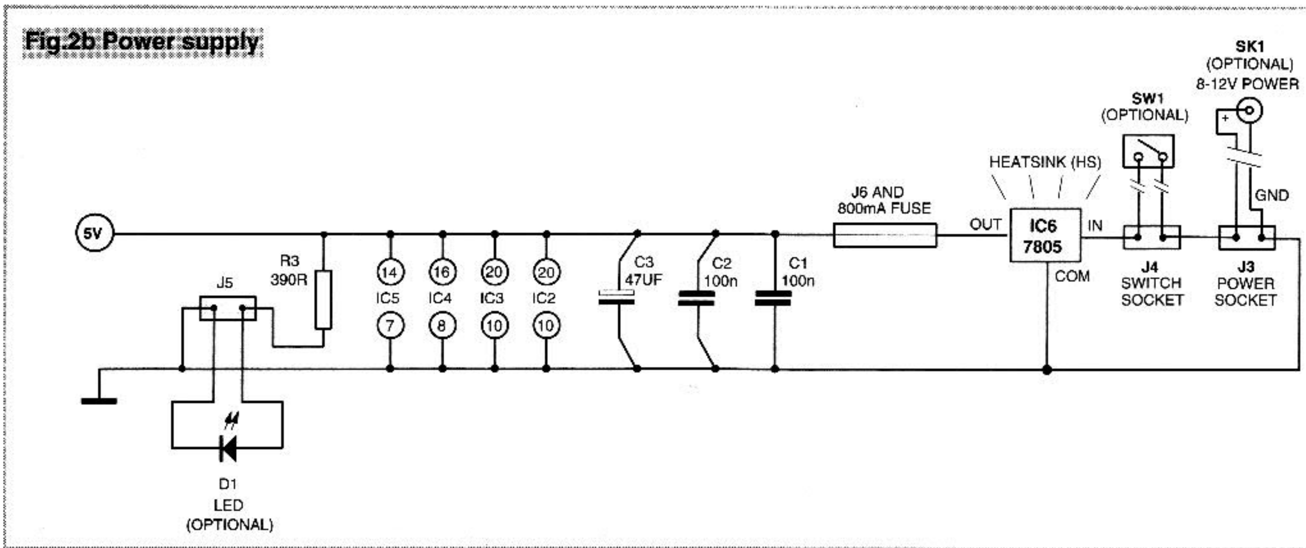


Fig.2b Power supply

description of the Centronic port and the way to control it can be seen in an article entitled 'Mission control' which appeared in April's issue of the Electronic in Action.

The card consists of an 8255 PPI which is the heart of this card, a 74LS241, a 74LS244, a 74LS365 tri-state buffer IC and a 74LS02 NOR gate. The complete circuit diagram of the I/O card is given in Figure 2.

8255 PPI

Figure 3(a) shows the pin-out functions of this chip. GND (Pin 7) and VCC (Pin 26) are connected to the negative and +5V power supply rails, respectively. This IC has 24 input/output lines which are arranged in three 8-bit ports namely Port A, B and C. The 8255 has four internal registers, three of which are called peripheral registers and are associated with Port A, B and C. The fourth one is the control register. The three peripheral registers are used for data transactions between the 8255 PPI and external circuits and the control register is used to initialize the operation modes of the PPI. There are 8 bidirectional data lines (DB0-DB7, Pin 34 to Pin 27) through which data are written to or read from the internal registers under the control of -RD (Pin 5) and -WR (Pin 36) lines. The address lines A0 (Pin 9) and A1 (Pin 8) are used to select a particular register. The relationship between the address lines (A0 and A1) and the registers is shown below:

Internal Registers	A0	A1
Register A	0	0
Register B	1	0
Register C	0	1
Control Register	1	1

-CS (Pin 6) line must be taken low to enable the IC. RESET (Pin 35) line is active high and will set all the lines of Ports A, B and C as input lines. In normal operations, RESET line must be held low.

The 8255 PPI has three operation modes: Modes 0, 1 and 2, by which the three ports can be configured as inputs or outputs. Table 1 summarizes the operation modes.

The operation modes of the 8255 PPI are initialized by writing an 8-bit control word to

Modes	Description
Mode 1	Port A can be set as an 8-bit input or output port. Mixture of inputs and outputs is not possible. Port B is configured in the same manner as Port A. Port C is split into two halves (upper 4 bits and lower 4 bits) with each half configured as either inputs or outputs. The mixture of inputs and outputs in each half is not possible. All the outputs are latched.
Mode 2	Mode 2 configures the 8255 PPI as strobed I/O ports. Port A and B are configured as two independent 8-bit I/O ports. Each of them has a 4-bit control port associated with it. These control ports are formed from the lower and upper 4 bits of the Port C, respectively. In this mode, data applied to an input port must be strobed in with a signal produced in external hardware. An output port is provided with handshake signals that indicate when new data are available at its outputs and when an external device has read the values.
Mode 3	Only port A can be initialized in this mode. In this mode, port A can be used for bidirectional data transfer. This means that data can be output or input on the same eight lines. If Port A is initialized in Mode 2, pins PC3 through PC7 are used as handshake lines. The other three pins, PC0 through PC2, can be used as ordinary I/O lines if port B is configured in Mode 0. These lines will be used as handshake lines of Port B if the port is configured in Mode 1.

Bit No.	Description	Function
Bit 7	Mode set flag	1=Active
Bit 6	Mode selection	00=Mode 0 01=Mode 1 1x=Mode 2
Bit 5	Mode selection	
Bit 4	Mode control of Port A	1=Input, 0=Output
Bit 3	Mode control of upper 4 bits of Port C	1=Input, 0=Output
Bit 2	Mode selection	1=Mode 1, 0=Mode 0
Bit 1	Mode control of Port B	1=Input, 0=Output
Bit 0	Mode control of lower 4 bits of Port C	1=Input, 0=Output

Table 2 Bit functions of the control word

Control Word	Bit 4	Bit 3	Bit 1	Bit 0	Port A	Port C (upper)	Port B	Port C (lower)
128	0	0	0	0	O	O	O	O
129	0	0	0	1	O	O	O	I
136	0	1	0	0	O	I	O	O
137	0	1	0	1	O	I	O	I
130	0	0	1	0	O	O	I	O
131	0	0	1	1	O	O	I	I
138	0	1	1	0	O	I	I	O
139	0	1	1	1	O	I	I	I
144	1	0	0	0	I	O	O	O
145	1	0	0	1	I	O	O	I
152	1	1	0	0	I	I	O	O
153	1	1	0	1	I	I	O	I
146	1	0	1	0	I	O	I	O
147	1	0	1	1	I	O	I	I
154	1	1	1	0	I	I	I	O
155	1	1	1	1	I	I	I	I

Table 3 note: Bit 7=1, Bit 5=Bit 6=0

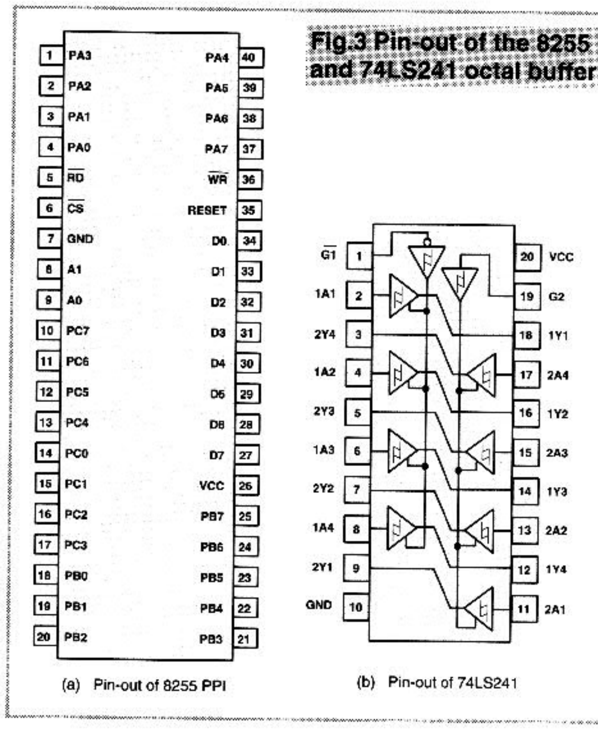


Fig.3 Pin-out of the 8255 PPI and 74LS241 octal buffer

the control register. The bit function of the control word is explained in table 2.

In this article, we will concentrate on Mode 0 which is adequate for the present applications. For other modes, please refer to the manufacture's data sheets.

In Mode 0, as we already know, Port A and Port B can be configured as either inputs or outputs. Port C is split into two halves which can be also configured as inputs or outputs. All possible control words for configuring Ports A, B and C are listed in table 3.

Construction

This I/O card is constructed on a single-sided printed circuit board. The full size foil pattern and component layout are shown in Figure 5 and 6. The PCB board is available from the EIA PCB service and a complete kit plus the control software is available from the author at a price of £30 including P&P. Cheques should be made out to X. Qiu and sent via the EIA office.

Components may be mounted on the board in the following order: links, resistors, DIL IC sockets, capacitors, Electrolytic capacitors, PCB connectors, Voltage regulators, Centronix female connector, fuse holders, 26-way DIL sockets and finally the ICs. It is suggested that IC sockets are used for all the ICs.

Testing

After soldering, check all the joints and connections to make sure there are no shorts due to excess solder. Only when you make sure that the board is properly constructed, can you connect the power supply to the card. Since the card is simple to construct and involves no adjustment at all, it will work straight away if all the ICs are OK and properly located in position. To test the output of the ports, connect the card to the Centronic port via the printer cable and run the sample program (which will configure all the 24 lines as outputs). A logic tester described in Application 5 next month (Integrated driver ICs) can be used for testing the logic level of the outputs. If a logic generator is at hand, the input function of the ports can be tested as well. However in this case the program needs a slight change. When testing the card, readers should be familiar with the pin functions of the 26-way expansion socket (see Figure 1) and know the configuration of the ports. It should be pointed out that connecting a logic output to an output of the 8255 may cause permanent damage to the 8255 PPI.

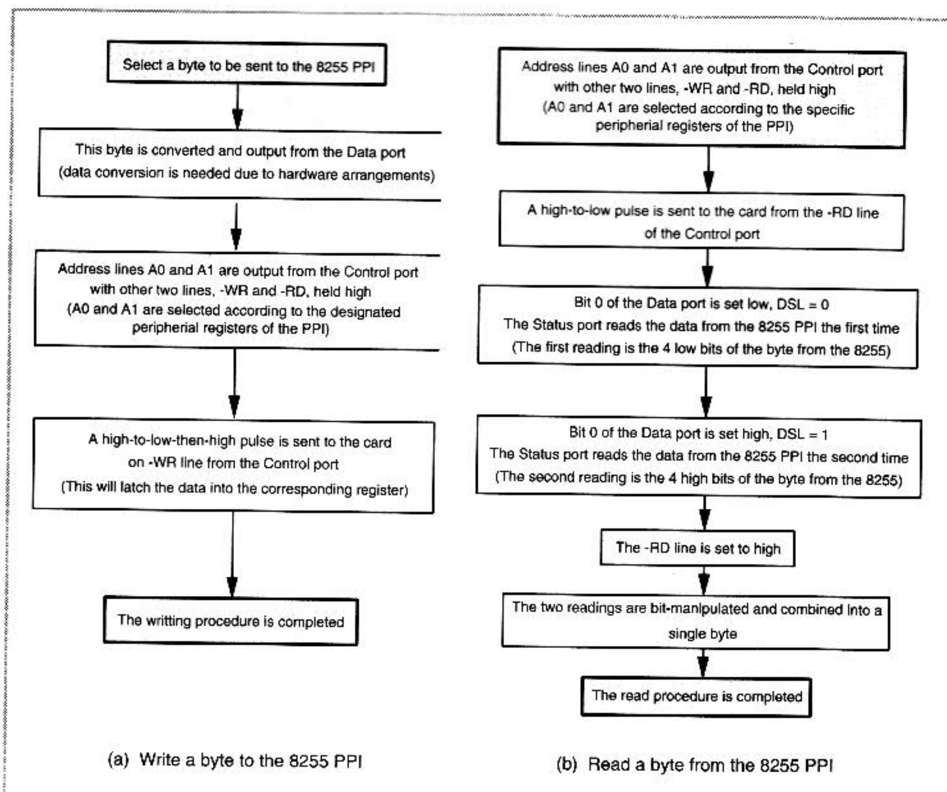
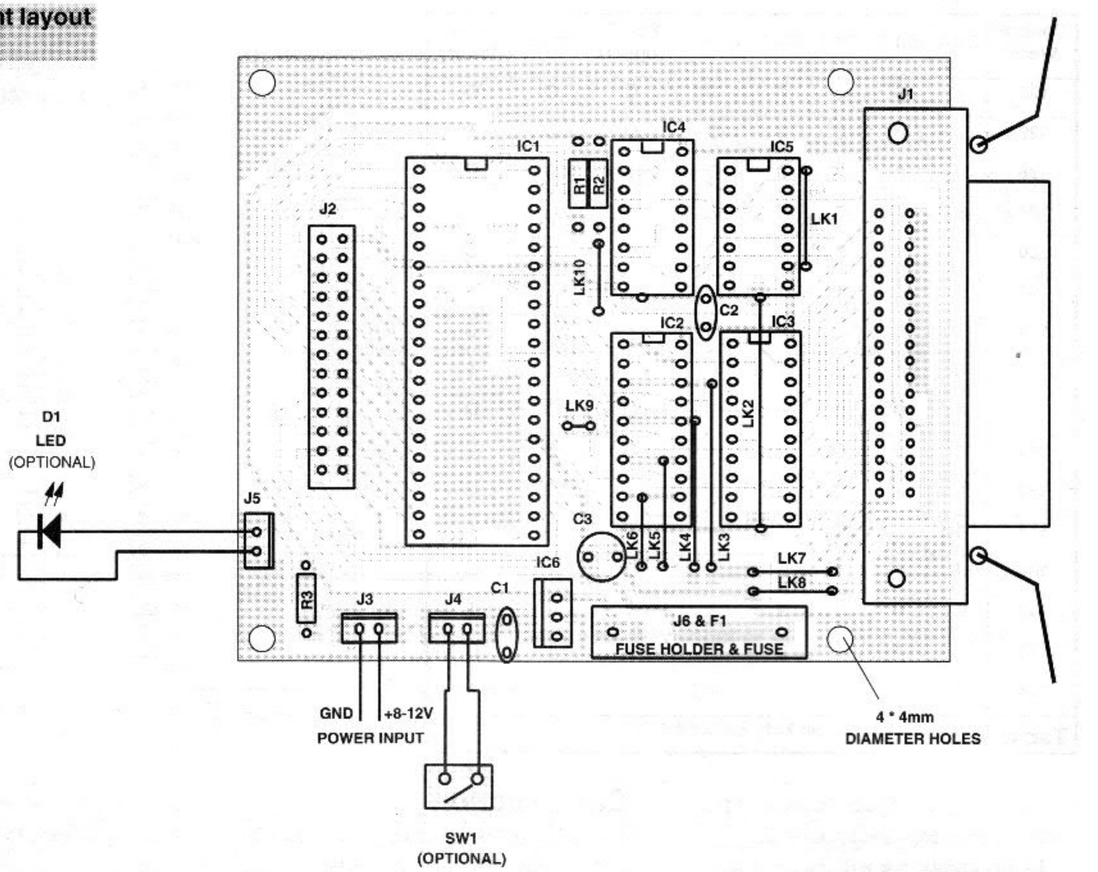


Fig.4 Procedures for writing data to and from the I/O card

Fig.5 Component layout of the I/O card



Parts

Resistors
(0.25W, metal film 1%)

R1,2	20K
R3	390R

Capacitors

C1,2	100nF, Ceramic disc
C3	47µF, electrolytic

Semiconductors

IC1	8255 PPI
IC2	74LS241 Octal tri-state buffer
IC3	74LS244 Octal tri-state buffer
IC4	74LS365 Hex tri-state buffer
IC5	74LS02 NOR gates
IC6	7805 5V regulator (1A rating)

Additional items

J1	36 pin female Centronix-type connector
J2	26 way DIL male socket
J3,4,5	2 way PCB connectors
J6	Fuse holder
F1	Fuse, 800mA
LK1-LK10	0.6mm diameter copper wire or similar
Spacers	6BA spacers for PCB mounting (4 off)
HS	Heatsinks for 7805 power regulator

Optional items

SK1	2.5mm power socket
SW1	toggle switch
D1	5mm LED

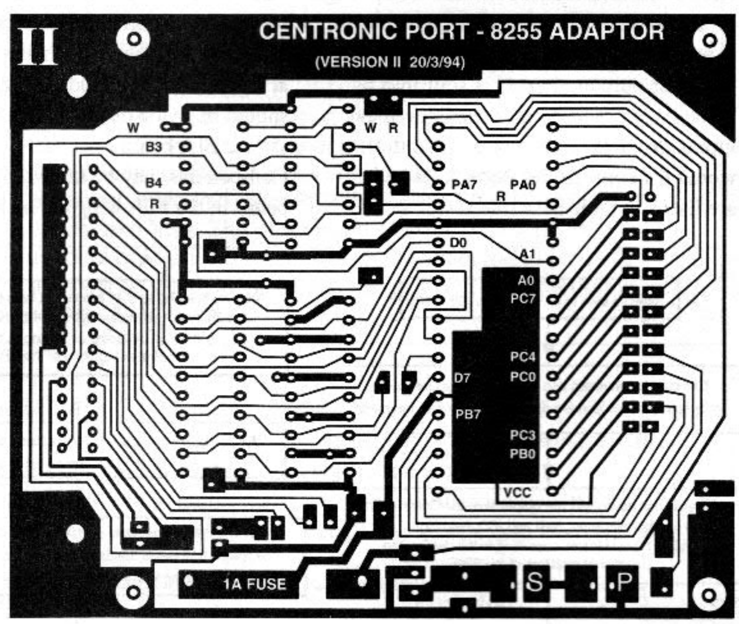


Fig.6 Foil pattern

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TRADE & CORPORATE ENQUIRIES WELCOME

Smarter than the average card

Paul Freeman-Sear reports on the wider use of Smartcards

The buying power of that now familiar piece of plastic called a credit or debit card has served us well for many years. But technological progress has ensured that this simple token will be superceeded by an all embracing information card thanks to micro electronics.

The revolution in surface deposition techniques, being able to 'spray' molecular layers of semiconductors on a chip means that complex integrated circuits can be made on extremely thin layers, indeed, thin enough to be mounted within the thickness of a credit card.

From then on it didn't take a genius to work out the potential of such technology placed within a plastic card. With the potential for such a sizeable memory one can store large amounts of personal information including your own health and wealth. It could become an identity card with your life history placed upon it. Needless to say there would be a variety of official bodies that would want to see such a datafile if it existed. Officials like the Inland Revenue, the Health Authorities, insurance companies and prospective employers would all like to get their hands on your vital statistics to see if you are too high a risk to the insurance companies, a liability to health authorities and a debtor to the revenue.

Assuming a card with such a wealth of information existed, there are pitfalls to this idyllic information state.

For some people it might be the easiest thing in the world to loose the card. To others it might be termed a convenient loss if officials require extra statistics about yourself for any investigation. Authorities would however make sure that they have your personal information on a secure database and the need for a personal smart card would be to update each others information file. Some may suggest that as you are already registered for life as soon as you come into the world and it wouldn't be a great step forward to have a standard WORM (write once read many times) database implant at birth - A Smartcard under the skin.

Plastic cash

Where most people will see this new card is through its spending power. As a funds transfer card or electronic purse, it would be as invaluable as the credit card and eventually we could see the disappearance of cash, with all your hard earned money being held in a bank electronically.

One version of the smart card has been introduced experimentally on to a public transport system in the UK. One bus company uses it as a season ticket and is an electronic version of a pass card, which rather like the phone card currently in use, reduces its value the more it is used. The advantages are that less time is taken up dealing with cash transactions at each fare stage. At the moment it would seem to be transferable as there is nothing to prove ownership. At first sight it would seem apparent overkill to use a smart card for such a simple task. Surely the passive phone card would suffice? Well in this case, the hidden sophistication can provide more information to the service provider and just as the last journey is taken, the smart card would give a detailed analysis of all journeys made and at what time. The bus company would then have a complete record of individual movements. From a researchers point of view,

What is a smartcard?

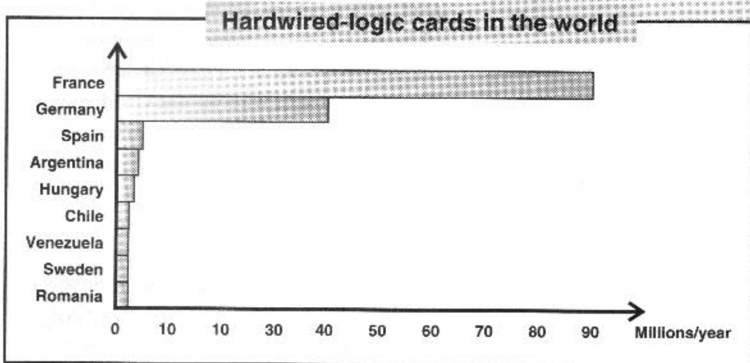
Smartcards are like conventional payment cards except that they have an embedded silicon chip in place of a magnetic stripe. This chip can contain simple memory storage, or memory with some intelligence in the form of logic or a microprocessor. The chip is accessed by a pad of contacts on the surface of the card, and can be used for a wide variety of purposes. Used as a phonecard, the chip is programmed with credits corresponding to money, which are cancelled as they are used. When all credits are used, the card can be disposed of (however, smartcards can also be used as rechargeable 'electronic purses' in other applications). Smartcards have the benefit of high security when making transactions and a low cost of IC. This security is available because the chip can perform dynamic operations at the time of use to defeat fraud. In the case of a phonecard, the payphone terminal issues a challenge in the form of a random number. The phonecard contains a response to this challenge with a result derived by applying an encryption 'key' to this number. This key is buried inside the chip's circuitry and cannot be accessed externally. Defeating this encryption is incredibly difficult, some would say impossible for all practical purposes.

it could provide an overview of mass personnel movements. The bus company could maximise its efficiency, thus saving company time and money from such an analysis.

Smart Experiments

However, the 'smarter', wider use of microelectronics is just beginning, in fact some would say this is the beginning of the 'smart age'.

The Smart card market is already estimated to be about 45-55 million units, telephone cards adding another 180-200 million units and the industry is still in its infancy. France dominates the industry and the larger volume users at present are in banking, mobile communications, payphones and pay TV. The latest interested sectors in the technology are health and public transport.



Other European countries, Norway, Switzerland, Italy, Spain, and Germany have followed suit. Over in the United States, the first smart card pilot scheme took place in 1986 where approximately 100,000 cards were used with Mastercard in Maryland and Florida. Since then many applications have been found for the card. One US Department is using 200,000 Smartcards to monitor and control crop sales. The Japanese are experimenting with smartcards for health and for identification purposes.

Wired for Action

Two types of microcomputer card exist. The first is a hardwired logic device where the non-volatile memory is hardwired to the external interface. These hard wired cards contain from 512 to 8K bits and would be mainly used for prepaid services rather like a bus pass.

The other microprocessor-based card

Vietnamese trial for advanced smartcard payphone system

There is a pilot project that could change the public payphone network of Vietnam.

Schlumberger Transactions Systems is to trial its smartcard-based public-payphone system in Hanoi, in a pilot project which might lead to a nationwide installation contract. In a trial that will last until mid 1994, two payphone systems will be compared for performance, ease of use and public acceptance.

Under the control of the capital city's telephone operator, Hanoi City Post & Telecoms, Schlumberger is installing many smartcard payphones that will be able to use phonecards containing integral silicon chips. A Malaysian competitor is offering a phone system accepting payment by conventional magnetic-stripe cards.

The competing tender proposes a privately-run system to be funded by levying an additional margin on international unit costs.

Schlumberger's proposal that the inherent flexibility from smartcard technology will not only help to bring Vietnam's telecommunications services to a state-of-the-art system but will also help to optimise business growth. Smartcards make this possible by means of their integral computing power. The benefits of the smartcard system will bring abbreviated dialling codes, graphical images, and access/identification checks - making the phones much faster to use.

The smartcard can make dynamic security checks, making transactions nearly immune to fraud compared to magnetic-stripe cards.

In the last few years, many communications companies around the world have either introduced smartcards, or have started to evaluate the technology.

The smartcard chosen for the trial uses a well-proven phonecard IC; the trial period began officially on 14th January 1994.

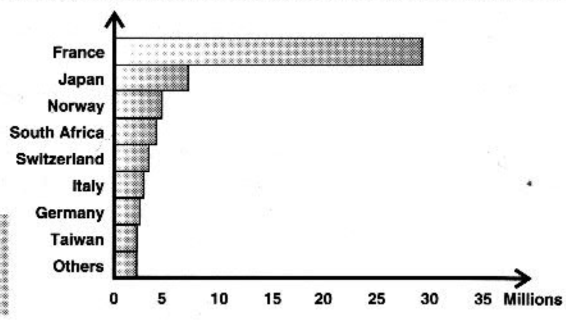
A further long-term application for this technology in Vietnam's economy is to move towards access to electronic funds transfer (EFT/POS) techniques to assist businesses towards cashless financial transactions.

Schlumberger also points to a fascinating medium-term prospect for smartcards in Vietnam, based on the experience of the way the technology has been treated in European countries. During early stages of use, the smartcard is merely a cashless payment mechanism and is issued with printed instructions for use. But once the technology is accepted, it takes on a life of its own, and firstly becomes an advertising medium, and then a popular medium for art and culture. The art and promotional uses of smartcards in Europe currently result in major additional revenue in terms of phone units that are created but never used.

Year	93	94	95	96	97
Geometry	1.2µm		0.8µm	0.65µm	0.5µm
Voltage	3.3V-5V	2.7-5.5V		1.8-5.5V	
Memory </25mm^2 EE	12K ROM		20K ROM/12K EE	20K ROM/16K EE	30K ROM/24K
Cost (1M units with 3K ROM 1K EEPROM	$1.2-1.5	1.1-1.4	1.0-1.3	0.9-1.2	0.8-1.1
Technology	ROM/EE			ROM/E Contactless	
				ROM/EE/Flash	
			ROM/EE/Public Key		

Table 1 Technology Forecast

Total numbers of Smartcards in the world



has an on board chip produced by SGS Thomson and Texas Instruments. It contains 256 cells including a 96 bit tamper proof reference. A German card made by Siemens and SGS Thomson has 416 cells of EEPROM with 208 bits of working memory. The access is controlled by a password and the operator is given four consecutive chances to get the code correct before the card is blocked.

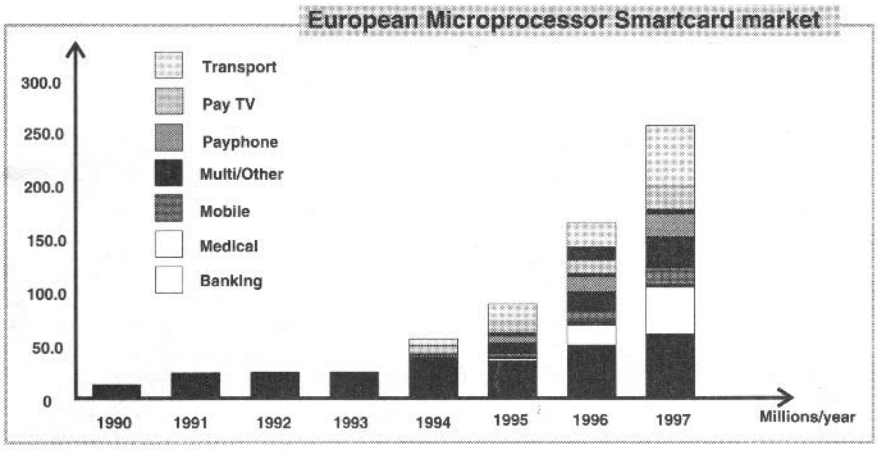
Smart or Dumb

When is a Smartcard smart and when is it just a memory. The term smart should imply that it can process and interpret data. This would mean using a microprocessor. A memory card is unable to do this and is often referred to as a dumb device. Your present credit card with the dark brown stripe on the back carries magnetic information and is limited in its coded content. This passive device could be likened to a low memory ROM. But because of its increased sophistication, the smartcard will have uses in high security applications for health records and in pay TV where an encrypted TV signal will need to be unlocked.

A typical high density smartcard will contain 8K of electrically erasable memory (EEPROM) with 10K-16K of read only memory (ROM) and 256 bytes of RAM and the demand for increased memory capacity is for ever on upward. Those that might want to use GSM mobile phones might be asking for facilities such as short dial codes, message storage and voice mail. But the trend is that customers are asking for more memory for a variety of applications and non volatile flash memory is emerging as a contender for this application. It has an advantage over erasable programmable read only memory (EPROM) in that is electrically erasable and occupies a smaller area than EEPROM, something that is important in smartcard applications. One drawback of flash memory is that it requires a 12V programming supply and is limited to around 100 cycles of WRITE/ERASE compared to 100K-1M with an EEPROM. Future smartcards may see a

Device	Size (mm)	ROM bytes	RAM bytes	NVM bytes	Comments
6805SC01	5.5x3.5	1.6K	36	1K E	Original French Banking chip
68HC5SC11	5.6x3.5	6K	128	8K E	Designed for pay TV and multipurpose applications
68HC05SC20	3.5x3.4	4K	160	128b E	Low density, cost sensitive applications which still need security, such as Electronic purse.
68HC05SC21	5.4x2.7	6K	128	3K EE	3.3-6V, standard in GSM phase 1
68HC05SC24	3.7x2.8	3K	128	1K EE	3.3-6V, Standard in French banks, used in pay TV, Electronic purse & general applications
68HC05SC26	3.8x3.6	6K	160	1K EE	3.0-6V Multipurpose and low voltage applications requiring larger ROM for operating system
68HC05SC27	4.9x4.2	16.4K	240	3K EE	3.6V used in GSM phase II and pay TV
68HC05SC28	5.3x4.9	12.8K	240	8K EE	3-6V, used in GSM phase II HI end as for SC27
68HC05SC29	5.3x4.9	12.8K	512	4K EE	Includes modular arithmetic processor. New applications include Health cards, banking and advance security applications.

Table 2 Smartcard chips Content and usage



mixture of flash memory and EEPROM if contactless cards are to be the norm. Potential operators are also looking for increased speed of operation to implement more complicated software and for higher level encryption. So there will be a need for fast co-processors perhaps using Digital Signal Processing (DSP). Even the 512 bits used for encryption today might become questionable if codes are ever broken and again faster processors would be required for more encrypted bits.

There could be some integration of memory and microprocessor cards where there might be a need for an electronic purse. These would replace the direct debit cards used by many banks. At the same time there would also be call for greater security so that in the event of the card being stolen or lost, the owner could feel secure in the knowledge that it could never be used by anyone else.

As the decade marches towards an end, advances in semiconductor technology has shown that by the end of the decade 100 million transistors will be achievable on a chip and with this comes an ever increasing memory availability and processing power. The smartcard will certainly benefit from this level of integration.

Neural nets for smartcards

Embed artificial intelligence into a smartcard and it will allow 'biometrics' to prove user identity by recognising voices or faces. This is the claim made by Neural Computer Sciences, an artificial intelligence company based in Southampton.

Neural Computer Sciences has become a partner in the newly-formed Esprit Chip Architectures for Smart CArds and portable intelligent DEvices (CASCADE) project, which has been set up in the European Community to develop the next generation of smartcards. The UK company's role is to develop a version of its neural network artificial intelligence system which is capable of being embedded inside a smartcard IC. It would provide support for highly sophisticated security checks using techniques such as biometric technology. This future generation of 'thinking' embeddable microcomputer chips will greatly expand the applications potential for smartcard technology, opening up markets for billions of cards worldwide.

The Smartcard is capable of performing a wide range of extra functions including very high security 'handshakes' with the transaction terminal or computer to eliminate fraud, and this is one of the key aspects which the CASCADE project is addressing.

With integral 32-bit RISC-based processing power, a CASCADE smartcard will be able to perform security functions which for all practical purposes are immune to attempts at fraud. These include biometric checks which might verify a user's identity against a unique human characteristic such as a voice, face or fingerprint. The inclusion of artificial intelligence may allow the embedded microprocessor to make the same kind of judgements as a human when faced with a voice that has changed because its owner has a cold, a face which now has a beard, or a fingerprint which has been scarred, since a sample was first captured and stored for comparison purposes.

An example of the potential use of biometrics is during a credit card purchase made by telephone: a process currently wide open to fraud. Using a telephone with an integral smartcard reader a neural network embedded inside the card could validate transactions. The vendor's terminal could request the prospective purchaser to speak a random word or phrase. In real-time, the terminal would run a signal processing algorithm on this speech to generate a profile - a sequence of perhaps a couple of hundred bytes of data which is then transmitted back in encrypted form to the user. The user's smartcard - with its integral neural network - would then analyze this profile to determine if it belongs to the card's real owner. As this security checking relies on data embedded inside the card's chip, and software inside the terminal, it is virtually inviolable.

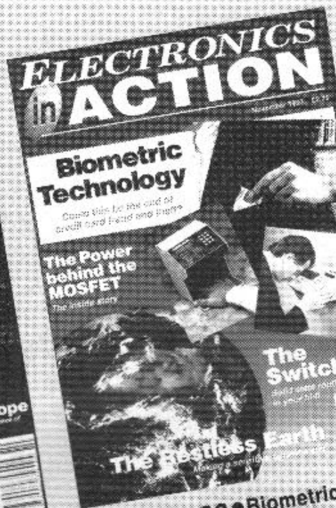
The CASCADE project - currently funded by the European Community at approximately 3M ECUs - will develop this next-generation smartcard technology. The project is expected to take 2.5 years, with the results available in 1996.

Southampton-based Neural Computer Sciences has been selected for their part in this project because of its leading role in the development of neural networks. It was the first company in the world to develop a Windows-based system, opening the technology up to a much wider range of commercial and industrial users. The other members of the consortium are Gemplus the French smartcard manufacturer (and the prime contractor behind CASCADE), the UK's ARM who are providing the design for the 32-bit RISC processor, France's Dassault who are working on card readers and terminals, Domain Dynamics of the UK who offer signal processing technology which simplifies biometric pattern recognition, the University of Louvain in Belgium who are working on encryption techniques, and France's University of Lille who are working on the card's operating system. The Paris office of ARTTIC has been appointed to provide operational project management services.

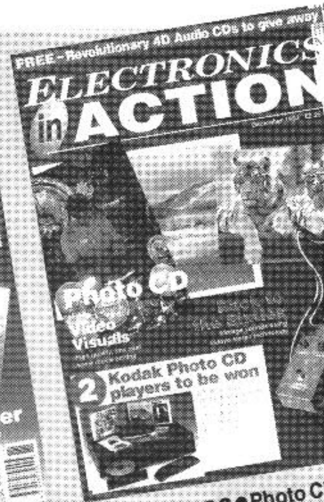
Neural Computer Sciences want to develop ultra-compact neural networks capable of operating within the limited resources of a small low cost silicon chip. The company's previous experience with its NeuDesk product provides an important background for this work. This software, which runs on a standard PC, has already led the company to develop 'skeletonizing' algorithms which strip down neural networks after creation to optimize their run-time speed and efficiency. This should help to realise the goals of CASCADE.

Brian Kett from NCS says "New techniques to embed a neural network on silicon are valid for catalyzing a range of other applications, such as the provision of silicon sensors capable of monitoring the health of a piece of machinery, or of being embedded inside locks to make them intelligent. Whole new markets and industries could be made possible".

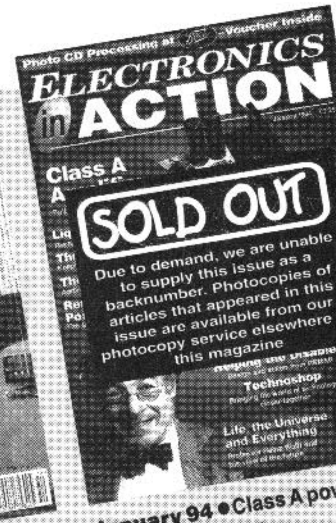
October 93 ● Fractal Imaging ● The Telescope Pt1 ● Anti-Howler ● Audiophile Pre-amp ● Sine wave generator



November 93 ● Biometric Technology ● The Switcher Pt1 ● Seismometer Project ● The Telescope Pt2

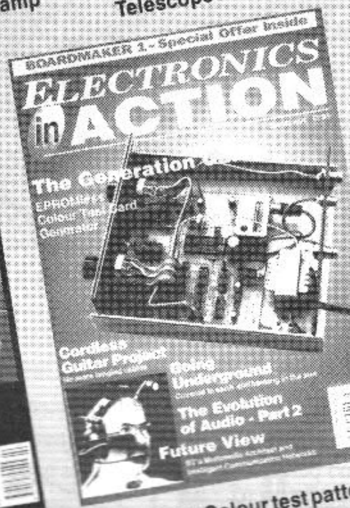


December 93 ● Photo CD ● 4D Recording ● Video editing unit ● Stereo tremolo unit ● The Switcher Pt2

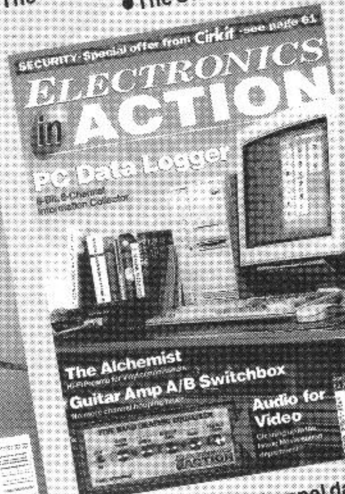


January 94 ● Class A power amp ● The Harmoniser ● Remote control extender ● The Switcher Pt3

February 94 ● Virtual Reality ● Class A amp Pt2 ● Hatchery Controller ● The Switcher Pt4



March 94 ● Colour test pattern generator ● Cordless guitar project ● Plug-in mains wiring tester ● Intelligent Communication Networks ● The Switcher Pt5



April 94 ● 8 bit, 8 channel data logger for PC ● 5 band graphic equaliser ● The Alchemist - HiFi preamp ● A/B Switchbox for guitar amp ● Water level detector

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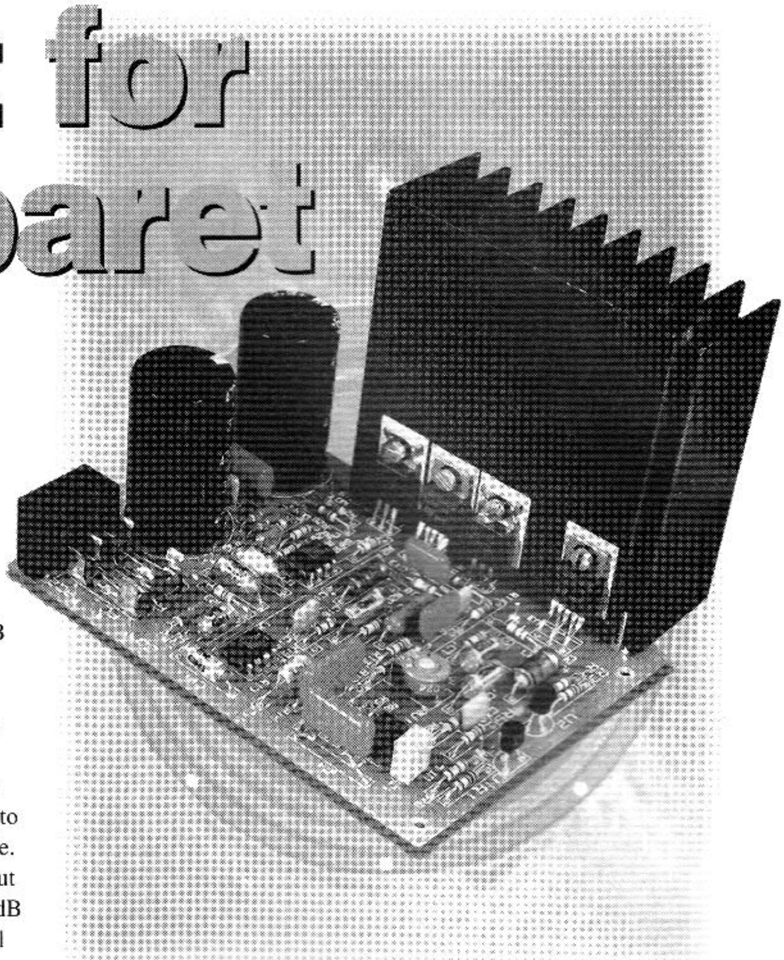
An Act for the Cabaret

Part 2



In a flurry of activity Peter Roberts begins building his 'Cabaret' Active Loudspeaker

Let's dispel a myth about the bass reflex speaker. It is usually held that the fast cutoff rate will give poor transient response e.g. ringing or overhang. The LF response of a bass reflex speaker is that of a high order, high pass filter and these always have some overshoot. The ear/brain perceives a transient 'ring' as an extension of the event in time. How could this not be a problem? Our old friend Thiele considered this. The time taken for the sound in a room to die away is the reverberation time. This is defined as the time taken for the sound level to drop by 60dB from the original level. At low frequencies the reverb time just defined will be longer than the time heard by the listener. To see why, Figure 1 shows the Robinson and Dadson equal loudness curves. The minimum audible frequency level (MAF) at 25Hz is 68dB. Given a nominal sound intensity level of 100dB, this is 32dB below our nominal level. Thus the signal only has to drop 32dB to be inaudible. This is about half the 60dB reverb level and it halves the time for a 25Hz signal to be inaudible. Thiele points out that a properly adjusted vented box need cause no perceptible colouration due to ringing. If the design is not right and there is a peaky amplitude response, i.e. poor damping, the transient rings may be audible.

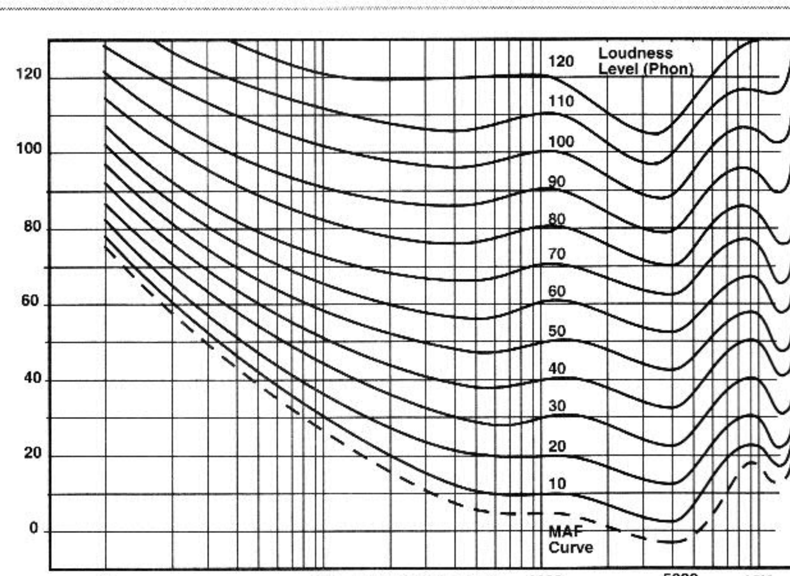


Fig.1 Robinson and Dadson equal loudness curves

Having unburdened myself of that interesting fact, there is an advantage with the transient response of this speaker in that it uses a sub-Chebychev alignment. See Figure 2 for the transient response of various types of bass reflex design.

Hitting the high notes

I shall continue with a brief recap of Part 1. A special amplifier which has a negative output resistance is used to lower the speaker bass distortion and improve the damping. Also, a sixth order bass reflex design is used to lower the cone excursion and provide a free rumble filter.

The woofer specified for this design, a Morel MW1075, is a 250mm unit with a very smooth sound over the bass and midrange. See Figure 4 which shows the makers frequency response. Note the bass peak at 40Hz which is flattened by the above techniques.

The MW1075 has a medium compliance of 178 litres and a Qt, defined as the sharpness of the resonant peak, of 0.65 which is comparatively high. This is deliberately chosen high, so that the negative resistance can lower the Qt and lower the distortion by a large percentage. Since there is a direct relationship between the Qt and box size, it enables the enclosure size to be reduced to 60 litres, otherwise the cabinet volume would be about the same as the compliance, i.e. 178 litres. Incidentally, the negative resistance is used to lower the Qt to 0.30.

The tweeter is the Elac metal dome. It is mounted in the cabinet at a height giving on-axis listening, when sitting in an armchair. It was selected after listening tests on a number of different units. Some sounded poor with either harshness or glare. One type which should have sounded good had a horrible squawk, which disappeared after a week of running, the tweeter then sounded pleasant. The Elac units sound good "straight out of the crate" If a new drive unit or speaker initially sounds bad, if possible, give it a weeks running to see if the unit settles in. There was not enough time to run-in all the trial tweeters.

Other tweeters could be used in this design, if they have a reasonably flat frequency response and you like their sound, since an adjustable potentiometer is used to match the tweeter sensitivity to the woofer. I will now go through the design, which neatly integrates all the system functions on a single PCB. The layout is fairly critical, so constructors are advised to use the PCB available from the address at the end. Firstly I have chosen a relatively new op-amp for this design. With the OP275 device, the audiophiles prayers for a decent device have been answered. Distortion is 0.0003%, yes that is the right number of zeros, slew rate is 22V/µs Noise is 6µV/Hz all for a current of 5mA. These modern chips are so good it does not seem worthwhile designing discrete circuitry for these applications any more.

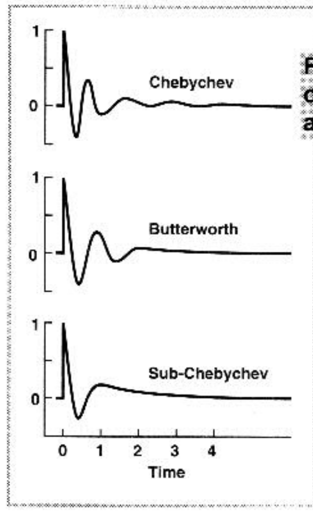


Fig.2 Step response of the base reflex alignments

Input stage

Referring to Figure 3, the filter and output stages of the amplifier have a gain, which cannot be lowered, for functional or stability reasons. Thus, we have to attenuate the input to achieve reasonable listening levels. A potential divider is used for this, and is switchable so that in one switch position the speaker simulates a passive speaker, thus it can be driven from your existing amplifier output. In the other position, a CD player or pre-amp output could be used directly. The unit supplying the speakers must have a volume control! Here is a possible application for a passive pre-amp.

The potential divider degrades the ultimate signal to noise ratio, but in practice, this is not noticeable. The potential divider feeds into a unity gain buffer. If you wanted, you could replace the potential divider with an externally controllable volume control, but for me this is an inconvenient arrangement.

The output of the buffer feeds an active high pass filter, whose turn-over frequency is 30Hz, with a Q of 1.53 giving a boost of 3.7dB. This filter is second order and together with the fourth order bass reflex system, produces the sixth order alignment. As well as reducing the sub-sonic cone excursion it acts as a rumble filter. The port is tuned so that the box resonance is 25Hz, which gives the correct sub-chebychev alignment.

Crossover circuit

This is the Linkwitz-Riley type with cross-over point at 3.0kHz. The second high pass filter is built around the tweeter power amplifier. A potentiometer is provided to set the tweeter level.

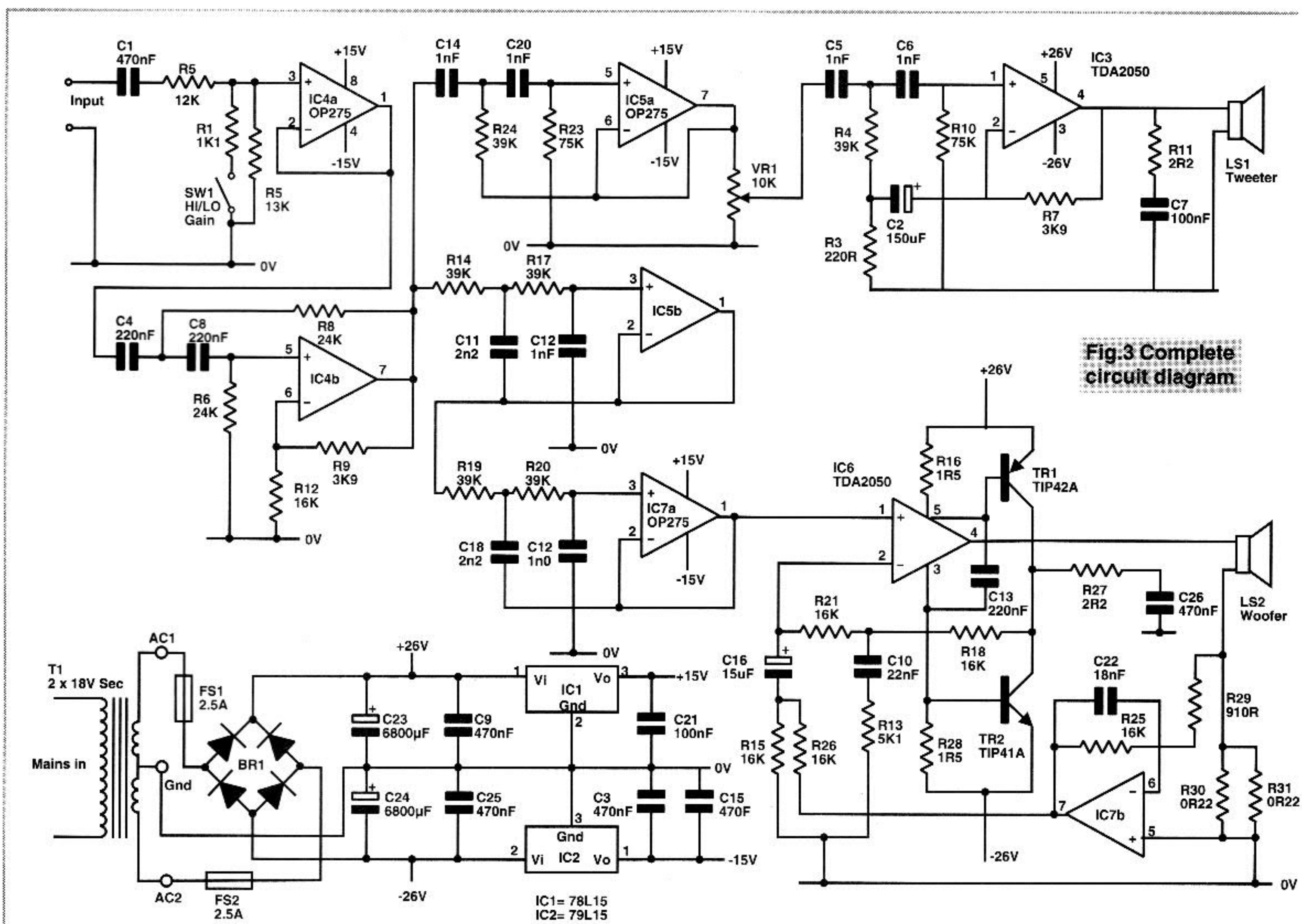
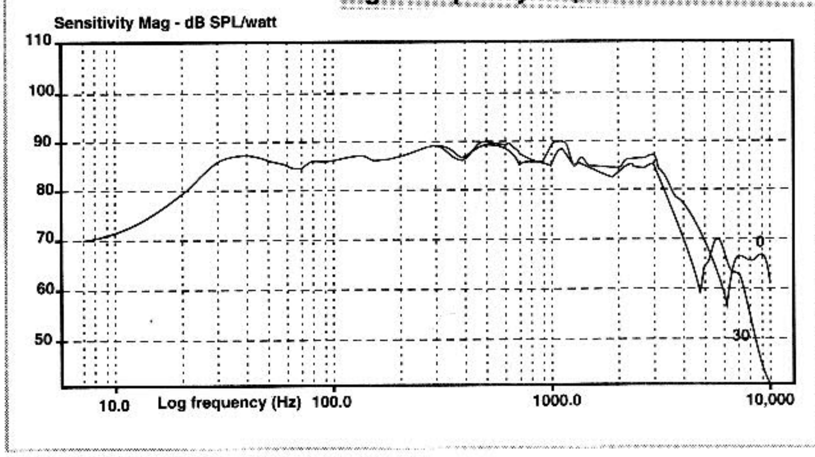


Fig.3 Complete circuit diagram

Fig.4 Frequency response of MW1075 unit



Power amplifiers

These are based on the TDA2050, an improved higher power version of the ubiquitous TDA2030. This device has a distortion of 0.03% at 20W output and has short-circuit protection and thermal shutdown. For heavy duty applications like this, a problem is the limited power dissipation of the TO220 type package. To avoid heat causing untimely thermal shutdowns, a circuit dating from the early days of monolithic op-amps is used. A pair of power transistors sense the current drawn by the TDA 2050. When the current gets high, the transistors gradually take over the job of supplying current to the speaker load. This shares the power dissipation between the devices. Since the tweeter needs relatively little continuous power this treatment is not applied to the tweeter power amplifier. Selected high voltage versions of the TDA2050 are used to cope with the power supply voltage.

Negative resistance

Feedback on an amplifier changes the gain and also changes the output resistance (or impedance). If voltage feedback is applied the output resistance is lowered. Positive current feedback also lowers the output resistance but to the greater extent that it can be zero or negative. Positive feedback and negative resistance usually apply to oscillators. This circuit will oscillate if the negative resistance generated exceeds the speaker coil resistance, as the gain is theoretically infinite. Since we generate -3.9 ohms, this circuit should not be used with drive units having voice-coil resistances of less than 3.9R.

A small resistor in series with the woofer coil senses the output current. The voltage developed across this resistor is amplified by IC7b and fed back to the power amp, giving positive feedback. The drive unit impedance increases with frequency and this could lower the output. To avoid this, the positive feedback is rolled off using C22. The negative feedback is reduced at the same time to give a flat response into the speaker load. C10 and R13 reduce the negative feedback.

Power supply

This is conventional and uses a toroidal transformer. The single fixing screw normally used for mounting toroids is not good enough for a wooden cabinet, so a hardwood batten is laid across the top. This is secured with 3 long screws and pillars. Neoprene washers isolate the transformer at top and bottom.

Construction hints

The beauty of the bass reflex type speaker is the comparatively simple box design. The only proviso is that the enclosure is leakproof, despite being a ported design. The panels are made from flooring grade chipboard 18mm thick. Its easiest if you can find a supplier who can cut the panels accurately. The panels can all be cut for one speaker out of a standard 2440 x 600mm sheet, even with the tongue and groove feature (cut off, of course). The panels, except for the rear panel are held together with long chipboard screws and wood glue.

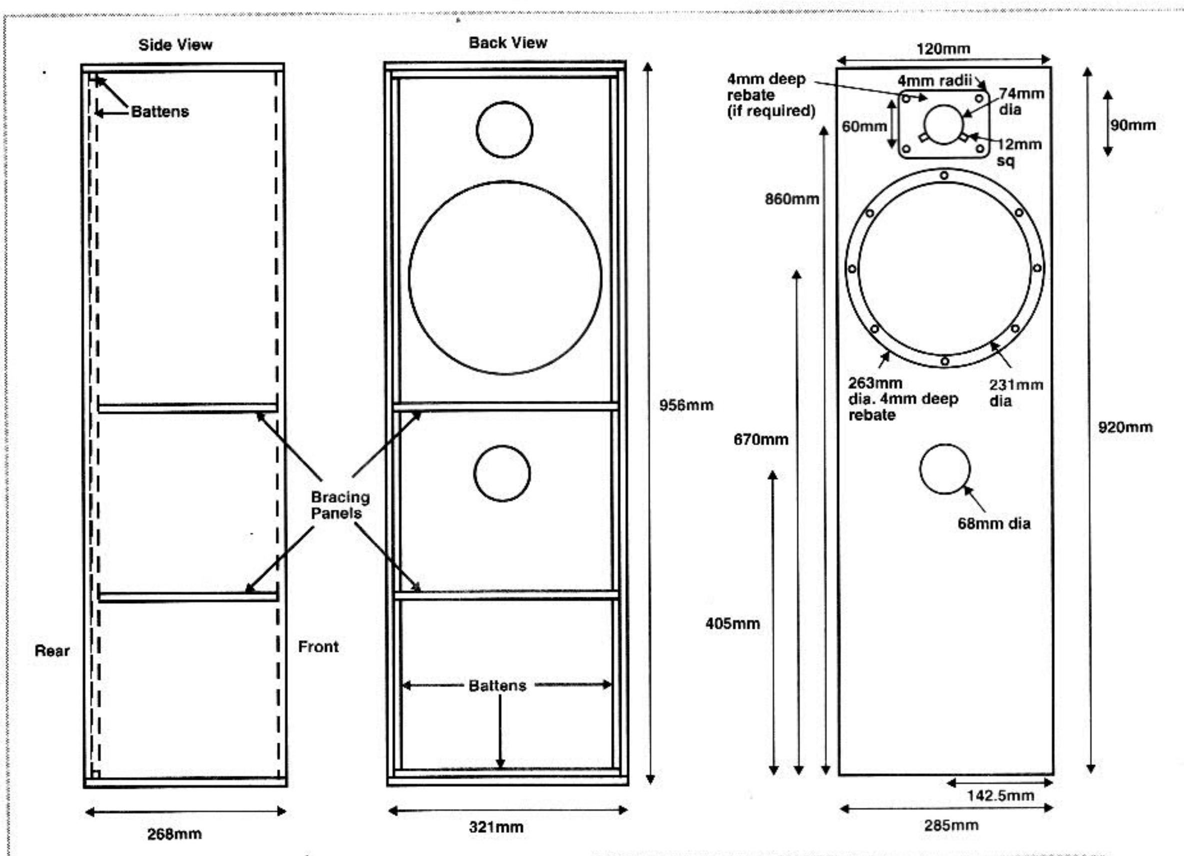


Fig.5a Speaker cabinet construction details

This gives a strong joint which does not really need support battens in the corners, however you could fit these if desired. The screw holes need fairly accurate marking and drilling and counter- sinking. A pilot hole is required, in the piece in which the screw thread goes. The back panel is screwed to battens from the back, so that it can be removed without harming the finish applied to the top, bottom and sides. Since these battens assist with an airtight seal they should be accurately fitted.

Bracing panels are used, as the cabinet is tall. The speaker and port holes can be cut in the baffle after the cabinet is built as the construction acts as a holding jig. The drive units could be rebated with a router, in which case you would cut the rebates first and then use the router to cut the speaker holes. The alternative is to obtain a 321 x 956mm sheet of 4mm plywood, cut the speaker shapes in this and glue it over the baffle. This effectively gives flush mounting of the tweeter and minimises edge diffraction effects. To mark out the tweeter terminal cutouts, you can draw round the supplied gasket, then enlarge to 12mm square. The port is a 198mm length of 68mm (outside diameter) plastic pipe glued in with epoxy adhesive.

The panels are damped using a self adhesive bitumen sheet. The cabinet is lined with 25mm thick foam to stop internal reflections. The front to back dimension is relatively small and if you wanted a really firm base you could use as stands, a piece of wood with a longer front to back dimension. Otherwise spikes would be a good idea, as would some form of additional ballast in the base (keeping it clear of the electronics!)

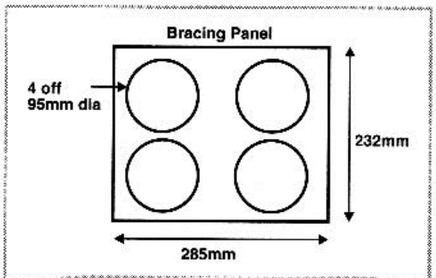


Fig.5b Bracing panel detail

Building the electronics

This is relatively easy since all components except the transformer are mounted on one PCB. The first item to fit are the Veropins, as they are a tight fit. A light tap with a hammer when the board is supported on a block of wood is probably the best way to get them in. The only other point to watch is that the power devices have to be isolated from the heatsink. These devices should be attached to the heatsink before soldering. With a multimeter check for insulation between the device mounting screw and the device metal case. Note that the bridge rectifier, the ICs and the electrolytics only go one way round.

Once all the components have been mounted and the fuses clipped in, a test can be done by connecting the transformer and switching on. Do not connect the speakers yet. Check that the supplies are about 27V and the supplies to the 8pin ICs pins 4 and 8 are -15 and +15V respectively. The output DC voltages at WO and TW should be zero. If this is OK you can switch off and connect up the speakers. Touching the input pin should produce a hum.

Assembly

Solder some twisted pair leads to the PCB for the inputs, outputs and supply. Set the pot VR1 to halfway in its travel. Fit the transformer and PCB

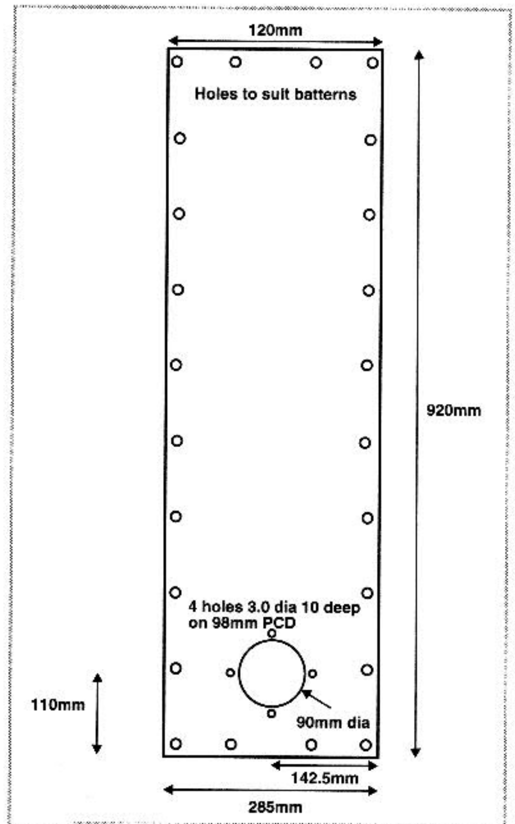


Fig.5c Rear of speaker detail

Parts

Resistors

(All 1% Metal film)

R1	1K1
R10,23	75K
R4,14,17 R19,20,24	39K
R3	220R
R5	13K
R6,8	24K
R11,27	2R2
R16,28	1R5
R7,9	3K9
R13	5K1
R12,15,18 R21,25,26	16K
R29	910R
R30,31	0R22
VR1	10K preset

Capacitors

C1	470nF/63V polyester
C2	150µF/6V3 axial elect
C3,9,15,25	470nF/63V ceramic
C5,6,12 C14,19,20	1nF 2.5% polystryrene
C7	100nF 100V polyester
C10	22nF 1% polypropylene
C13	220nF/100V polyester
C16	15µF/16V axial
C21	100nF/63V
C22	18nF 5% polyester
C23,24	6800µF/35V elect
C26	470nF/100V polyester

Semiconductors

IC1	78L15
IC2	79L15
IC3,6	TDA2050 (selected)
IC4,5,7	OP275
TR1	TIP42A
TR2	TIP41A
BR1	4A 200V

Additional Components

FS1 2 fuses 2.5A 20mm
Fuse Clips
Heatsink (Drilled and tapped)
PCB with legend
TO220 device mounting kits x4
Screws
Mounting bushes
terminal pins
Single pole switch

Speaker components list

Morel MW1075 250mm Woofer
ELAC metal dome tweeter 25DT50
Recess plate
Port tube
Gland for mains lead
Mains lead 2 core
Transformer Toroidal 18V Secondaries
Fixing screws and washers
All the above are available as a kit.
Foam
Bitumen sheet

Cutting list

(18mm flooring grade chipboard)
2 panels 920 x 285
2 panels 920 x 268
2 panels 321 x 268
1 panel 285 x 232
Optional panel 4mm plywood 956 x 321
Remember to double quantities for a pair

to the cabinet, in opposite corners of the base. The mains cable gland can now be fitted to the recess plate, which has built-in terminals. Solder the input wires to the terminals and run the mains lead through the gland. Temporarily fit the recess plate to the back panel. Connect the transformer and loudspeakers up, so that you can check everthing works at this stage. It is best to set the tweeter level up now. Mount the drive units temporarily in the baffle. Apply a music signal and set the pot VR1 to give the correct treble balance when compared with another hi-fi speaker. When the tweeter level has been set and everything is OK, switch off and if necessary, clamp the leads to the cabinet, so they don't rattle.

The woofer is then sealed to the baffle by applying a continuous bead of silicone sealant to the recess. Use the supplied gasket to seal the tweeter. The drive units are then screwed to the baffle. The recess plate has a gasket to seal it. Well, how does it sound? The bass extension and power are formidable as you would expect from a large enclosure. If the full extent of the performance is used, this is a speaker for people with detached houses or understanding neighbours. The bass is extremely crisp and well damped with no evidence of overhang or ringing. The mid range clarity which active speakers show is evident.

Finally, an update. Several formulae were quoted last month. The one at the bottom of page 26 should have read:

$$Q_{ts}=f_r\sqrt{(Re/Rs)}/f_2-f_1$$

The third line above this should read:

Compute $\sqrt{r_o} \times R_e$

The Kit

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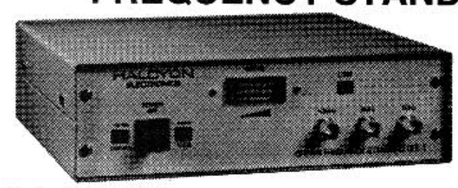

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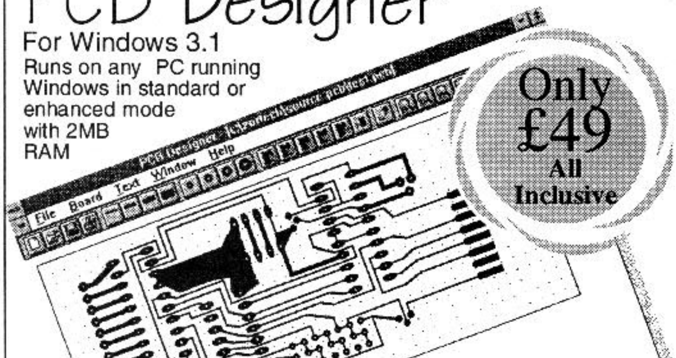

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Software Review

PCB Designer for Windows

Paul Stenning puts this eponymously titled software package through it's paces

Regular readers may be aware that I use Seetrax Ranger 2 for all my electronic design work. Although this is a superb package, it is primarily aimed at the professional user and is far too expensive for occasional home use. Indeed many of the popular low cost PCB design systems for home users still cost around £125 once postage and VAT has been included, and is still too expensive for some.

For this reason, I was interested to read an advert for PCB Designer for Windows, from Niche Software. At an all inclusive price of just £49, it will be of interest to many hobbyists.

The software will run on a 286 or better PC running Windows 3.0 or 3.1 in standard or enhanced mode, with at least 2MB of RAM. It is supplied on a single 3.5" disk (5.25" disk available), and comes complete with an installation leaflet.

Installation is easy and a separate program group is set up, containing the PCB Designer icon. The files take up less than 1MB of your hard disk.

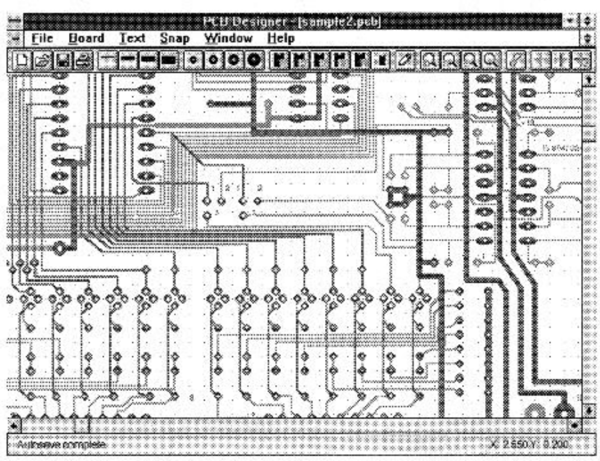
Obviously for this low price you would not expect to get all the facilities of a product costing over £100. What you do get is a computerised version of the "dot and tape" method of PCB design, either single or double sided.

There is no printed manual so costs are kept low, although full details and a tutorial are included in the on-line help system. This is very well written, and should not be regarded as a last resort.

PCB Designer is very easy to use, and most users should get to grips with it in just a few minutes. Start with the on-line tutorial, as it covers all the major features of the software.

A library of pad groups for IC's and transistors are included, as well as pads for some surface mount devices. Unfortunately it is not possible to add new devices to this library, although I understand this feature is planned for a future release.

Designing a board with PCB Designer is simply a matter of placing the components and pads where required, and joining the dots with tracks. Up to four different track sizes can be included in a design, and these sizes can be altered if required. Text can be added in any of the fonts available on your Windows system.



Individual tracks can be rerouted simply by highlighting them and then dragging by the corners. Additional corners can be added to tracks, but can result in tracks being slightly off grid.

Component groups can be selected by dragging a box around them, and then moved as required. When items are moved this way the tracks are "rubber-banded", to retain the connections. For maximum flexibility, if items are moved individually the tracks do not move.

With a Windows application, it is possible to have more than one design open at a time. However, this version of PCB Designer it is not possible to copy sections from one design to another.

The completed PCB can be sent to any printer supported by Windows. A number of printing options are available, including twice size. The print quality is very good, even with a basic nine pin dot matrix printer.

As Windows supports a wide range of printers and graphics boards means that more time can be spent enhancing the application, instead of writing endless device drivers. A user with a more obscure printer will not have to worry that it won't be supported by new software, as long as it's supported by Windows.

Anyone planning to have their PCB's produced professionally should note that PCB Designer does not currently have a Gerber file output.

Technical support is available by mail or Compuserve only, there is no telephone support. The product is so straightforward to use that you are extremely unlikely to need any help.

The first copy of PCB Designer I received contained a couple of minor bugs. After contacting Niche Software, a disk containing a fixed version arrived within two days. You would be hard pushed to get bugs fixed this quickly (if at all) by a larger software company.

If you need a basic PCB design package and don't want to spend a fortune, PCB Designer is the software you have been waiting for. It is extremely easy to use, quick to learn, and represents superb value for money. Don't be put off by the lack of a printed manual - you won't need it!

PCB Designer is available from:
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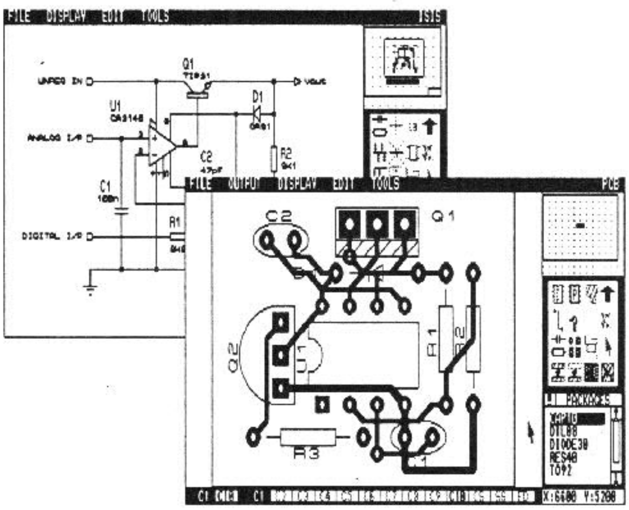

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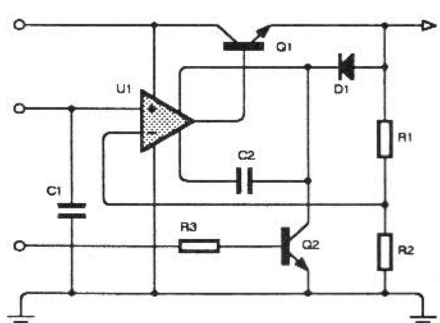

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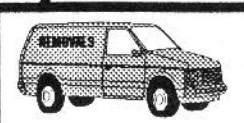

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the MicroMix

Part 1

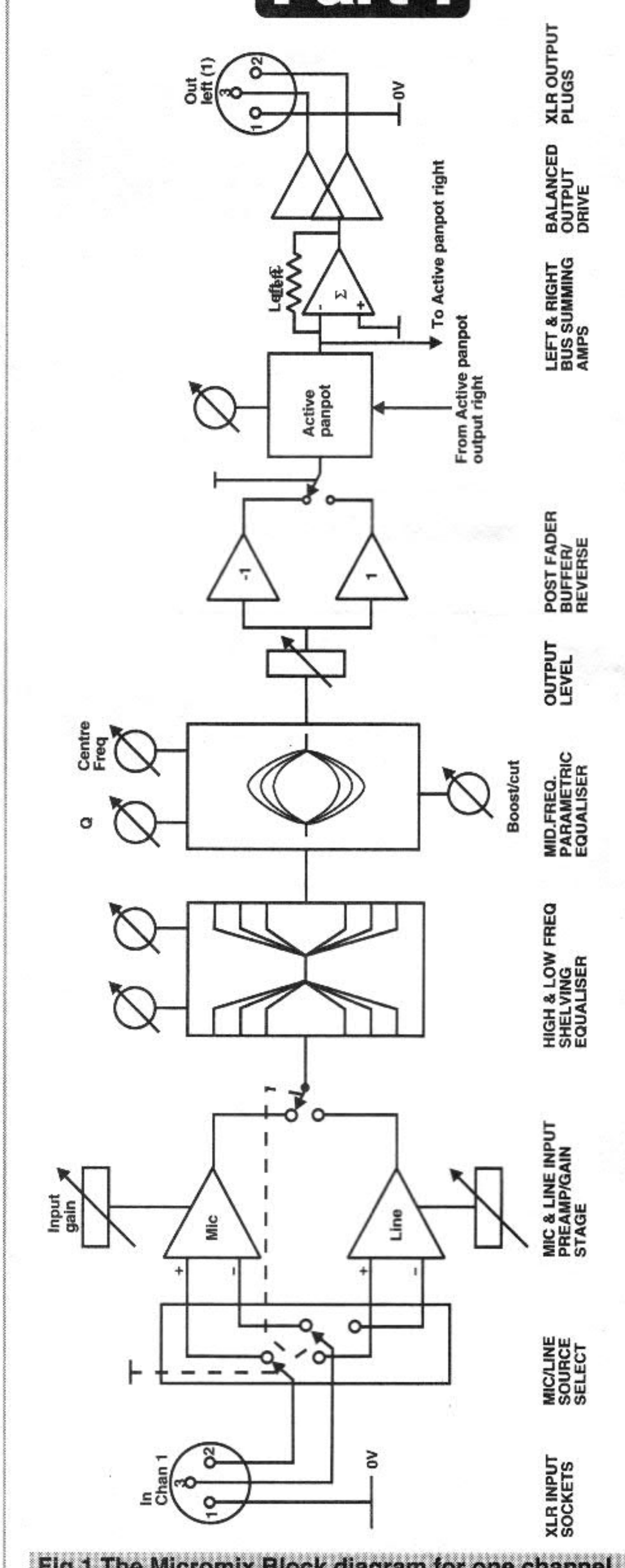


Fig.1 The Micromix Block diagram for one channel

Possibly the World's Smallest Mixer - A Dual-Channel, miniature Mixer with Balanced Mic/Line Inputs, EQ and Pan and Fade Facilities
by Mike Meechan.

Consider the following Saturday night(mare) scenario which is possibly re-enacted one hundredfold throughout the country. You've naively agreed to act as promoter-cum-engineer-cum-roadie-cum-organiser-cum-tea-boy for the neighbourhood band night extravaganza at the local student's union/pub/club etc. Everybody involved has told you what a great guy/girl you are for helping them out, and for the princely fee of a couple of pints of what the chosen establishment considers to pass for good beer, you're providing an opportunity for the up-and-coming local 'talent'. The record company A&R men suppress loud guffaws and phrases like 'eternally-grateful', and 'couldn't-have-done-it-without-you', (damn right) ring ironically in your ears as you lug the umpteenth two-hundred weight bass bin up three flight of stairs, and across an expanse of well-worn parquet flooring that, for all the world, looks like Culloden Moor on a bad night (and seems twice as forbidding). T minus 10 arrives and you relax, smug and content in the knowledge that you've worked out the sound system to the n'th degree (which, in reality, means you've accepted pragmatically, on the night, you're going to have to be infinitely flexible and twice as accommodating). In spite of all this forward planning, one of the sixteen bands appearing over the two hour duration of the gig (you thought that Bob Geldof had a tough time at Live Aid) has drafted in an extra vocalist/ instrumentalist - who cares, when it comes down to it, it's an extra *muso*. Whatever or

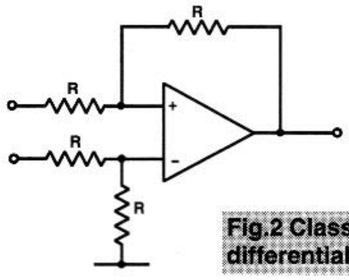


Fig.2 Class instrumentation differential input amplifier

whoever they are, they've at least brought along a microphone, but nothing else, and now all of the mixer's/combo's inputs are fully dedicated to other sources... The shops are closed, all your friends have departed with some haste and joined the Foreign Legion, every mic is needed on the stage, the gig starts imminently and the MC is getting decidedly jumpy (jumpier?!). What do you do? If you're not a reader of this magazine, you can either:

1) Down your pint quickly and exit stage left, justifying this action by saying that they weren't *really* such good friends anyway, and in the global scheme of things, the gig wasn't *that* important...

2) Explain to the offending muso that there's nothing you can do, and possibly risk an archetypal prima-donna luvvie-type tantrum, complete with attendant copious tears and stamping feet, or a punch in the face...

3) Despair, get inebriated, and hope nobody notices a microphone is unplugged until it's too late...

Or, if you're a reader of this magazine, smart, au fait, one step ahead of the rest, generally with it etc., you reach casually for your equipment bag and pull out the latest in miniature analogue technology, The MicroMix...

The MicroMix

What is The MicroMix? Very simplistically, it's a two channel Mic/Line switcher/preamplifier/mixer. It can mix together two line level or two mic level signals, or any combination of the two. Furthermore, it offers full gain control, Mic/Line source switching, a three band equaliser, Pan and Master level controls. On the output side of things, there's balanced line, high level output stage, capable of driving the longest or most difficult cable/jackfield combination with high CMR and low distortion.

Finally, all of the above-described ensemble fit into a die-cast aluminium box no bigger than a typical guitar FX pedal. Despite the fact that physically, it's probably the smallest project I've ever designed and built, it features the usual studio-quality electronics. It *can* be battery-powered -two PP3's crammed into an already-cramped interior - but the circuitry, it has to be said, has been optimised for high sonic performance and overall compactness, and not low power consumption, and with a typical need for around 120mA or thereabouts, any batteries aren't going to last too long. An external split PSU (described later) is thus recommended for all but the direst of emergencies.

Figure 1 shows a block diagram of the system. Inputs are via female XLR's although 1/4" jack sockets can be substituted for these types where the jack socket is more appropriate to the intended application (i.e. with guitars). A front panel-mounted latching push-button selects either Mic or Line-style preamplification characteristics, altering impedance and gain range of the input accordingly, from 1K for balanced Mic inputs to around 10K for Line inputs. A padless mic preamp circuit topology allows from 0-70dB of gain for Mic Inputs, and around 0-30dB for Line Inputs. The EQ section consists of a three band parametric equaliser i.e. bass, parametric middle, and treble, with bass and treble frequencies fixed at 80Hz and 12KHz, (good punch and fizz respectively) whilst the midrange is alterable over a 20:1 frequency range, from 300Hz to 6KHz, with Q variable from 0.5 to 5 over this range. Pan and Level facilities subsequent to the EQ determine what proportion (if any) of Inputs 1 and 2 are fed to balanced Outputs 1 and 2, e.g. Channel 1 Input PAN control could be set such that equal of proportions of Inputs 1 and 2 are present on Channel 1 Output socket (i.e. Pan control central). Conversely, the unit could be configured, using these same controls, as a dual mono preamplifier i.e. Channel 1 Input appears only at Channel 1 Output, and Channel 2 Input appears only at Channel 2 output. Furthermore, the Line Input stage can be reconfigured as a DI High Impedance Input Buffer for guitars and the like, with the XLR's replaced, in this instance by the ubiquitous 1/4" jack socket.

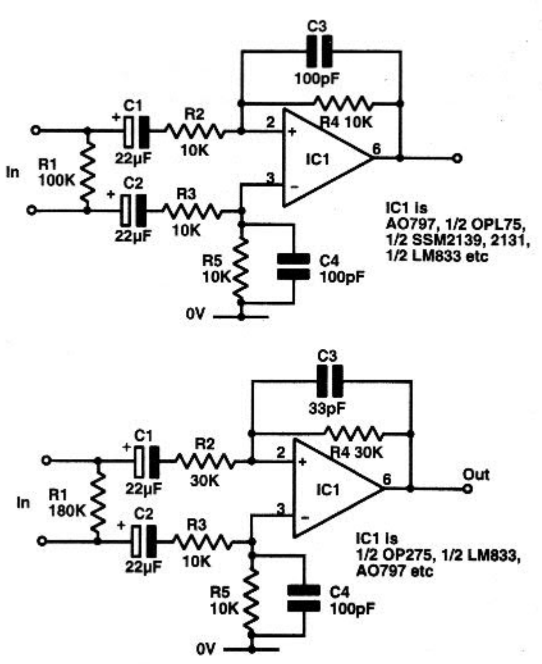


Fig.3a) Equal value differential amplifier b)Differential amplifier with component values optimised for matched dynamic impedance

Mic Inputs

Whilst transformer and discrete transistor microphone amplifiers have many unique merits, it is generally more economical of time and PCB real estate to consult the manufacturer's databooks and choose, as I did, one of the numerous, all-in-one, pro-audio IC's dedicated to low noise amplification. (I'll leave the transformer-versus-active discrete argument for another article)... Using a dedicated pro-audio IC such as the SSM 2017 eradicates a great number of circuit design problems in an effortless manner. The IC fabrication process ensures that the transistors and resistors in the input stage are perfectly matched which, in turn, means first class noise and CMR performance.

The SSM 2017 comes under the somewhat ostentatious heading of 'multi-device input amplifier', since it cascades both transistor and op-amp technology within the chip architecture. A fuller explanation of this architecture and a list of its specifications is given in 'The Works' section next month.

Line Input Stage

This section, too, presented something of a quandary for me as regards device specification. The easy route would have been to use something like the Analog Devices SSM2141 Line Receiver IC in this area (although discrete designs for the inputs and outputs might have seemed to present more of a challenge from the point of view of a purely electronics exercise). Furthermore, economics and ease of servicing is of immense practical significance in a studio or sound reinforcement system. So where at all possible, the use of a readily obtainable chip to replace a whole host of discrete components, must be a worthwhile goal. However, a device like the SSM2141 Balanced Line Receiver achieves its phenomenally good common-mode rejection qualities by eliminating the need for any passive components external to the IC. All resistors necessary are fabricated on the chip and laser trimmed for accuracy. Whilst good from the point of view of absolute performance in the area of CMR, it does mean that we've got no easy way of altering (raising) the input impedance without compromising this performance. High Input Impedance is necessary where we wish to interface the Line Input with guitars and the like which require an impedance somewhat higher than 10K (typically around 200K) if the natural sustain and timbral qualities of the instrument are to be maintained. To this end, it is worth looking at what a good discrete design of differential line input amplifier must offer if it's to compete successfully with its transformer (or integrated package) rival.

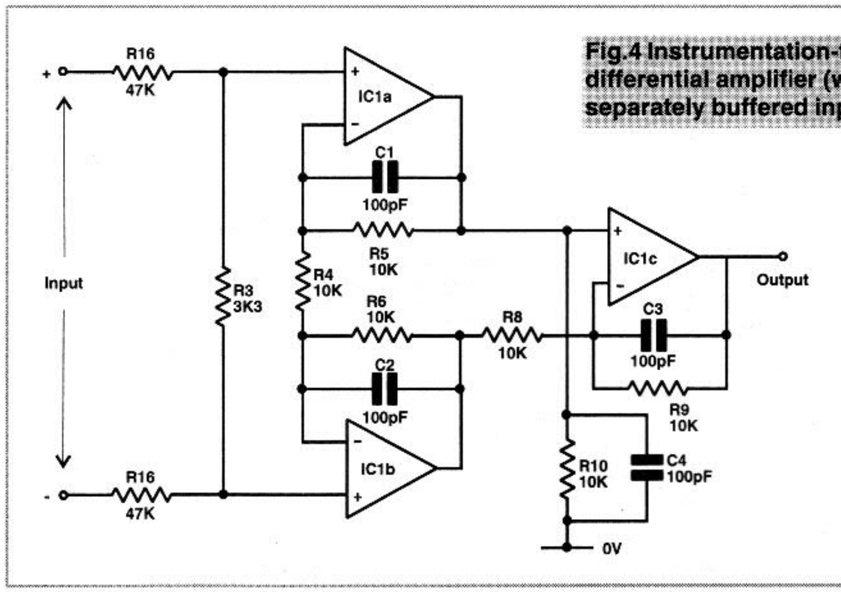
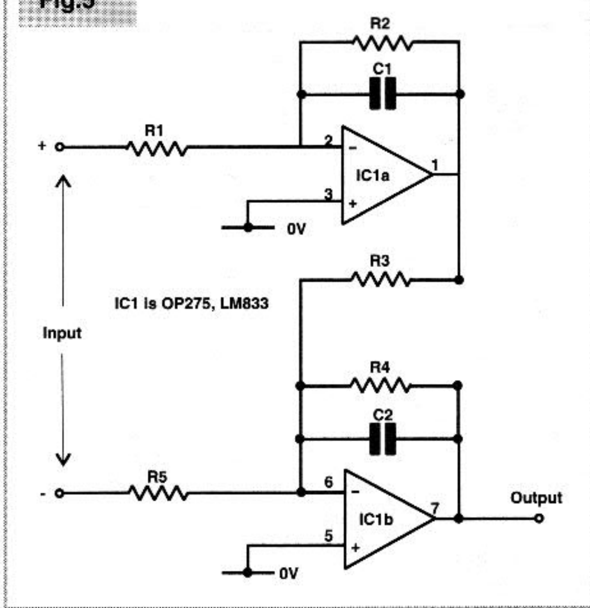


Fig.4 Instrumentation-type differential amplifier (with separately buffered inputs)

Fig.5



Differential Line Input

Figure 2 shows a typical one op-amp differential input amplifier. Although this is a perfectly adequate arrangement for system internal transfer of differential audio signals, its performance falters somewhat when forced to encounter anything but ideal input source conditions. A simple analysis of the circuit under typical input signal conditions should serve to highlight the problems we can expect to encounter when we employ a simple circuit such as a line input stage.

Consider what happens when we apply a varying signal to one input at a time whilst the other is left unconnected to our signal source. For signals applied to the inverting input, impedances around the op-amp are equal and it behaves as a unity gain inverter as the non-inverting input is, to all purposes and intents, grounded. However, applying a signal to the non-inverting input causes the inverting input reference to change too, because the impedance, by virtue of the fact that it is now being variably bootstrapped by common-mode and non-differential voltages, will also change.

Although impedances to both inputs can be arranged in such a way that both halves of the differential signal are inputted to the amplifier via defined resistors, regrettably, this is at the expense of common-mode performance. With this configuration, there is a serious conflict between trimming the op-amp for good common-mode rejection, and trimming it for good differential gain. This is because impedance balancing ruins CMRR, whilst optimising CMRR imbalances impedances to such an extent that if the source impedance is considerable, instant imbalance results. Here, the source impedance simply adds itself to the carefully optimised values of input and feedback resistor.

A simple and elegant solution to this is shown in Figure 4. This circuit separately buffers the inputs to the differential amplifier, and consequently requires three op-amps. Figure 5 shows another circuit which eliminates one of the three op-amps at the expense of creating an input which, although truly differential, is not fully 'floating' with respect to ground. For an active input stage to compete successfully against its transformer rival, it must be impervious to any imbalance in the termination at the input. Put simply, there should be no drop in output level should one of the input 'legs' be shorted to ground, as might be the case when an unbalanced signal appears at the input.

Another input stage using op-amps is a cunning two op-amp configuration as shown in Figure 6. This negates the input impedance disparity of the single op-amp circuit, while offering a good CMRR and fulfilling all the other criteria. It is known as the 'Superbal' and it is this type which features in The MicroMix, since input impedance is easily altered to suit any given application.

Next month, we look at the parametric EQ and phase switcher. The concluding part discusses the PSU, before all loose ends (construction, testing and use) are brought together. The complete Parts List will also be given at this time.

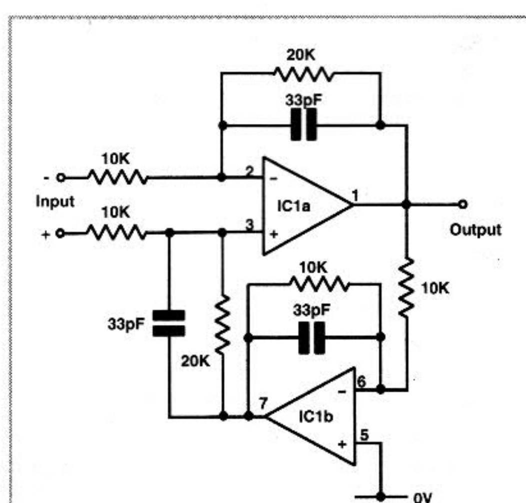


Fig.6 'Superbal' differential amplifier

From A to D

Douglas Clarkson takes us for a run round the 'High Resolution Serial Interface A/D Converter Circuit' -The HI7159

The majority of analogue to digital conversion devices cater for rapid speed of conversion and with relatively low data resolution. The specification of 12 bits in 25 microseconds is typical of devices costing around £10. While 16 bit devices are now available (and even 18 bit) they tend to be expensive and offer no easy way of transferring data to a PC.

With IBM compatible PCs being now widely available there is a growing demand for A/D converter devices which can directly use the RS232 serial link as a means of transferring data and without involving data translation circuitry. While it is possible to use a conventional A/D converter device and translate its parallel digital output to RS232 the amount of additional circuitry required is considerable and leads to complex circuit design.

The Harris HI-7159A device is a 5 ½ digit A/D converter which meets many of the requirements of more flexible A/D using the serial link of the PC. Table 1 provides a summary of the features of the device. While the device can be operated in parallel mode and fast microprocessor serial link, the major attraction is the RS232 connection. Such a device allows considerable simplification in equipment design where, for example, data is processed by a dedicated microprocessor or PC with serial input. An alternative way of connecting the device would be to use the parallel printer port of the PC.

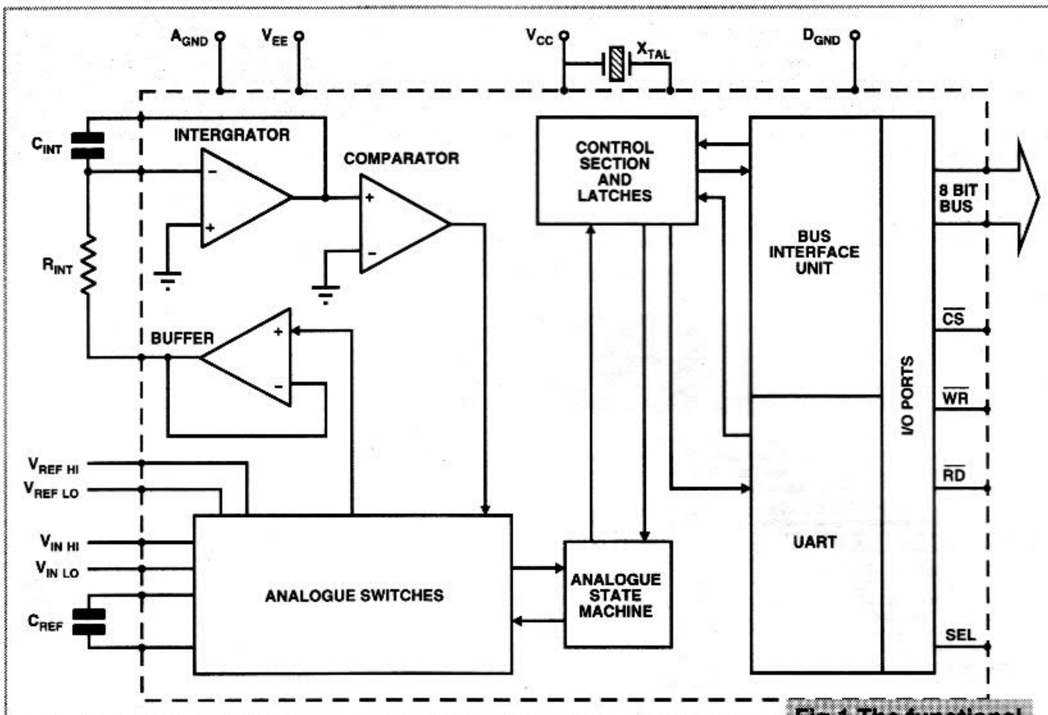


Fig.1 The functional block diagram of the HI-7159.

Feature	Value
Total counts 5½ digit mode	200,000
Total counts 4½ digit mode	20,000
Number conversions 5½ digit mode	15 per second
Number conversions 4½ digit mode	60 per second
Baud rates	300, 1200, 9600, 19200
Voltage range	+ 2 V to - 2 V

Table 1: Summary of HI-7159A features

Theory of Operation

The functional block diagram of the device is shown in Figure 1 and pinout configuration detailed in Figure 2. The HI-7159A uses the technique of multiple integrations in its 5 ½ digit mode. A first integration measures the count to 3 ½ digits or 1mV per count. The residue on the integrator is multiplied by a factor of 10 and then integrated and reference de-integrated. This is subtracted from the 3 ½ digit result and yields a 4 ½ digit result. This process is repeated twice yielding a 6 ½ digit result which is rounded to 5 ½ digits.

Conversion Types

The device makes available three basic conversion types. In error mode only, the unit connects V IN HI and V IN LO to A GROUND. This measures the internal offset voltage of the device. In the uncompensated mode the device uses as input the voltage difference between V IN HI and V IN LO. In compensated mode the device takes account of

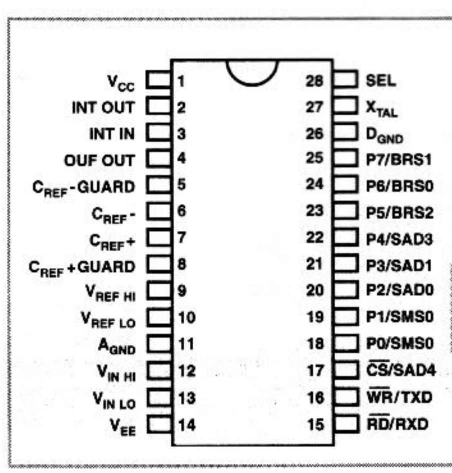


Fig.2 Pinout configuration of the HI-7159.

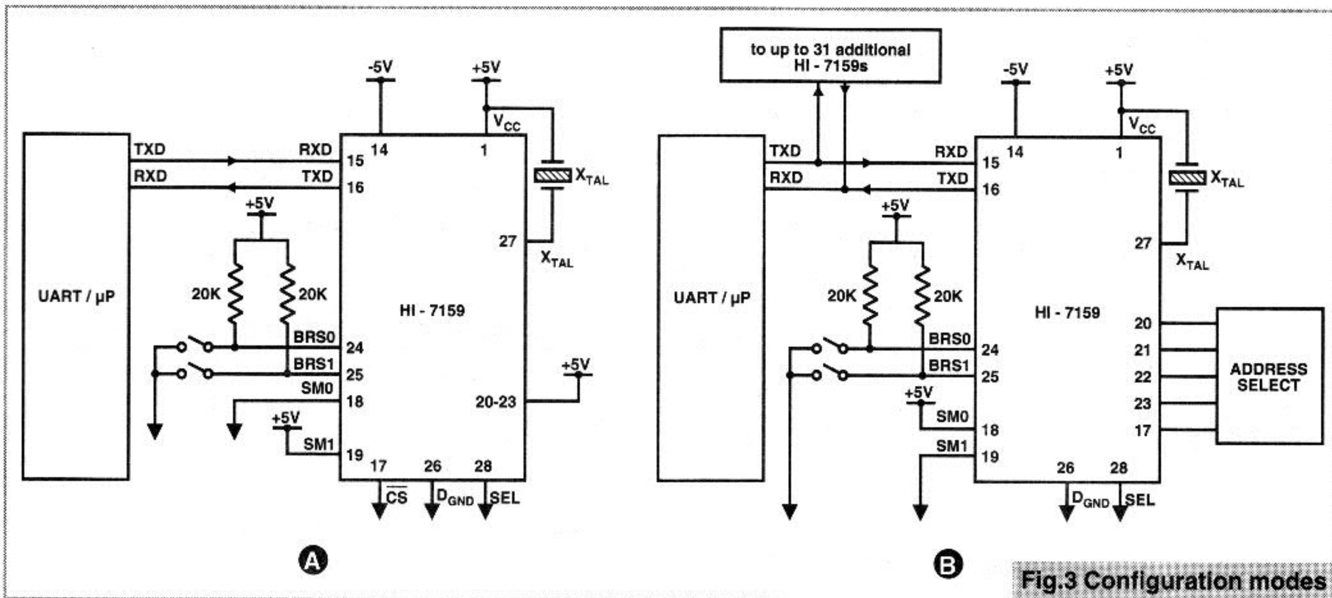


Fig.3 Configuration modes of serial mode 1 (single channel) or serial mode 2 (multiple channel) of the HI-7159.

internal offset errors and effectively undertakes a separate Error Only mode conversion and an Uncompensated Mode conversion. It then makes a digital subtraction of the two. Thus a compensated conversion takes twice as long to perform as an uncompensated one.

Since in most situations the device status is stable and the internal offset is essentially constant, the compensated mode need not be undertaken with every conversion. The Error Only mode can, be periodically read and uncompensated values updated for offset errors. This allows higher data rate sampling without compromising accuracy. If speed is not essential, then compensated conversion should be undertaken.

Serial Communication Modes

Connectivity by serial RS232 link is achieved by means of serial mode 1 (single channel) or serial mode 2 (multiple channel). Figure 3 shows the single channel configuration of serial mode 1 (analogue components not shown). The logic levels on pins 15 and 16 are TTL - translation from formal RS232 logic levels of PC connection is required. Such logic level changes can be undertaken (with isolation) using a device like the Newport NM232DD as shown in Figure 4. The isolation facility can be useful both for intrinsic safety and for noise reduction.

With a crystal of 2.457MHz, the specified switches can configure the corresponding baud rates as in Table 2.

Serial mode 2 allows connection to up to 31 additional HI-7159 devices. Each device addressed in this mode has a hardware selected address using four

BRSO	BRS1	Baud rate
GND	GND	300
GND	V_{CC}	1200
V_{CC}	GND	9600
V_{CC}	V_{CC}	19200

Table 2: Baud rate selection for modes 1 and 2

data lines using pins 17 (MSB), 23, 22, 21 and 20 (LSB). In this mode a command byte can be sent to select a specific device and all subsequent control and data exchange will occur with the selected HI-7159 device. This allows

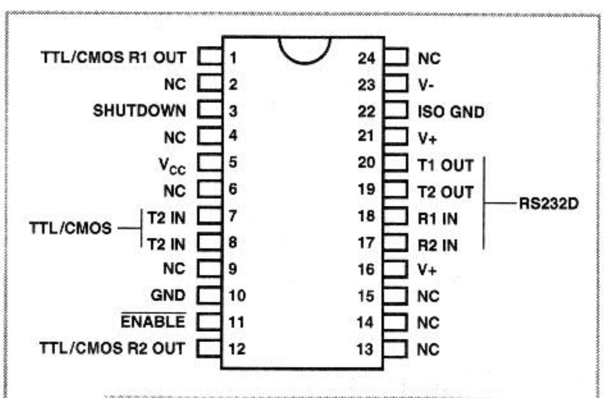


Fig.4 Pinout of the NP232DD - a device to translate RS232 levels of signal to equivalent TTL logic levels. The dual channel device also provides isolation between PC and HI-7159 circuits.

the serial interface connection to serve both as analogue multiplexer and device A/D converter. Data transfer in this multiple connection, however, is slower than with single access serial mode 1.

Controlling the HI-7159

The more common mode of use is serial mode 1, where a single channel is being accessed. Figure 5 indicates the command byte sent to the HI-7159 to initiate a specific activity.

Thus the option of single conversion, 5½ digits resolution and uncompensated would be set by a byte value of 12 (D3=1; D2=1). The option of single 4½ digit resolution and compensated value would correspond to a byte value of 6 (D2=1;D1=1).

Once the command byte has been sent the HI-7159 will proceed to undertake the conversion. Data can be read from the device by means of sending appropriate request bytes. The specified byte is returned after each request byte is sent. Figure 6 shows the structure of serial mode 1 request bytes.

In the request byte, D0 is always set to 1. In the programming loop to read back data, the status of the device is first read in order to check that the conversion has been completed. Thus as part of the process of reading the data out in serial mode 1 the following byte sequence would be sent:-

Function	Value request byte sent
status	13
digit pair 0,1	1
digit pair 2,3	5
digit pair 4,5	9

Figure 7 indicates the format of the status byte. The key bit of the returned status byte is bit D6 to check that a conversion has been completed and data is available. The status byte allows also checking of the mode of function of the HI-7159. Thus where a specific mode has been selected at the point of checking for data conversion via bit D6, the status of single/continuous, compensated/ uncompensated and error bit can be inspected. It is a check the device has previously been 'primed' for correct operation.

(RESERVED)	CONTINUITY	RESOLUTION	CONVERSION TYPE	COMMAND BIT
D7 D6 D5	D4	D3	D2 D1	D0
128 64 32	16	8	4 2	1
0 0 0	single 0	5.5 1	comp 1 1	0
	cont.1	4.5 0	uncomp 1 0	
			error 0 1	

Fig.5 Command byte options

(RESERVED)	BYTE REQUEST	RESERVED	REQUEST BIT
D7 D6 D5 D4	D3 D2	D1	D0
128 64 32 16	8 4	2	1
0 0 0 0	digit pair 0,1 0 0	0	1
	digit pair 2,3 0 1		
	digit pair 4,5 1 0		
	converter status 1 1		

Fig.6 Structure of serial mode 1 request status.

Data Format

The format of the input/output serial data is fixed and cannot be altered and comprises one start bit , eight data bits, even parity bit and one stop bit. This can cause a problem, however, when the HI-7159 device is addressed using Microsoft QuickBasic which can handle at most eight data bits and parity bits. Thus while seven data, even parity or eight data no parity are supported in QuickBasic, eight data AND even parity are not. The PC interface is quite capable of handling the format of the HI-7159. In developing software for the device using PCs, it is important to check what interface support is available in the selected language.

One way of getting round the difficulty with QuickBasic, however, is to use a package such as PDQCOMM (available from Grey Matter at around £65.00 + VAT) and which allows users to link in more flexible code so that the extended data formats can be accommodated. This level of software 'fudge' requires programmes to be compiled and linked before they can be run which is more time consuming than the 'run and go' mode of the normal BASIC environment. Once the final code has been developed, the additional CALLs included in the software will release the potential of the HI-7159.

Figure 8 shows the digit byte format of data returned after specific status request bytes have been issued.

Thus a complete sequence of data in serial mode 1 will require one status byte and three data bytes. For serial mode two, however, six data bytes are required since each element of data is returned individually as 'singles' and not packed as 'pairs' as in serial mode 1.

Moving the data out from the compact data format can be tedious. The next section of code of a BASIC subroutine indicates how the data can be unpacked from bytes of data as seen below.

The routine works by using the AND function to set binary bits for each byte and then shifting bytes in bits 7 to 4 to the right by division by 16.

where C is the value specified in Table 3.

The 2.4576MHz clock signal will provide exact division for baud rate signals. A 2.4MHz crystal will result in an integration period of 16.67ms - exactly the length of one 60Hz AC cycle. This results is relatively small errors in absolute baud rate values of around 2.3% which should not give rise to interface difficulties.

```
1000 REM subroutine to convert serial mode 1 data
1010 REM dp01$=digit pair 0,1
1020 REM dp23$=digit pair 2,3
1030 REM dp45$=digit pair 4,5
1100 dig1 = (ASC(dp01$) AND (128 + 64 + 32 + 16)) / 16
1110 dig0 = ASC(dp01$) AND (8 + 4 + 2 + 1)
1120 dig2 = (ASC(dp23$) AND (128 + 64 + 32 + 16)) / 16
1130 dig3 = ASC(dp23$) AND (8 + 4 + 2 + 1)
1140 dig5 = (ASC(dp45$) AND (32 + 16)) / 16
1150 dig4 = ASC(dp45$) AND (8 + 4 + 2 + 1)
1160 pol = (ASC(dp45$) AND 128) / 128
1170 ovr = (ASC(dp45$) AND 64) / 64
1180 REM now calculate digit value
1200 dig = dig5 * 100000 + dig4 * 10000 + dig3 * 1000 + dig2 * 100 + dig1 * 10 + dig0
1210 IF pol = 0 THEN dig = - dig: REM complete sign
1220 REM have got value in dig and also overrange status in ovr
1250 RETURN
```

Conversion Times

Table 3 indicates the various conversion times of the device as a function of conversion type for a crystal clock frequency of 2.4576MHz.

At other clock frequencies the time of conversion is given by:

$$t_{conv} = \frac{C}{f_{clock}}$$

Analogue Components and Inputs

Figure 9 indicates typical analogue components and inputs of the HI-7159. The crystal is placed across pins 1 and 27 as shown. The reference voltage Vref can be specified with reference to a

	5½ compensated	5½ uncompensated	4½ compensated	4½ uncompensated
time	130.2ms	65.6ms	32.8ms	16.4 ms
no/sec	7.68	15.24	30.48	60.96
C	320,000	160,000	80,000	40,000

Table 3: Conversion times of HI-5159

* CONVERTER * STATUS			CONTINUITY	RESOLUTION	CONVER TYPE		PARITY ERROR
D7	D6	D5	D4	D3	D2	D1	D0
0 no update	0	0	single 0	5½ 1	comp 1	1	no 0
updated	1		contin. 1	4½ 0	uncomp 1	0	yes 1

Fig.7 Status byte format.

separate Vref lo and similarly the input signal Vin hi can be referenced to an input signal Vin lo. In most applications Vref lo and V in lo will be tied to analogue ground (pin 11).

A precision integrating A/D converter such as the HI-7159 depends on optimum performance of the integrating capacitor Cint. Leakage or dielectric absorption will result in linearity errors. A high quality polypropylene capacitor should be used and in the integrating mode, the stored charge is used as a memory device. Any signal degradation will result in loss of accuracy.

For operation at 2.4MHz value of Cint and Rint should be 0.1µF and 30K ohms respectively. The full scale input voltage Vin should be twice that of the value of Vref. A reference voltage of 1.0V sets the input swing to +/- 2V.

A stable input reference voltage is essential since it is directly linked to the accuracy of the output measurements.

In the transfer characteristics of the HI-7159, there is a difference in linearity for positive and negative sections. On the negative side the values over read by 0.006% or 12 counts in 200,000. This error can normally be handled in software.

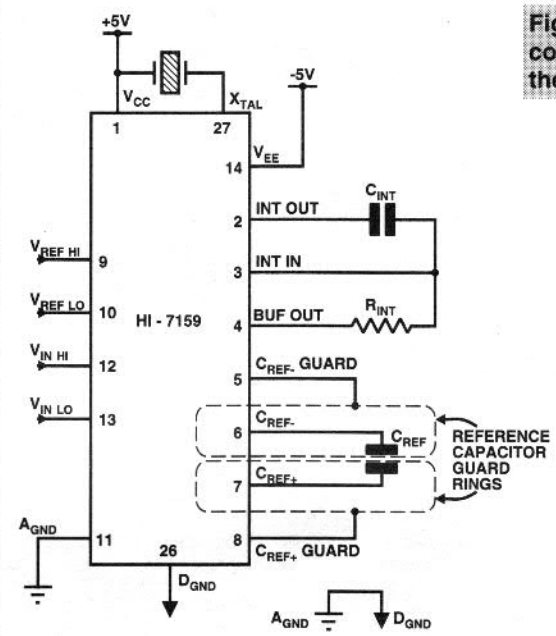


Fig.9 Typical analogue components and inputs of the HI-7159.

Applications

The HI-7159 is a device with a broad range of applications, particularly in data logging and general instrument technology and reduces considerably the number of support chips previously required to implement this level of function. Manufacturers might note the key to successful use of such devices will be software packages or chunks of code which can be readily assimilated into user applications.

The 5½ digit range in resolution readily allows use of the system in weighing balance technology. For a resolution of 0.1mg this allows measurement of 20g full scale or with a resolution of 1mg at 200g full scale.

Using the serial mode 2 connections, multiple channel facilities can be handled on the one serial RS232 line. This technology is particularly apt for environmental monitoring where data may be sampled for a given channel once every 30 seconds - examples being temperature, wind speed, wind direction and light or ultra violet level.

There are also options to use serial to parallel chips like the Intersil IM6402 where a serial input can be translated to a digital parallel byte output. This can be used (with care) to set digital control lines by means of latches to implement the function of analogue and digital multiplexers. This way, a single HI-7159 could be used with an analogue multiplexer device.

DIGIT BYTE	D7	D6	D5	D4	D3	D2	D1	D0
digit pair 0,1	MSB0	-	-	LSB0	MSB1	-	-	LSB1
digit pair 2,3	MSB3	-	-	LSB3	MSB2	-	-	LSB2
digit pair 4,5	pol	ovr	MSB5	LSB5	MSB4	-	-	LSB4
Where pol = polarity (1 = pos); ovr = overrange (1 = overrange)								

Fig.8 data format of returned bytes:serial mode 1

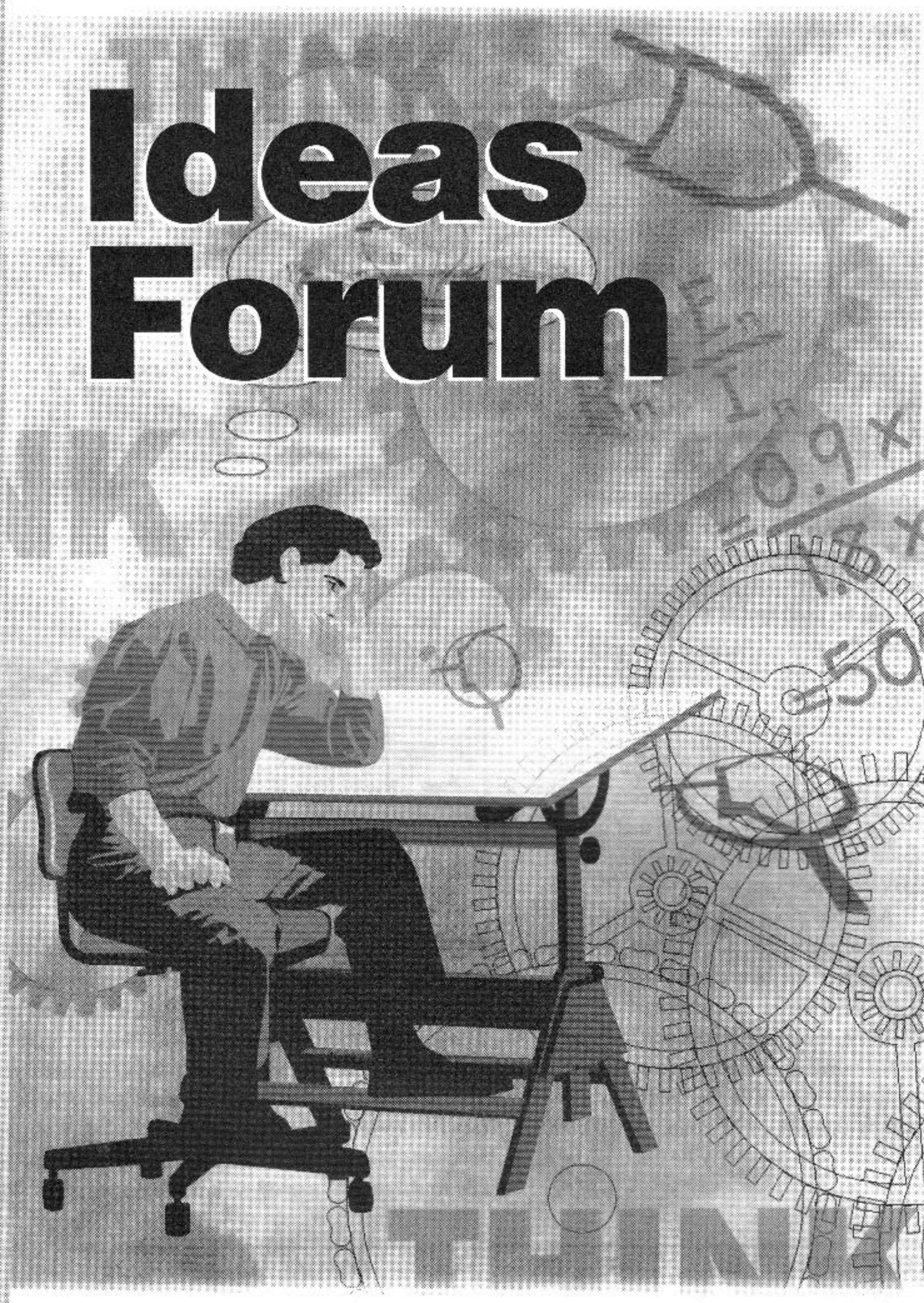
JUNE

The Beat goes on
Our blood is pumped or pulsed around our arteries within our bodies. In order to do this the artery walls have to be elastic to bulge and send the pulse of liquid onward. Elasticity is related to something called the Youngs modulus of the material. Arteries can harden with age as we all know for a variety of reasons changing the elasticity and hence the velocity of the pulse. There must be an electronic way to measure this velocity between two fixed points on the skin. This would then indicate some condition of the arteries. Surface techniques can use piezo electric transducers but what of the arteries deeper inside? A simple ultra sound Doppler technique perhaps?

Thermal Switches
Fibre optics work by sending light using total internal reflection and that depends on the difference in refractive index between the fibre and the outside coating. A change in temperature will alter refractive index. Given certain materials, there will be a point in temperature where the refractive indices are equal. The light then ceases to get through. This non invasive method of temperature switching could be used in a variety of applications for low or medium temperature warnings.

Pipe Monitor
A pipe containing liquid will ring in a characteristic way if tapped. The sound will also change with temperature. Reading the contents of the pipe ultrasonically could give an indication of the fluid state.

Ideas Forum



Make the most of your brainpower and come up with some brilliant ideas

Ideas never come easy do they? Some say that talking to a like minded person will bring out the best in you. The more you talk, the greater the chance that an idea will come out in conversation. Also to some it depends on what the weather is like or how much sleep you have had the previous night.

All great inventions start as little notions that get scribbled down and expanded upon, and that's what the Electronics in Action Ideas Forum is all about. Now you are the inventors.

Even though great inventions come to mind, the tragedy is you may dismiss the idea as worthless. So if you think of a good idea discuss it with a friend to see if they agree with you that what you have to tell the world is brilliant. Then ask yourself, do lots of other people want to hear about it and would you like them to benefit from your idea? Is there a market for it? If there is, who will mass manufacture it? These are some of the questions that have to be thought about. Use the suggestions on this page.

If you have any suggestions or have developed any of the ideas that have been appearing in this column we would love to hear from you, feel free to drop us a line. It could be the first step along the road to fame.

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307397
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109931 L U
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WAVEGUIDE ADAPTOR

A waveguide to transmission line adaptor which can serve as a low reflection interconnect between a waveguide and various transmission lines such as coplanar waveguide, trench waveguide or other lines of similar geometrics.

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FABRICATION OF COPPER INTERCONNECTS

Submicron ultra large scale integrated (ULSI) circuits require long metal interconnects having small contacts and cross sections. Previous methods of depositing Cu interconnects have suffered from poor step coverage, high resistivity from residual ions, and high costs. This invention mitigates those problems by providing a low temperature, self-encapsulating method of Cu interconnect fabrication.

707769 L U
IMPROVED INTERLEAVED VIDEO TAPE
Through a simple alternation on existing videotape recorders, three different programs can be recorded, or interleaved on a single tape. During playback, the playback head(s) can be used to track any of the programs. The interleaving method permits the viewer to interact with the recorded programs to alter the continuity and content to include portions of either program.

7792 P L G
METHOD OF PRODUCING ALUMINA FIBRE
An object of the invention is to provide an electrically conductive alumina fibre consisting essentially of aluminium oxide suitable for use as an electric or electronic material, particularly for electric or electronic circuits or connectors thereto at high temperatures or in chemical agents or corrosive atmospheres. Another object is to provide a method of producing the electrically conductive alumina fibre.

807796 M L G
HETEROEPITAXIAL GROWTH OF A 2D MATERIAL ON A 3D MATERIAL
a method of heteroepitaxial growth of a two dimensional single crystal superthin film material, such as a layered superconductive substance, on a normal surface of a three dimensional material such as semiconducting material. The method is very important in that it facilitates production of new electronic devices using key elements of heterojunction, such as quantum well type semiconducting laser, high electron-mobility type transistors, heterobipolar transistors, resonant tunnel elements, superlattice elements, etc.

109909 M L G
FORMATION OF MONOMOLECULAR FILM
This invention is for a method of forming monomolecular film on a liquid surface and an overlaying apparatus thereof for preparation of a single layered or a multi layered film, which eliminates defects in the conventional method and apparatus of forming an L-B film.

907794 M L G
LIGHT EMITTING SEMICONDUCTOR DEVICE
The object of this invention is to solve the shortcomings and limitations of the conventional art by providing an improved light emitting semiconductor device. With the semiconductor device of the invention, fluctuation of the radiated output after switching operation is substantially eliminated, high speed modulation is possible by simple arrangement, and the amount of the radiated output during the non-emitting period is suppressed to a very low level.

307797 M L G
MANUFACTURE OF POLYCRYSTALLINE SILICON FILM
This invention is intended to provide a method of manufacturing a polycrystalline silicon (poly-Si) film having the crystal axis strongly oriented in the <100> direction and having a very smooth flat surface.

409619 M L/J C
1553 AVIONICS SYSTEMS AND SUB-SYSTEMS DESIGNS
Know-how offered in electronics to meet the required 1553 specifications. These specifications are also those required for military applications. Technology expertise has been developed in: 1553 components and suppliers, 1553 test equipment, 1553 systems and subsystem architectures, and 1553 based system design, hardware and software.

7596 L U
LC INVERSION CIRCUIT
Automatically preionised double-sided fourfold LC inversion. The invention is a double-discharge circuit for production of high voltage, high current pulses to produce, for example, a population inversion in a gas discharge laser.

407598 L U
ELECTROMAGNET RESONATOR
using superconducting alternating winding capacitor. The invention provides an electromagnet resonator, comprising two or more non-intersecting, substantially overlapping surfaces of approximately similar size and shape.

607601 L U
INSECT ATTRACTOR
An apparatus for attracting and killing mosquitos and other similar insects. The device radiates heat and moisture attracting the insects to a sticky surface where they are destroyed.

708861 C L R
MINIATURE MICROWAVE DIELECTRIC RESONATORS
are designed from thermally stable, low loss and high dielectric materials with temperature coefficient of frequency from -9 ppm/C to +9 ppm/C over a wide frequency range. Dielectric resonator made of ceramics with Q-factor 3000.

8918 U L C
HIGH POWERED FLICKER FREE LIGHTING SYSTEMS
Portable gas discharge lighting. Use of electronic, lightweight ballasts up to 20 KW.

909683 W L U
SWITCHED RELUCTANCE MOTOR
High performance motors, with a fast dynamic behaviour for torque and speed are required in numerous applications. Switched Reluctance Motors get their torque from the variable reluctance of the magnetic circuit, combined with a current regulation. The result is a motor with a high torque (even at zero speed), high speed and an extremely fast dynamic behaviour.

809542 W L/J C
CONTACTLESS VARIABLE RESISTOR
An electronic variable resistor which does not involve any rubbing contact. Gives a high degree of linearity (1 degree) and operates over a wide temperature range and angles up to 340 degrees. Manufacture of the resistor is very simple and its operation is unaffected by dust and dirt giving a long operating life (min 5 million cycles) allows continuous rotation.

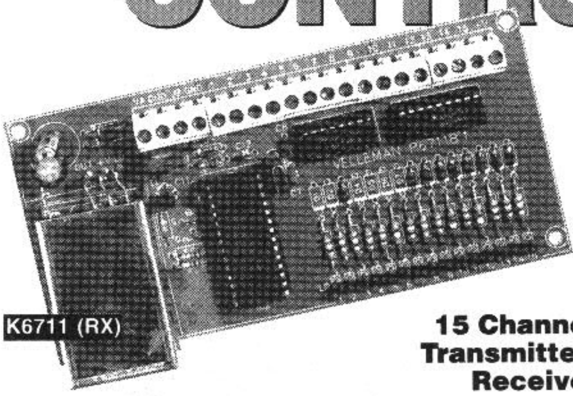
809558 P L U
CMOS RESISTOR
circuitry for making an integrated circuit CMOS transistor function as a linear two-terminal resistor. This low cost technique avoids the need for matched pairs of transistors and separate substrate wells. Applications include frequency selective elements in active filters, precision feedback amplifiers and single ended low distortion circuits.

909789 M S R
ENERGY SAVING FLUORESCENT LIGHT DIMMER
A patent is offered, aiming to give the exclusive right to exploit an unusual circuit configuration for driving as discharge tubes at reduced currents. Available technical reports and circuits could form the basis of products enjoying unique advantages, especially in retrofit applications.

MORE TECHNOSHOP NEXT MONTH

IR REMOTE CONTROL KITS

Another Exclusive Reader Offer from Cirkit



K6711 (RX)

K6705 (RX)

15 Channel IR Transmitter and Receiver

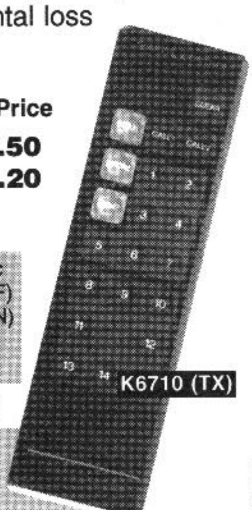
This control system has unlimited possibilities, including; controlling lights, garage doors, or for building into televisions, cassette recorders, or tuners.

The receiver is built around a modern processor, memorising two accessable output states.It also has 15 independent outputs with an option of change-over switch or pulse operation. The transmitters' aluminium housed keyboard, has a safety key that prevents accidental loss of memory content.

	Usual Price	Offer Price
K6710 (TX)	£40.80	**£36.50**
K6711 (RX)	£36.90	**£33.20**

Specification: K6711 (RX)

supply voltage	8-14Vdc or 2x6-12Vac
supply current	10mA (all outputs OFF)
	150mA (all outputs ON)
RX range	±30 metres
outputs	50V/100mA



K6710 (TX)

Specification: K6710 (TX)

supply voltage	9V battery
TX carrier frequency	38kHz
TX range	±30 metres
standby current	0.1uA
supply current	10mA (during transmission)

IR Code Lock Transmitter and Receiver

K6704 (TX)

If you find mechanical locks too difficult or always forget the combination of your keyboard code lock, then these two kits are the ideal solution. They can be used for all sorts of applications such as; arming and disarming your car alarm, switching central locking, securing buildings, and opening garage doors. You determine your own system code from 60,000 combinations, allowing several transmitters to be used with one receiver or vice versa. The transmitter is supplied with a keyring housing.

	Usual Price	Offer Price
K6705 (RX)	£23.70	**£20.90**
K6704 (TX)	£16.11	**£14.50**

Specification: K6704(TX)

Supply	LR44 button cells
Key ring housing dimensions	60x30x15mm
On/off indicator	LED display

Specification: K6705 (RX)

Supply voltage	10-16V or 2x9V
Range	up to 10m
Relay switching current	10A
Output signal	Selectable - either toggle or momentary

Please print your name in **BLOCK CAPITALS**

Please send:

.... K6705 (RX) at **£20.90**
.... K6704 (TX) at **£14.50**
.... K6710 (TX) at **£36.50**
.... K6711 (RX) at **£33.20**

plus **£1.40** for postage and packing.

Method of payment

☐ Cheque ☐ Postal Order

☐ Access or BarclayCard

☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

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Future View

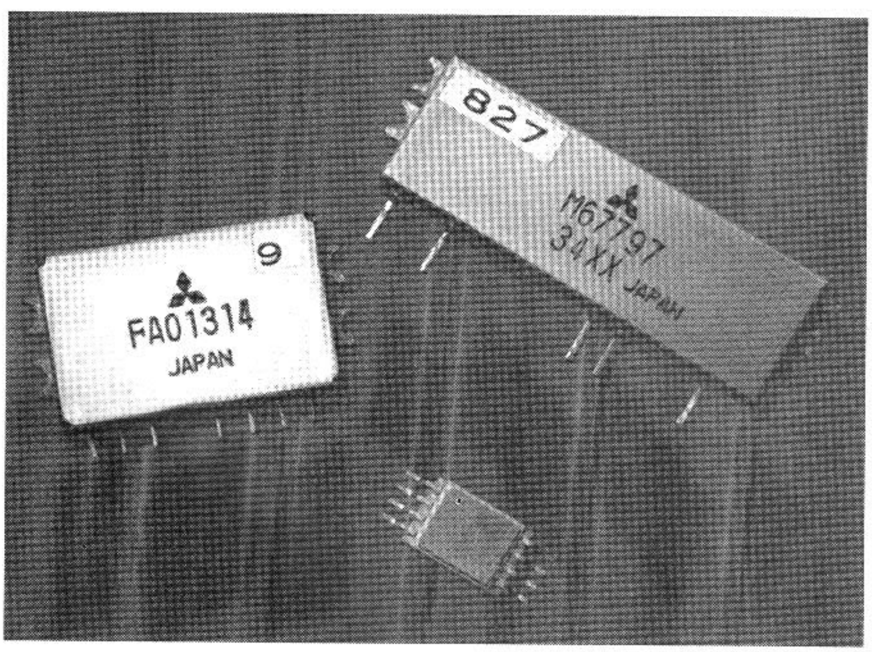
Low Power GaAs MMICs

by Paul Springate

In the never ending quest for smaller and lightweight portable telephones, Gallium Arsenide chips and RF modules, the devices that can provide those needs, are set to take a quantum leap in size reduction and in reducing power.

With the onset of portable digital telephone systems or GSMs as they are known, Mitsubishi has produced an RF module, code named M67797 which uses MOSFET technology for the Class 4 mode of operation. This is a classification which refers to the output power of mobile telephones. The chips operate on 890 to 915MHz and they provide an efficiency of greater than 30% to give a minimum of 3.5W power output. The device originally measured 37 x 11.4 x 3.5mm but this has now been reduced to 25 x 12 x 4mm.

In the Personal Communications Network (PCN) industry, Mitsubishi is similarly using a hybrid GaAs chip to achieve a gain of 32.5dBm over the 1710-1785MHz region. The efficiency of the device is greater than 38% and operates on a supply voltage of 5.4V. The device is housed in a 25 x 14 x 4mm package.



Early designs of the MOSFET circuitry required it to operate from 6V to achieve the required 3.5W capable of driving Class 4 mobile phones. This has to be compared with other bipolar devices requiring 7.2V and their effective use at around 900MHz is also limited. The MOSFET answer means that one less battery cell is needed for portable equipment. They also provide improved linearity across the frequency band.

The Mitsubishi RF module is based on several discrete transistor chips and additional components to bias and match the transistors in a hybrid microwave IC. The plug-in module, matched to 50 ohms input and output not only eased design problems but also had the major spinoff of reducing costs in volume quantities whilst maintaining high reliability.

Most portable telephone manufacturers will use the same phones with different RF sections to match the GSM or PCN requirements. With a future demand for smaller designs and reduced power for portable telephones, there will be a need for Monolithic Microwave Integrated Circuits MMICs. Mitsubishi currently has a lead in this area, manufacturing devices for analogue and digital applications.

In GaAs hybrid ICs, where not all the components are on a single chip, similar manufacturing techniques are used compared to the silicon RF modules but GaAs is used for the transistors as it provides higher frequency operation compared with silicon. Furthermore, it operates at higher efficiency and lower voltage. Nonetheless, GaAs hybrids still require the same lengthy manufacturing process, involving many steps and additional components, incurring added cost even in large volumes.

GaAs MMICs, used for power amplification, represent a major stride forward in technology, giving additional benefits for handheld and portable apparatus. Mitsubishi is already supplying small size, low profile MMICs in high volume to many cellular manufacturers.

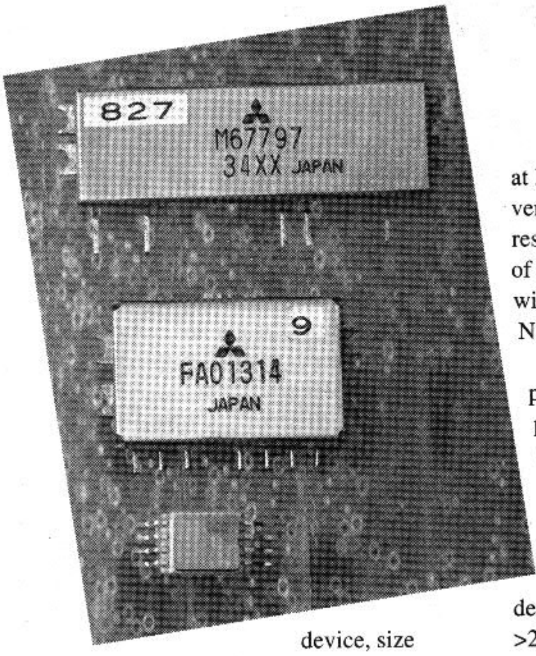
For portables, GaAs MMICs maintain the advantages that GaAs has over silicon while also offering a monolithic process geared towards low cost, high yield mass production. The end solution is much smaller than a hybrid microwave IC and ideal for future miniaturisation and cost reduction.

GaAs MMICS are monolithic in design and are similarly made to digital ICs. All components - transistors, resistors, capacitors, inductors, air bridges and transmission lines - are built upon the substrate, using the same lithographic process.

MMICs have air bridges built within their structure to give higher performance. These are bridges of gold metallisation that spans the FET and minimises the length of required bond wire to the device. This also minimises lead inductance.

The via holes or holes through the substrate on the device are used for direct source to ground connections and spiral inductors provide a space saving element. Separate MMIC chips are used to provide cost effective active and passive parts within the overall device as in fabrication their production yields are different.

For the matching elements of the



device, size makes it too expensive to incorporate these on the active or passive chips and so a separate ceramic matching circuit is used offering low loss.

With the market trend for even lower voltage operation for telephone handsets, the next target is for 3V operation. Using current technology, most handset components are able to operate at this level but power amplification provides a tougher nut to crack. The solution lies in GaAs but the costs are higher.

Alternative approaches using new transistor structures are currently being explored by Mitsubishi to improve electron mobility and also higher power at lower voltage. It is very likely that as a result the next generation of handheld telephones will operate from three NiCad cells.

Mitsubishi's GaAs power amplifier MMIC provides the right design for the European Digital Cordless Telephone standard (DECT) at 1.80 to 1.90GHz. The 3.5V device generates >25.5dBm.

DECT MMICs will be used for wireless Local Area Networks, portable computer and data stream communications applications.

For analogue applications, Mitsubishi manufactures GaAs MMIC solutions for Amps, ETACS, NMT900, IDO, DDI and NTT telephone systems. The latest MMIC chip works from 3.5V operation (MGF7109) which has been developed for the NTT market and is now being shipped in 0.5g leadless packages measuring just 10x9.2x1.8mm.

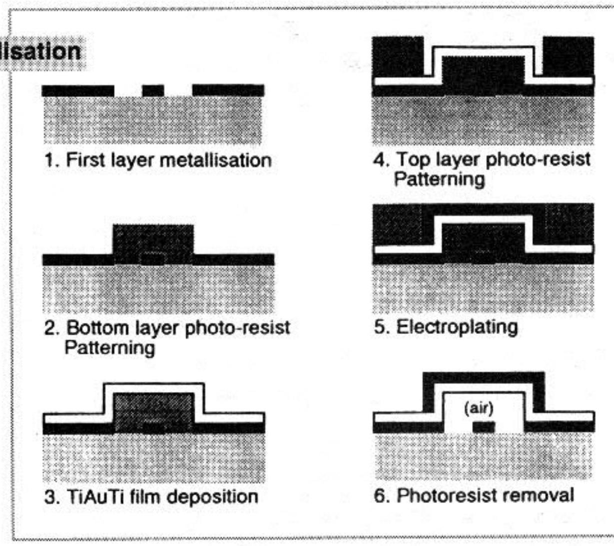
MMICs provide higher integration combined with higher performance and low voltage operation. Packaging is already extremely small and there is the added benefit of surface mounting for production.

Future DECT GaAs MMICs are now set to incorporate the antennae switch within the package. Furthermore, the low noise amplifier could also be incorporated and to extend the benefits further, MMICs could provide an even easier design route with a negative voltage generator integrated into the package.

Mitsubishi is planning a PCN MMIC with samples being released in the third quarter of this year. These devices will initially provide 32.5dBm at 5.8V operation and this voltage is likely to drop to 4.8V during 1995.

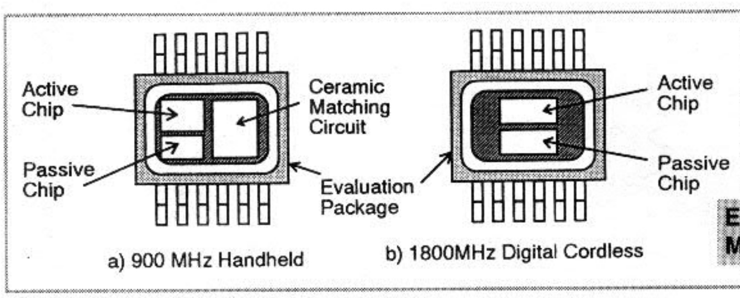
Paul Springate is product marketing manager for Mitsubishi Electric UK's GaAs, RF and Optoelectronics products.

Air Bridge Metallisation

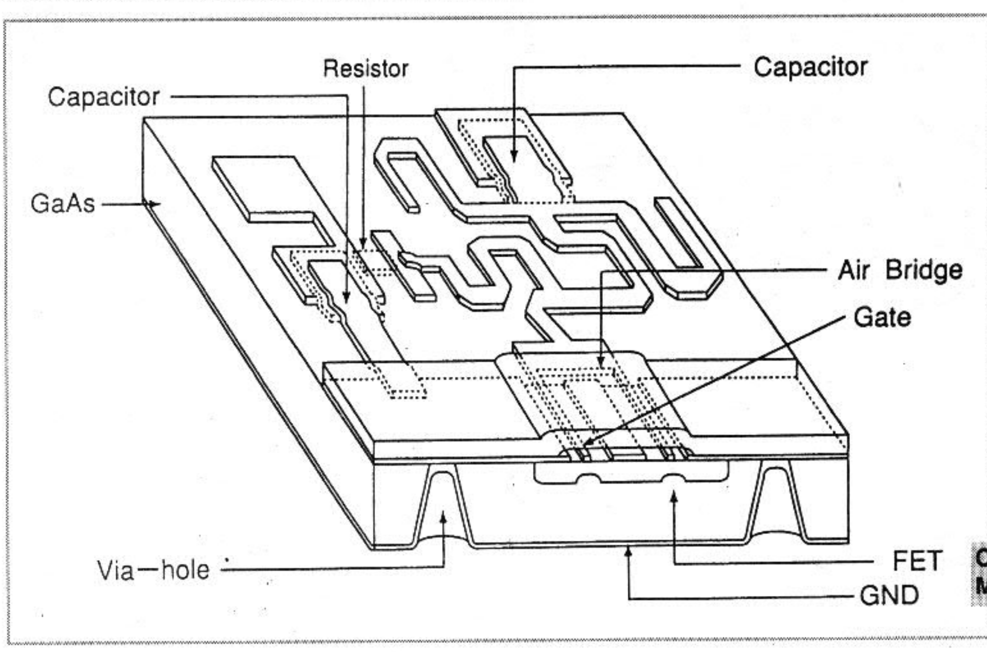


	Hybrid Module	MMIC	2nd generation MMIC
Outline	W D H 12×17×4 (mm^3)	W D H 11×14×2 (mm^3)	W D H 10×9×1.6 (mm^3)
Weight	3.5g	2.2g	0.5g

Reduction of package size



Elements inside the MMIC package



Components of GaAs MMIC Chip