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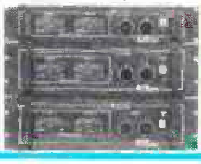

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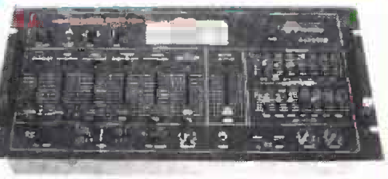

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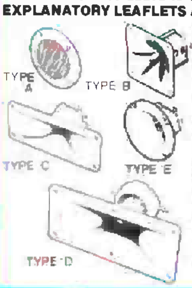

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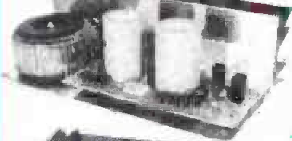
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS T.H.D. typical 0.001%, Input Sensitivity 500mV. S.N.R. -110 dB. Size 330 x 175 x 100mm.
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OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection. 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
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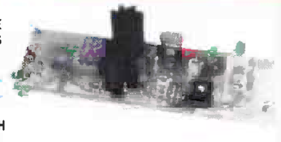

PHOTO: 3W FM TRANSMITTER

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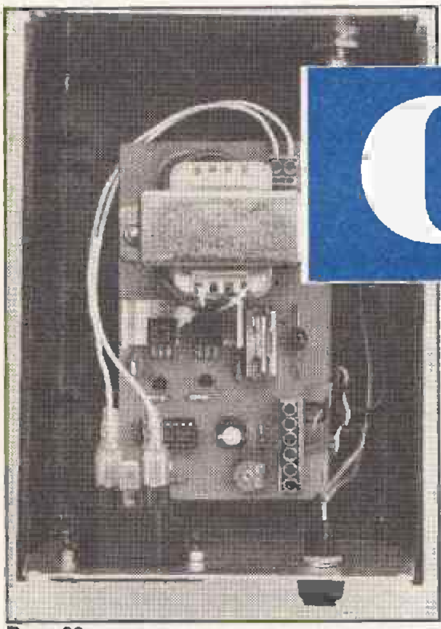
Features & Projects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Regulars

Editorial

by Paul Freeman

Firstly many thanks for the return of our reader survey. It certainly helps to know your views on the sort of material you require in ETI.

The convergence towards a certain computer format has emerged from your replies and that standardisation seems to be moving towards an IBM PC format. I think we would all agree that standardisation is essential if information is to flow freely and easily between computers and their operators. Japanese manufacture of PC clones must have played a significant role in this process bringing greater availabity, portability and lower cost to the consumer.

Conflict of interests

I very often have a good laugh over how media news journalists attempt to report on scientific concepts.

"The simplification process can end in further confusion for the viewer or reader. Their lack of comprehension illustrates the need for a very broad based education for journalists and many other individuals in society including government officials".

"The best people at present to simplify scientific jargon are scientists themselves when asked to do so. They have both the everyday language and specialist knowledge to do just that. The sooner the news media realises this the sooner we could start to address the terrible problem of the arts/science imbalance in education, governmental bias and a society fearful of technology".

OPEN CHANNEL

High definition television, in the guise of the HD-MAC derivative, long the spearhead of Europe's television manufacturers, looks as though it might finally bite the dust.

I've been predicting this for long enough, of course. My first qualms about the system have always been my main argument against it. It is not a digital system. MAC uses a quasi-digital principle - its very name (an acronym of multiplexed analogue component) tells you this - to transmit analogue signal elements of video and audio components, in a time-switched multiplexed manner. So, while Mac offers the benefits of higher picture and sound quality due to the separation and independent transmission of the signal parts, it still uses an analogue base.

This makes it little more than a temporary stepping stone to a more permanent digital transmission system.

Even more than this - the stepping stone which MAC affords us, as we cross the river from analogue to digital television technology, isn't even in the right direction. If we go the HD-MAC route, the stepping stone takes us out to the still waters of the river. And we know what still waters do...

The eventual aim of television broadcasting, is to transmit all signals totally digitally.

If we go the MAC route now, the stepping stone gives us a breather for a few years while we stand in the deep waters of the river, but then the jump to the riverbank on the digital side of the river is no shorter thanks to being there. We still need to jump, and being in the deep waters there may be a greater chance of drowning.To be honest, I see and understand what the European manufacturers are trying to do. By creating a new system they hope to create a new marketplace. Everyone in Europe will (they hope) buy a new MAC-based television, so everyone (especially the manufacturers) will be happy. But I believe now's not the time.

NICAM stereo and a change to a better PAL-based system (probably the format known as PALplus) can give excellent sound and pretty good pictures, too. True, technically not so good as HD-MAC, but cheaper, less confusing to Joe Public, and a stepping stone more in line with a cohesive transition from analogue to digital television.

Wait till a viable digital system has been developed. That's my advice.

What's On Radio?

Every now and again, the ether gets clogged up. Too many people broadcasting too many things, to too many receivers. You know the sort of thing; Radio 1 wants a new FM frequency but Radio 2 won't move. Well, yes. That's a simplificatin, but it illustrates the point.

Taken globally, what's good for one country may be an anathema to its neighbours. There is an established procedure setup to define what frequencies can be used by the various countries in the world, and for what specific purposes. The procedure is to hold a World Administrative Radio Conference (WARC), and to thrash out the requirements and frequency slots available to each member country, and the purposes to which these frequencies can be put. Generally these WARCs, held every few years, plan for the foreseeable future with a pretty clear vision. There is therefore little argument over the conclusions, and they are binding as they are integrated into the Radiocommunications Regulation, which is an Internationally recognised treaty. Looking at the conclusions of one of these conferences, therefore, can give an idea of the way things are going to develop over the coming years. Developers request use of radio frequencies because they have a pretty good idea of what they want to do in the near future, so by looking at allocated frequencies it's possible to make some basic predictions about TV, radio, satellite and mobile comms.

The latest WARC was held earlier this year, albeit allocating frequencies mainly only available as from the year 2007. Nevertheless, its main conclusions are pretty interesting to us. First, high definition television allocations by satellite are allocated to the 21GHz waveband in Europe. The Americas' slot for the same will be the 17GHz band.

Second, digital sound radio services have been allocated two slots. Terrestrial services will be digitally broadcast in the VHF band, but satellite services will be in the 1450-1490MHz band.

Finally, and what personally is most interesting, low earth orbit (LEO) satellites have been allocated two bands. Radio location and data transmission satellites (called small LEOs) have frequencies below 1GHz. Large LEOs, on the other hand, are in the 1.6GHz band. These large LEOs will be used for voice telephony.

Low earth orbit satellites are those satellites which orbit quite closely to earth's surface. Because they orbit much closer to earth than geostationary satellites, their orbit time is much quicker, and several satellites need to be in operation to allow total global coverage. I mentioned Motorola's Iridium project a few months' ago in Open Channel and this is a classic example. Iridium is so named, because the system uses the same number of satellites in low earth orbit as the element iridium's atomic number, that is - 77. Such a system of LEO satellites will realise potential of a mobile communications network in which fairly simple hand-held (pocket-sized, wristwatch sized?) transmitter/receivers could be used anywhere around the world.

You're Calling It What?

Talking about low earth orbit satellites allots me to tell you something which you might find amusing. Motorola's Iridium project is being slightly redesigned. It's now planned to give each satellite greater transmission and reception capabilities by carrying 11 extra transponders. Because of this, fewer satellites will be needed to provide world coverage. Instead of 77 satellites, it's calculated that only 66 will be needed. This should greatly reduce costs, of course. But it does mean that the project name should be changed, doesn't it? Instead of Iridium, we'll have to start calling it by the name of the element with the atomic number of 66 - Dyspiosium.

Keith Brindley

ETI NEWS

BT LAUNCHES LOWEST COST VIDEOCONFERENCING SYSTEM

Face-to-face meetings between people at their desk-tops are now possible following BT Visual and Broadcast Services's launch of its VC7000 videoconferencing system.

Costing just £7,500, BT describes the VC7000 as the lowest cost videoconferencing unit in the world. It allows small groups of people to see each other and show documents and objects regardless of their location. It can also be used for giving presentations, showing product designs and holding training sessions.

BT believes that this low price will vastly increase the size of the visual services market. Steve Maine, BT's Director of Visual and Broadcast Services said: "Traditionally, users of videoconferencing have been large corporations, but the launch of this unit will enable smaller companies to reap the benefits of visual communication."

"The launch of the VC7000 is undoubtably the first step towards the visual services mass market. It will radically alter the way people do business by allowing them to have instant face-to-face meetings with colleagues, customers and suppliers regardless of location."

BT has already sold the first VC7000 units to National Power. Tony Stewart, National Power's Customer Services Manager, Telecommunications, said: "The VC7000 has completely changed the economics of videoconferencing and will play an important part in improving desk to desk communication between key people in National Power. I also see this as an enabler to a whole range of other business applications. For example, remote help desks could act as a central core of expertise."

The unit is manufactured by the Norwegian company Tandberg and complies fully with the CCITT's H.320 series of international videoconferencing standards. It works over BT's dial up digital network ISDN, at 64 or 128kbits/sec.

"Because the unit conforms to international standards," continued Maine, "It will interwork with any currently existing standards-compatible product, including all the BT H.320 equipment that has been sold in the last three years.

"This is the first of many new products which will come onto the market in the next few years. Standards are vital because our customers must be able to buy a kit which is compatible with equipment manufactured by other companies.

"In addition, the price of equipment will only drop if manufacturers can produce it in large quantities, and they will only do this if they are confident that the market will continue to grow."

BT also announced earlier this year that they will be launching a PC-based videophone, in collaboration with IBM, in the first quarter of 1993. Further launches of videophone products will take place later that year.

MINIDISCS IN EUROPEAN RECORD STORES BEFORE CHRISTMAS

The new portable audio system for digital recording and playback will be available in the shops for Christmas.

Focusing on portbility, the first products on sale will be two types of Walkman, the playback/record and the playback only version, as well as a MiniDisc car stereo model.

An MD software catalogue will be available in time for product launch listing 300 titles, with 500 titles being available by the end of the year.

Many leading record companies have already confirmed that they will support the introduction of the new disc-based digital recording and playback system with a selection of albums from their top artists, resulting in an initial launch catalogue of around 300 titles, spanning the whole range of music repertoire, from classical to rock.

MD software will be available from: EMI Music (including labels such as EMI, Capitol, SBK, Chrysalis and Parlophone), Factory Records, Mute Records, ARS Records, Curb Records, Sony Music (labels include Columbia, Epic, Def Jam and Sony Classical) Virgin Records (labels include Virgin, Circa and Ten) and most recently support from the Warner Music Group. Further backing from additional record companies is confidently expected. Many major artists are already scheduled for the launch catalogue, amongst them: Michael Bolton; Depeche Mode; Bob Dylan; Erasure; The Gipsy Kings; Michael Jackson; Lenny Kravitz; George Michael; Gary Moore; Robert Palmer; The Rolling Stones; Roxette; Simple Minds; Soul II Soul; Bruce Springsteen; Talking Heads and Technotronic.

Not only has Sony confirmed its belief that Compact Disc should continue as the benchmark home audio format, but the company has enthused the record industry with its intention to prioritise portable - rather than home-based - music enthusiasts with an SCMS-equipped recording & playback MD Walkman, a playback-only MD Walkman and an MD in-car system.

Although within its protective

slim-line cartridge, an MD disc measures approximately 2.5" (6.4cm) in diameter, MD premastered software is based on the same optical disc recording principle as CD, with information recorded as pits on the disc's surface. Given that the shape and distribution of these pits are similar for both formats, MD software can be manufactured using existing CD production equipment with relatively minor modifications. Within the Sony group, three software production facilities in Europe (DADC Austria), Japan and the US are already custom pressing orders from record companies and by the end of the year, monthly production from these plants will total 1.5 million discs worldwide.

Accolades for MiniDisc are coming in from throughout the music industry: "MD presents the consumer with the quality and convenience of CD, along with portability and recordability features," said Jim Fifield, President and CEO, EMI Music Worldwide. "The music fan will be very excited about this new optical carrier."

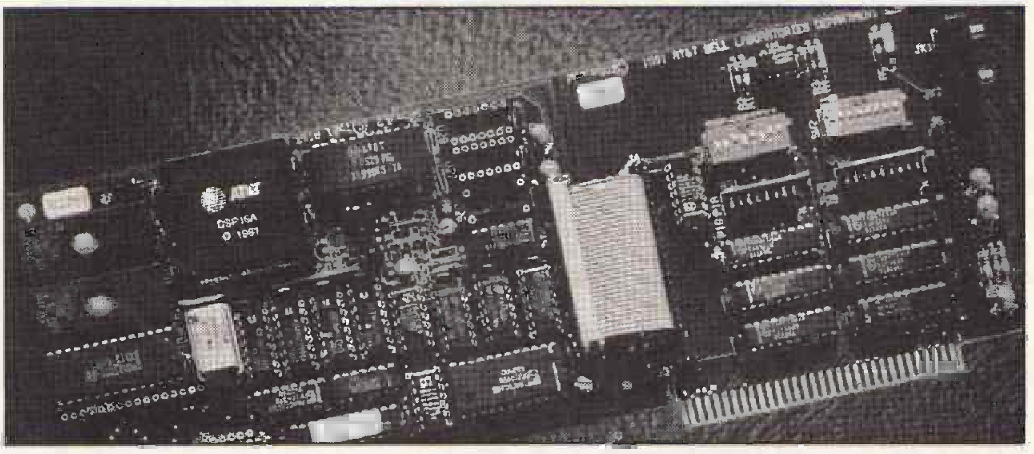
Bob Krasnow, Chairman, Elektra Entertainment, called MD the "best format since Thomas A. Edison."

Added George Michael, internationally renowned recording artist, writer and producer: "The sound is phenomenal....it's the future and I want the first one!"

Disc Media:
The Future of Audio

Ten years after the debut of Compact Disc, the introduction of MD brings a whole new dimension to the listener's enjoyment of music. The random access capability and ease of use offered by CD have always met with a very positive response from European consumers. Sony developed the high-tech MiniDisc because it is convinced that today's consumer demands the features and benefits optical media can deliver - not only in the realm of home audio, but also in mobile, portable and personal listening applications where reliability and durability are critical. MiniDisc brings to Walkman, portable systems and in-car stereos the random access capability of a disc medium in a compact size. It also delivers a sound quality approaching that of CD, ease of handling and a simple, high quality recording capability vastly superior to that of the conventional compact cassette.

VOICE RECOGNITION FOR CONSUMER PRODUCTS



AT&T Microelectronics has produced a voice recogniser for speedier automatic dialling. Users can 'train' the hardware to act on up to 40 key words or phrases, which are recognised within 0.5sec, even under noisy conditions, such as those encountered on the move in a motor vehicle, or in an industrial environment. Sophisticated noise cancellation algorithms allow the voice recogniser to achieve 95% accuracy in such situations, a figure which exceeds 98% in environments with low background noise.

Its principle application will be in automatic dialling where users can dial a number simply by speaking the name of the person to be called. The technology is also sufficiently flexible and low-cost to be used in products as diverse as microwave ovens, industrial controls, and digital answering machines.

Based on AT&T's WE-DSP16A digital signal processor chip, the voice recogniser also includes a 32K x 8, 150nsec SRAM block, and the interface logic required to marry host processor, DSP, and memory. The training algorithm is used to improve reliability of recognition. The target user says the key word or phrase, and the recogniser effectively stores this in memory. The hardware then asks the user to repeat the key word, and combines the information obtained in the two passes, to improve recognition and reduce the possibility of false keyword detection.

Reader enquiries to Vic Drake, Admail 4 International Ltd,Tel:0732 460424

ARTISTIC HARMONY BRIDGES THE EUROPEAN DIVIDE

In these uncertain economic and political times, Art is set to play an increasing role in developing a wider sense of communality between the diverse cultures of the new European Generation.

CEREC (Comite Europeen pour le rapprochement de l'economie et de la culture) and Northern Telecom have launched the first ever pan-European Arts sponsorship programme.

Sponsored by global telecommunications company, Northern Telecom, Northern Telecom Arts Europe (NTAE) forms a unique funding programme designed to enable European Arts establishments and artists to engage in collaboration and exchange.

Incorporating all Art forms, from the diverse fields of music and theatre to dance and photography, from classical to contemporary, this initiative aims to extend the boundaries of the familiar to stimulate new ideas.

NTAE is worth a minimum of £750,000 (sterling) to the Arts over a three-year period. In the first year, awards of £50,000 will be given to professional Arts organisations based in France, Germany and the UK., extending into at least three further European countries during 1994 and 1995.

FASTER FRACTAL COMPRESSION FOR WINDOWS

Iterated Systems Ltd has announced Images Incorporated version 2.0 for Windows, the next release of their Fractal Transform image compression and enhancement product for end users,

Version 2.0 offers faster fractal compression in software alone, and now handles full screen Super VGA image files. It also supports batch processing, provides on-line help and has a simplified installation routine.

Alan McKeon, Managing Director of Iterated Systems Ltd, commented: "Responding to market demand, this new version overcomes the previous 640 x 400 pixel barrier, and compresses substantially faster." He added: "As part of our mass-market strategy, we have reduced the price by one third to £299."

Images Incorporated v2.0 for Windows is designed for use in desktop publishing, desktop presentations and other image-handling situations. Users can build up a library of photographic quality images conveniently compressed to very small file sizes using Fractal Transform image compression.

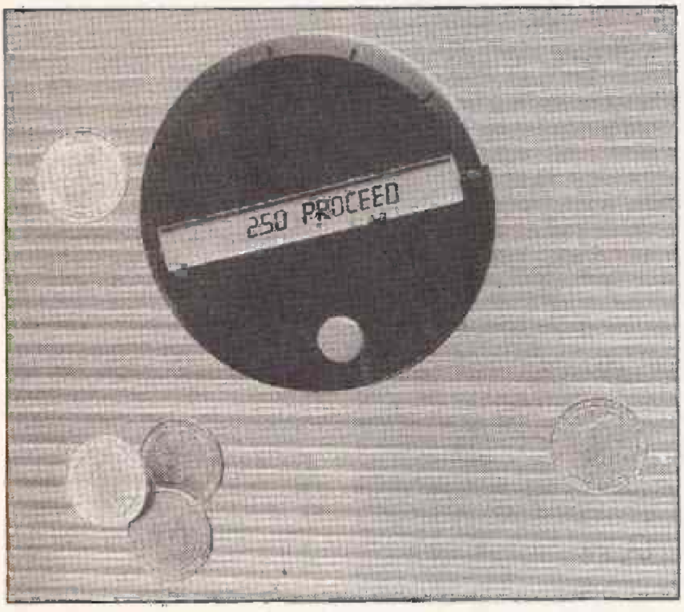
Compression ratios of 100 to 1 can be achieved, while retaining the image quality. Decompression is typically quicker than displaying the original image file. Further, fractal compressed images are resolution independent, meaning they can be decompressed and displayed at several scales.

Images Incorporated also features Fractal Transform resolution enhancement. This technique is applied to original, uncompressed image files, allowing a zoom in facility without pixelation. Additional detail is fractally predicted and added virtually losslessly to the original image data, without compression. This is useful for resizing images, or for increasing the number of dots per inch to allow printing at a higher resolution than the image was scanned at. The technique is unique in that it predicts infinite detail, while other methods use pixel averaging which causes smeariness.

Existing users can upgrade to version 2.0 for just £45 plus VAT.

Images Incorporated is available through selected dealers for £299 plus VAT. For nearest reseller, potential users should call Iterated Systems direct on 0734880261. Academic Discount is available to education establishments.

ELECTRONIC TOLL & TRAFFIC MANAGEMENT SYSTEM



Dover Electronics, Binghamton, NY, and AT/Comm, Inc. of Marblehead, MA, have entered into an agreement that will allow them to exploit the burgeoning markets for radio frequency identification systems in the transportation industry. The first product is a system for non-stop electronic toll collection. This tested and patented technology allows motorists to travel non-stop through toll lanes, thereby reducing traffic congestion as well as fuel consumption and auto emissions. The system was recently tested at speeds in excess of 90 mph. by New Hampshire State Police.

Designed and marketed by AT/Comm, this approach to toll collection is being heralded as the most advanced in the market based on its two-way radio communication techniques, known as 'read-write'. Europe, the Pacific Rim, and most recently the Illinois Tollway have specified microprocessor-based transponders with read-write capability for electronic toll collection. Most other competitors for this multi-billion dollar market have only recently responded to AT/Comm's advancements, announcing plans to develop and test read-write systems of their own. AT/Comm owns broad patents on read-write technology.

In the electronic toll collection, read only refers to a non-stop toll collection process that uses either barcode tags or radio reflective tags to simply 'read' the ID of a passing vehicle. This process is very expensive and complex (and a worry to privacy advocates) because it requires toll agencies to centrally maintain toll accounts and travel records for all their once anonyous patrons. Moreover, read only systems require that all electronic toll lanes on a toll road be networked to validate possibly hundreds of thousands of motorists' account balances. If read only technology were applied on a regional basis, this would require a substantial new bureaucracy to manage possibly millions of toll accounts and to keep track of everyone's travel. For toll road agencies, which charge tolls based on entry and exit locations, read only is an impracticality.

Read-write refers to a non-stop toll collection process that provides intelligence in the transponder. Not only can this vehicle-borne device be 'read' as it passes through a toll lane, but information can also be 'written' onto the transponder. This could be the entry point of a turnpike so that the proper toll could be calculated upon exit.

The AT'Comm system is the most advanced form of read-write. It is known as microprocessor-based read-write, which allows the transponder to be 'read', be 'written' to, and also provides processing to manage the data internally. The smart, microprocessor-based transponder maintains prepaid toll accounts in the transponder, thus relieving the agency, and ultimately the motorist from the cost associated with centralired accounting. Like a postage meter, the transponder is electronically charged with a value, and that value is reduced each time the car passes through a toll lane. An LCD display and audio alarm on the device also gives the motorist real time information on his or her account.

The AT/Comm smart transponder is also a platform for other 'Intelligent Vehicle Highway Systems' (IVHS) applications such as incident warnings, automated parking, commercial vehicle access control at airports, and other traffic management uses.

TECHNOSHOP '92 - A PLAN TO HELP UK MANUFACTURERS BEAT THE RECESSION

Where manufacturing firms are trying to ride out the world recession by cutting back on R & D investment, they are naturally reluctant to spend money now on buying in new developments from outside.

But, many of the organisations around the world who have invested in R & D during this period are now having to prune their operations even harder. Some research organisations, who normally market their top R & D output to major corporations, are keen to talk to any firms who are astute enough to be making their product plans ready for implementation when the end of the recession is in sight.

So there are some good 'buys' around in the technology market and one UK organisation, a not-for-profit company called The Technology Exchange Ltd has published a two volume catalogue covering 5,000 currently available licence and joint venture offers following a search of over 3,000 organisations in 34 countries.

Organisations like Krupp and Aerospatiale, universities and institutes like MIT, UCLi and Cornell are amongst those whose offers have been selected for publication.

Firms buying the catalogues can choose the offers they require, get a confidential introduction by fax and post, then hold preliminary meetings at the annual Technoshop Fair.

Then negotiations, which generally proceed slowly, can be ready for implementation when the recession ends.

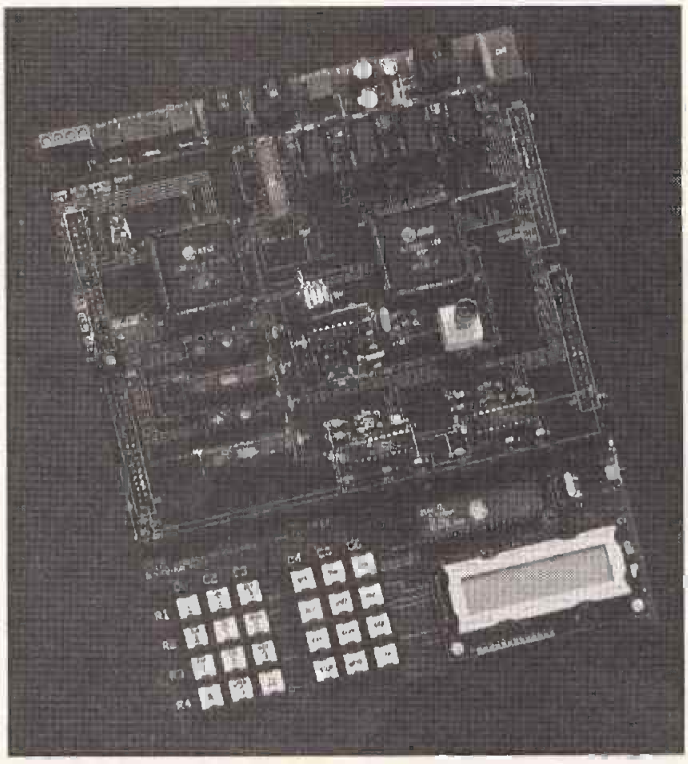
So manufacturers, can avoid making an investment until the last moment and be ready to launch new technology products just when their competitors are reviving their old product lines which have been in cold storage for a couple of years at least.

In 1990, when the first two volume catalogue set called "The Next 5,000 New Products" was published, over 800 firms in 51 countries used them and requested 3,000 introductions. Over 500 negotiations were underway within six months after publication.

For further details fax: The Technology Exchange Ltd on 0525 860664 or write to them at Wrest Park, Silsoe, Beds MK45 4HS.

CHIPSET FOR TAPELESS ANSWERING MACHINE

A new telephone answering device (TAD) chipset, developed by AT&T Microelectronics, provides the core functions required to build a tapeless answering system, in either standalone or integrated products. By replacing the traditional mechanical tape recorder, the TAD chipset allows more reliable and low-cost answering machines to be designed.



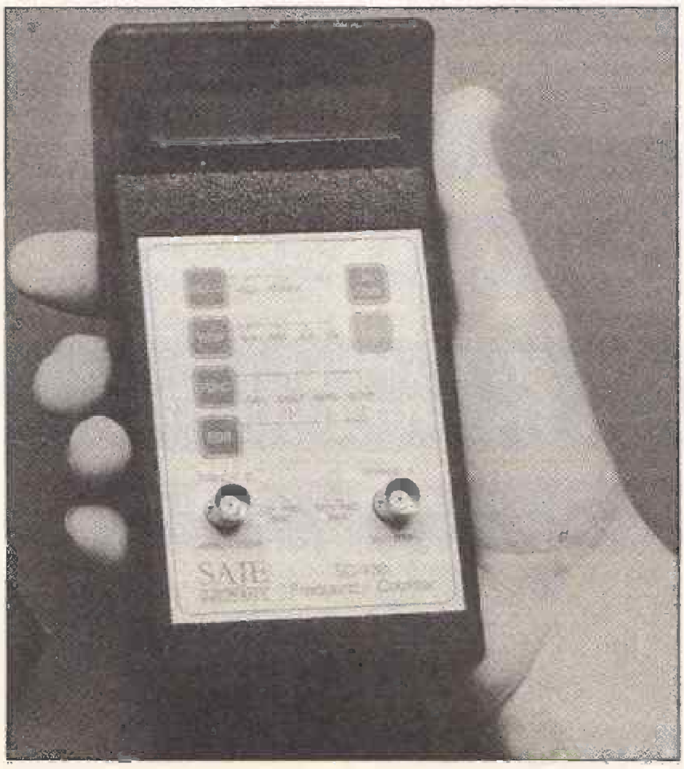
The highly integrated DSP-based chipset enables a fully featured answering machine to be configured using just the chipset and a host microcontroller, memory and an analogue switch.

The TAD chipset consists of a ROM coded DSP16A1, a T7513B 8-bit µ-law codec and an AT&T custom chip which provides the necessary clocks, control signals and power management. Incorporated in the chips are software algorithms to perform all the functions necessary for speech compression, telecommunications signalling, memory management and remote operation via touch tone (DTMF) control.

A low bit rate, high quality, speech coding algorithm, developed by AT&T, enables approximately 2.5 minutes of message storage per Mbit of memory, allowing up to 76 minutes of recording in 32Mbit of memory. In addition, cost is reduced by a proprietary memory-management system, which allows the use of low-cost audio grade DRAM (ARAM) for incoming and outgoing message storage. The addition of a read-only memory enables the TAD to play synthesised voice and user prompts, instructions and deliver message time labelling.

The TAD chipset is controlled by a system microprocessor via a 4 or 8 bit interface using a command/response-based architecture. Reader enquiries to: Vic Drake, Admail 4 International Ltd, Tel 0732 460424

LOW COST FREQUENCY MEASUREMENT TO 1.3GHZ



New from Saje Electronics are two microprocessor based hand-held frequency counters.

Their design incorporates an angle mounted 16 x 1 liquid crystal display giving excellent readability from a wide viewing area whether in hand held or bench applications.

Annunciators are displayed to assist in defining and editing set up and measurement criteria. A battery condition indicator gives readout of the battery condition.

Both instruments provide a full range of features including measurement of frequency, period, count and with a unique View facility enabling Min, Max, Average and Difference readings to be displayed. In Frequency mode a range of gating rates from 0.15 to 10 seconds is provided plus a switchable low pass filter. A display hold function is standard.

The SC-130 offers a frequency range of 5Hz to 1.3GHz and the SC-40 from 5Hz to 400MHz. Both instruments provide good sensitivity and high accuracy.

The instruments are housed in rugged ABS cases with a separate battery compartment for a PP3 size battery.

The SC-130 is priced at £109.00 plus VAT and the SC-40 at £89.00 plus VAT. Both instruments are designed and manufactured in the UK by SAJE Electronics.

For further information please contact:-

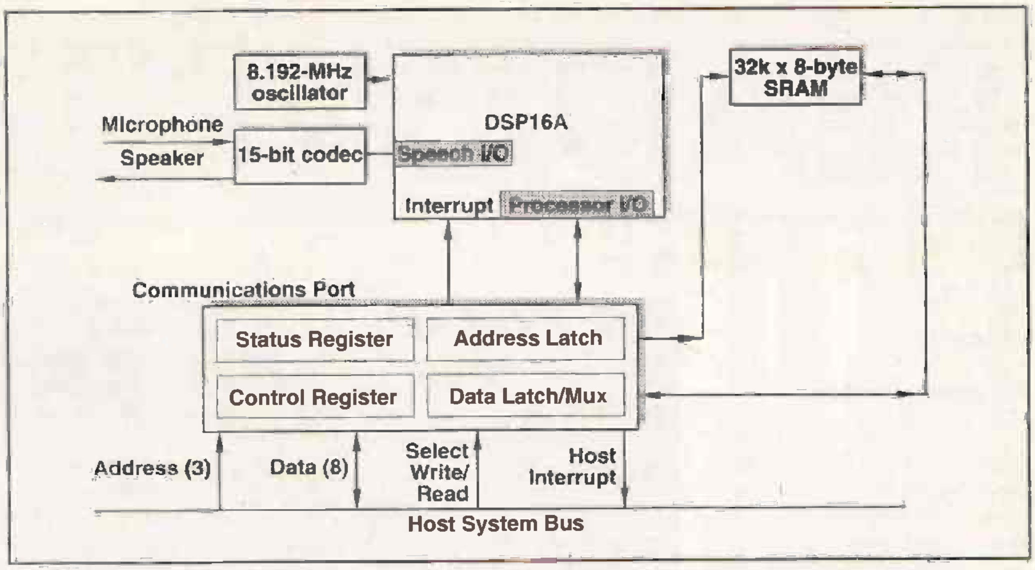
SAJE Electronics, Tel: (0223) 425440 Fax: (0223) 424711

More News Next Month

NEWS

...Stateside...

Voice recognizer



A low-cost voice recognizer may pave the way for evolution of voice dialling as a ubiquitous feature of mobile cellular phones.

Up to 40 spoken key words can be stored in memory, enabling hands-free voice dialing in analogue or digital mobile cellular phones. AT&T claims the speech-recognition algorithm refinements embodied in the voice recognizer were 20 years in the making at AT&T Bell Labs.

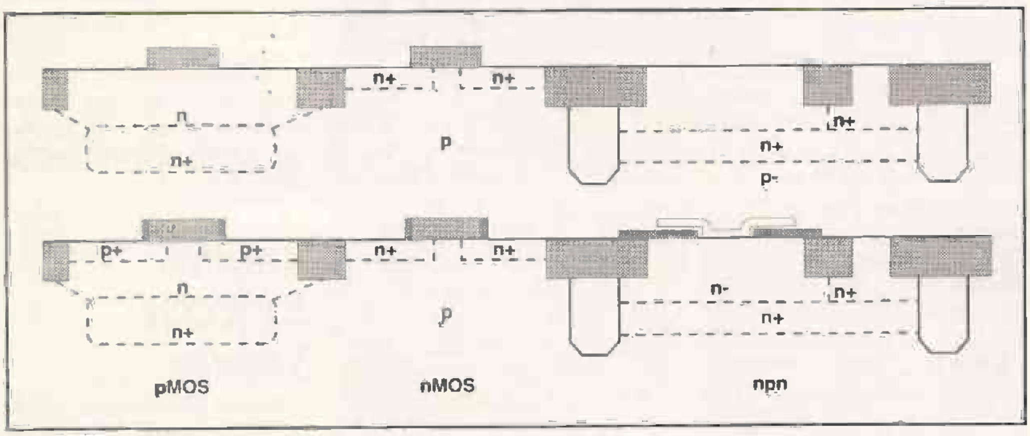
Beyond cellular phones, AT&T see applications for the technology in digital answering machines, modems, industrial controls and consumer electronics.

According to market-research firm Herschel Shosteck Associates the availability of low-cost voice recognizers will render cellular-phone voice dialing universal in a few years, though last year only 2-3% of cellular phones installed in the United States featured the capability.

The DSP16A with ROM-coded voice recognizer firmware on-chip will be available this autumn for $20 apiece in quantities of 10,000.

In the training mode, the recognizer permits the user to store up to 40 spoken words, each of up to two seconds' duration. The recognition mode allows the user to control a process by speaking a phrase that has been encoded and stored in memory. For instance, in cellular-telephone applications, the user would dial a number by speaking a key word (person's name) that is associated with that telephone number. The voice recognizer's response time is said to be better than 0.5 seconds.

AT&T Microelectronics has tested the recognizer in a car moving at 30 mph with the air conditioning on. In that situation, the recognizer "achieved 95% accuracy," meaning it could recognize a user command on the first try 19 out of every 20 times.



Manufacturing ferro-electric non destructive read-out memory

Sandia National Labs has agreed to help startup Radiant Technologies Inc. perfect the manufacturing of ferro-electric non-destructive read-out memory.

Radiant was formed by founders of Krysalis Semiconductor Corp. to focus on equipment for testing ferroelectric thin films. Radiant revealed it had won a patent on a special resistive element sandwiched in ferroelectric and semiconducting layers of thin film.

The Sandia equipment will enable the team to take the first steps toward developing thin films based on plasma-enhanced metallo-organic vapour deposition.

Ferroelectric materials, a class of perovskite ceramics with the capacity to hold a polarization state, have been explored for several decades as potential candidates for non-volatile memories. Recent work on ferroelectric thin films has linked the materials' future to improvements in thin-film deposition techniques, with many research teams exploring low-temperature deposition techniques to improve reliability.

Other materials research has sought to depart from the traditional, Lead zirconate-titanate (PZT) and Lead-Lanthanum Zirconate-titanate (PLZT) compounds used in ferroelectrics.

Since all memory reads in traditional ferroelectric devices require destructive readouts, which could be disrupted by single-event upsets, a truly non-destructive readout memory device such as the one proposed by Radiant would move ferroelectric research a giant step forward.

Radiant's design calls for depositing a semiconducting thin film atop a PZT thin film. The conductivity of the top layer is modulated by the PZT layer's state of polarization. Reading the device merely involves monitoring the current.

Because it is configured similarly to a programmable resistor, the Radiant design could be used in programmable logic devices and, possibly, as a replacement for analogue elements in neural networks and AI computing.

The memory is expected to have 10^{12} writes, unlimited reads and a minimum data retention of three years.

Radiant and Sandia will try to improve thin-film reliability along several axes, targeting the ability to process wafers at 400°C. The research team will look at biasing thermal substrate temperature and will also seek to adjust the chemistry of the processes by varying the metallo-organic precursors.

READ/WRITE ETI Letters

Window Opener Questioned

I refer to the artical 'Window Opener by Terry Pinnell. I imagine it would be a kind gesture if Terry was informed that it may be, cheaper, easier and not require keeping awake to operate a bedside control, if a simple fly screen was fitted to an open window in the first place before retiring with his book, when he could enjoy fresh air whilst reading.

Quite frankly, I cannot imagine a greater waste of effort on designing something for the sake of it.

J M Whiteley,
Ravenstone, Leics

Each to their own - Mr Whiteley. I agree in principle with what you say, but there could be occasions when the person in bed is not able to physically get out to open a window and it may be that a window is beyond normal reach say in tall buildings or industrial greenhouses. I think the idea is sound, but it is the application which must be questioned. - Ed.

Moving LED Display Requested

Having used circuits (or variations) from your magazine for many years, I am surprised that there is one item that I have not seen mentioned over the years. What I am trying to produce is an LED moving message display as seen in lots of shops and post offices. Although at first it seems quite simple, I soon discovered the whole problem can be quite complex.Can you or your readers give me any pointers towards any books/publications that can help me?

C N Eaton
Plympton, Devon

Yes, a good idea for a project and we will see what can be done - Ed.

DIY Warning for Electronics In Light Aircraft

Regarding the Light aircraft Intercom in the Sept '92 issue. As both a PPL and and electronics engineer, I feel I should warn readers that although the above project is an excellent design and certianly cheaper than any commercial unit , connection of this unit to the aircraft electrical/radio systems may invalidate the radio licence and could affect aircraft instruments, especially the magnetic compass. I'm afraid such systems must be certified by the CAA - Hence the high cost of such equipment. Many thanks for an excellent magazine.

Ed Dinning,
Newcastle

After a break of several years I recently purchased the September issue of ETI (I first started reading ETI in the seventies), and found it most interesting. However I must comment on the 'intercom for light aircraft' project. While this design is sound from the electronic view point, it has several drawbacks from the aviation side. While the author states that 'it is not wise to discard the previous microphone/phones etc 'immediately' in case of unit failure, this failure could happen at any time, and the headsets he describes are not compatible with standard aircraft radios. Commercial "carry on" units of this type normally use standard headsets with failsafe relay switching to by-pass the amplifier in case of failure or loss of supply. The legal situation also needs to be clarified. The Civil Aviation Authority regulates aviation in the UK, and any modification to an aircraft or its systems may only be carried out and certified by a licensed engineer or approved organisation. Any unapproved modification will render the aircraft's certificate of airworthiness invalid, and as a result the insurance also. This project could be considered a modification if it was directly wired to any of the aircraft systems, was physically attached, or derived its power from the aircraft supply. Velcro is not acceptable as a means of attaching equipment, the CAA recently issued a letter reminding approved organisation of the requirement to stress avionics installations so that equipment does not come loose in the event of an accident. For the record, I have been a CAA licensed engineer for ten years.

Robert Atkinson,
Christchurch, Dorset

Points noted, and in the interests of safety, I agree with you both entirely. Had the project originated from the UK, caution ary warnings may have appeared - who knows?. In retrospect, I'm sure the author would also agree that checking circuitry by other official sources is a must. - Ed.

Loop Aerial System Requested

TheSurround Sound Decoder in the July issue of ETI prompts me to write to you about a loop system for my own use at my home.I have great difficulty in listening to TV, or radio, because of a hearing problem, and the hearing aid develops condensation which makes matters worse. I wonder if any of your technical contributors could furnish details of the loop system used in public buildings, or a similar circuit that I could assemble for my own use. I am not in the clear as to how that system works, so any instructions would be greatly appreciated. Also any hints on the use of lapel mic's used with these systems.If I could obtain a circuit of some rig-up for such a system it would be the answer to my terrible problem.

P Trayers
Wirral, Cheshire

Active speaker With A Difference

As a long time regular reader (and keeper of old issues) many thanks for a stimulating and educational magazine.Recently considering the purchase of a MIDI synthesiser addition to my piano set-up, I was introduced during the demo to an apparently active and effective amplifier/speaker arrangement. There was one bass unit, floor standing, and two high frequency units mounted about ear level.I feel this could be an interesting home build project, or for Blueprint, discussing the frequency ranges required, active filter characteristics, and power requirements. I do not recall any similar project to use as a basis - could it be a first for ETI?

Peter J Metcalf
Paisley, Scotland

We have published a few active speaker designs over the years which have been in one cabinet. This might be an interesting variation - Ed.

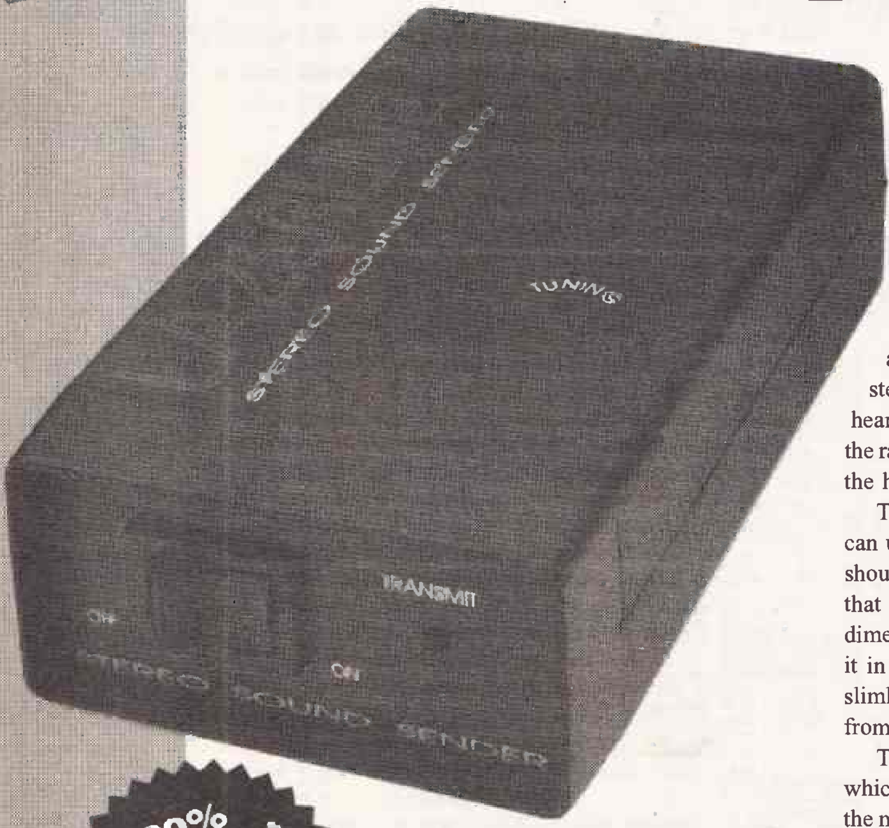
Another EPROM Service

Would you oblige if possible by publishing the following details of a service to ETI readers.

EPROM and CPU programming service to ETI readers, the following types at present programmed, 2708, 2716, 2732, 2764, 27128, 27256, 27512, 8048/49/50, 8748/8749/8750, data to be supplied on PC format disk 360k/720k 5" and Apple II 5" disk, £10 setting up charge, printed/typed lists also accepted, EPROMs supplied by customer or purchased from me, for further details contact:

Mr.D.J.Brown
2 Glentworth Avenue
Whitmore Park
Coventry
CV6 2HW

ETI Christmas Special Offer



20% Discount to ETI Readers

Have you ever relaxed in a hot bath, or shut yourself into your den for a peaceful hour or two - and wished you could take your CD/cassette/vinyl collection in there with you? Meanwhile, your hi-fi player is nestling snugly in its pride of place in the living room - and somebody else wants to watch the TV!

Dream no more. With the Lazerline Stereo Sound Sender, all you have to carry with you is a portable radio, and you can have the music of your choice anywhere in the house or garden.

The Lazerline Sound Sender is a powerful, full-stereo mini FM relay station. It can relay any audio signal (mono or stereo) from your CD player, hi-fi amplifier, television, VCR, etc., or any other audio signal source, to any FM receiver up to a 200-foot radius. All you have to do is tune your radio to the Sound Sender's frequency, and listen to your own music.

The Sound Sender can do other tricks, too. If you have a portable CD player, now you can listen to it in your car without disturbing the in-car wiring. Place it on a level surface, connect the Sound Sender - and tune in your car radio.

Used with a Walkman-style personal stereo radio and headphones, the Sound Sender acts as a cordless stereo headphone - useful if one of the family is hard of hearing. Connect the Sound Sender to the television, tune in the radio, and the listener can select a comfortable volume on the headphones, without disturbing other listeners.

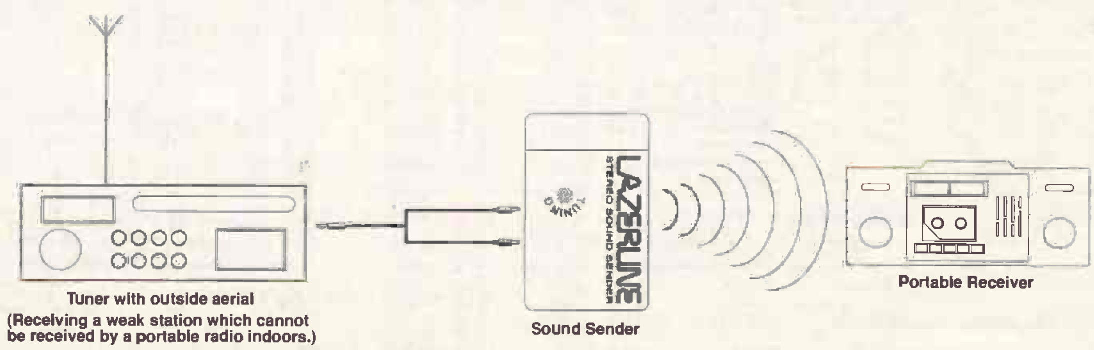
The Sound Sender is battery powered (by one PP3) so you can use it anywhere. Using an alkaline battery, battery life should exceed 150 hours. Automatic gain control ensures that the modulation level is always correct, and compact dimensions - 2.5 x 1.5 x 4.75 inches - mean that you can slot it in alongside any audio kit from your television to your slimline CD player. Listening volume is fully controllable from the radio receiver you are using.

The Sound Sender can be connected to any sound source which has a stereo output - including technology not yet on the market. It works well with mono-only output, too, with a simple cable-adaptor.

You can re-tune the Sound Sender if the preset frequency is inconvenient for you - but this wouldn't normally be necessary, as the operating frequency is away from broadcast frequencies in most areas.

Specification

The unit draws 3.3mA typically from a 9V PP3 battery. The current drawn, and the range of transmission, decrease very slightly as the battery runs out. In practice this means that an alkaline manganese battery will normally run the Sound Sender for about 200 hours, but can be relied upon for at least 150 hours. The typical channel separation is 30dB, while the frequency response extends beyond 13kHz. The inputs cope with a signal range of approximately 150mV to 1V RMS. The practical result of all this is that on most program material the received signal from the Sound Sender



sounds similar to that from an FM broadcast radio station.

The RF output of the unit is approximately 2mW, which gives enough range for any normal use while minimising the possibility of causing interference. When the unit is used inside a car, this power is sufficient to reach the car radio aerial no matter where on the car it is mounted.

The sound sender is normally sold for £69.95, but a discount of 20% is available to ETI readers. To obtain a sound sender at the special offer price of £55.95, just fill in the coupon opposite and post it to:

Lazerline
Unit 2
Castle Commerce
Old Road
Leighton Buzzard
Beds LU7 7RG

If you prefer not to cut your copy of ETI, photocopies of the coupon are acceptable.

Not licensed in the UK

YOUR GUARANTEE

You should be TOTALLY happy with our service as well as your purchase.
All goods are designed and manufactured by ourselves to a very high standard, and guaranteed for 1 full year.
In the unlikely event that any product fails to give complete satisfaction return it to us in undamaged condition within 7 days for refund or free replacement.
This is in addition to your statutory rights.

HOW TO ORDER

TO: Lazerline, Unit2, Castle Commerce, Leighton Buzzard, Beds, LU7 7RG

Please supply............Audio Senders at £55.95 + £2.00 p&p each.

I enclose cheque or crossed PO for..............payable to Lazerline.

I wish to pay by Visa - MasterCard, please debit my account. My card number is:

Signature

Expiry date

Name (on card)

Address

Postcode

Normally despatched within 7days, please allow up to 28 days for delivery.

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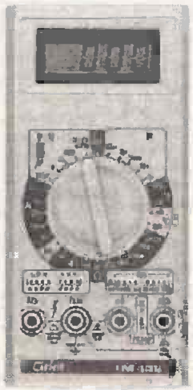
£30 off Europe's best selling oscilloscopes!

- Excellent quality, built to last a life time
- 2 year warranty
- Each 'scope supplied with 2 sets x10 probes, manual and mains lead.

Offer must end 31st Jan 93

PART NO.	DESCRIPTION	USUAL PRICE	OFFER PRICE
HM203-7	20MHz, dual channel	£397.15	**£367.00**
HM205-3	20MHz, storage 'scope	£716.75	**£686.00**
HM604	60MHz, dual channel	£716.75	**£686.00**
HM1005	100MHz, 3 channel	£930.60	**£899.00**



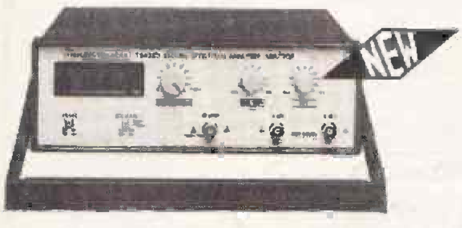
MULTIMETERS

The D-MM good value meters are now even D-MMer good value!!

The TM series of low cost meters, with 3½ digit LCDs, full overload protection, strong ABS cases and packed with features. Supplied with test leads, battery and manual.

Offer must end 31st Jan 93

PART NO.	DESCRIPTION	USUAL PRICE	OFFER PRICE
TM 5315	DC current (10A) continuity and diode test	£19.99	**£19.25**
TM 5365	Capacitance and frequency (200kHz) ranges	£36.50	**£29.99**
TM 5375	Frequency range (20MHz) and HFE test	£36.95	**£31.49**
TM 115	AC & DC current (10A), HFE and continuity test	£32.50	**£30.99**
TM 175	Freq. (15MHz), capacitance ranges with HFE, diode, continuity & LED test	£53.60	**£45.00**
TM 8020	3¾ digit display, freq. (4MHz) capacitance (40uF), AC+DC current to 20A	£54.76	**£49.95**
TM 8030	3¾ digit display, freq (4MHz), temp. (inc probe), AC+DC to 20A	£59.96	**£55.49**
7705	Capacitance meter, 1pF to 20,000uF	£39.82	**£35.90**



NEW

SPECTRUM ANALYSER ADAPTOR

- 400kHz to 250MHz frequency range
- LC display of centre frequency
- Calibration marker

The new TSA250 will adapt any conventional 'scope into a highly cost effective spectrum analyser. With numerous applications in RF design and development work, EMC investigations, and education.

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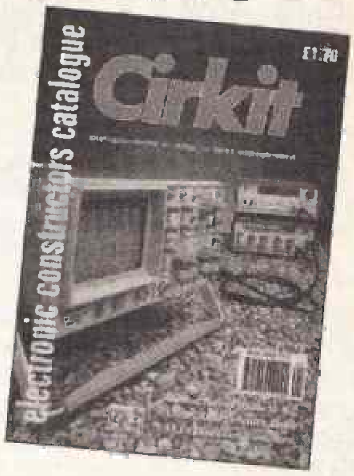

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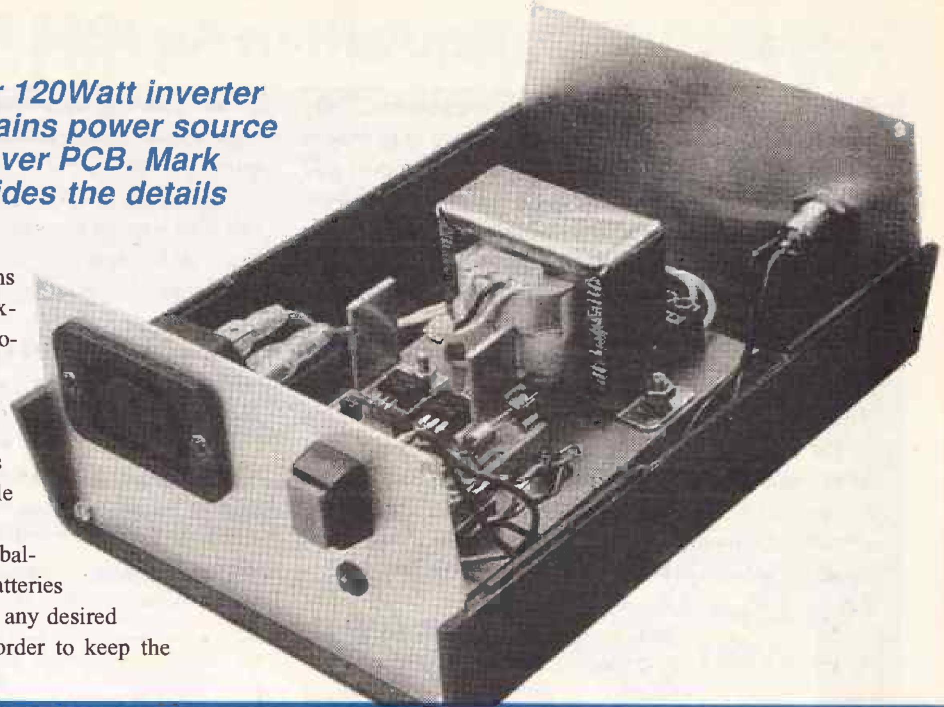
Build a 20,50 or 120Watt inverter for a portable mains power source using our cover PCB. Mark Daniels provides the details



A simple battery to mains inverter can be extremely useful for providing electrical power to small mains appliances in the event of a power failure, or for powering similar appliances in situations where no suitable mains supply is available.

Given a suitably large bank balance and an adequate stock of batteries it is possible to power virtually any desired load from an inverter, but in order to keep the

20/50/100Watt Mains

proportions within reason the load should be limited. As an example a 3kW load (about the maximum which can be safely run from a 13 amp socket outlet) would require an input current to the inverter of around 300 amps from a 12 volt battery, discharging a typical 60 ampere- hour car battery in about five minutes.

ETI Cover PCB Project

A more acceptable load limit for our typical car battery would be around 500 Watts, but this would still drain it in under one hour, which may be quite acceptable if the load is an intermittent one such as an electric drill or similar small power tool. Finding a suitable transformer ex-stock generally poses a problem with such a large inverter and added to that is the cost of suitable power transistors.

The smaller inverters, having an output of 100 Watts or less, are a much better proposition for the home constructor; all the components being readily available at very low cost.

The circuit described in this article is designed to be used with equipment having a power requirement of less than 20 Watts in the first place. By simple substitution of heavier power components the output of this design may easily be increased to 50 Watts, this is described in detail later. If a little more work and expense can be tolerated a load capability exceeding 100 Watts may be achieved, as will be explained at the end of this article!

Generating AC

There are many ways of generating the AC required for an inverter, some of which are usable only in very small applications, others require expensive or difficult to obtain parts.

One obvious choice for generating the required timing

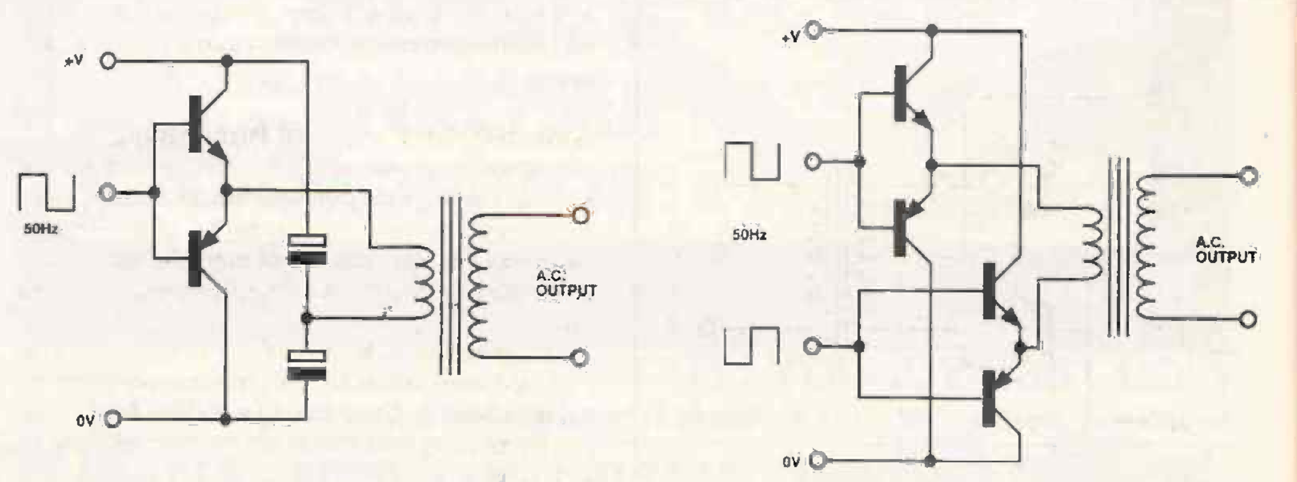


Fig.1 Inverter configurations

signals for the switching transistors is the ubiquitous 555 timer IC in its astable mode, which would have to be used in a single-ended or half-bridge configuration. This would result in quite a simple circuit, but it does pose two major problems; the worst of which is the low RMS output that is never able to exceed half the DC supply voltage. With a 12 volt supply the output is unlikely to be much better than about 4.5 Volts after transistor losses, etc. Also, the mark-space ratio of the signal from an unmodified 555 circuit will always be greater than the ideal 1:1 and consequently will not provide the best waveform for an inverter.

The two electrolytic capacitors in the half- bridge configuration of Figure 1a would need to have very large values for operation at a frequency as low as 50Hz if a practical amount of power is to be delivered to the load. The resulting design would work out much more expensive than is necessary.

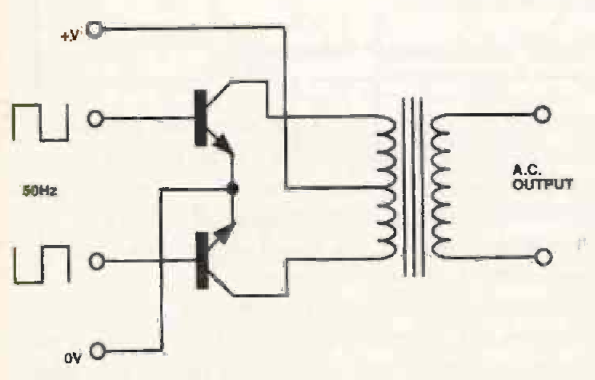
A full bridge configuration, as in Figure 1b has a greatly improved output and does not require expensive electrolytic

Inverter

capacitors and could be used to good effect with a 12 Volt supply. It does, however, require twice as many power transistors as the half-bridge and a more complex timebase circuit, which is little advantage in this particular application.

There is a third configuration shown in Figure 1c, which at first glance appears to overcome all of the problems associated with the first two circuits, but not without introducing a couple of minor ones of its own.

The power transistors used in the bi-phase, or push-pull circuit, of Figure 1c require a V_{ce} rating in excess of twice the peak supply voltage which, with a high DC input voltage, can mean costly or difficult to obtain components. The inverter described in this article runs from a nominal 12 Volt supply and can use ordinary low voltage power transistors which are readily available and inexpensive. This configuration requires complementary timing signals of equal mark-space ratio and obviously cannot be used with a standard 555 timebase.



Fortunately, most CMOS and TTL oscillators have complementary outputs and are ideal for this type of application. The CMOS option is chosen here for its additional advantage of wide supply voltage tolerance.

Printed Circuit Board Assembly

The majority of the components are assembled onto the single-sided glass-fibre printed circuit board, the component overlay for which is provided in Figure 4.

The easiest and safest method of assembly is to fit the small passive components and the socket for IC1 first, checking positioning and orientation before soldering. The three rectifiers, D1, D3 and D4 should be fitted next followed by transistors Q1 and Q2.

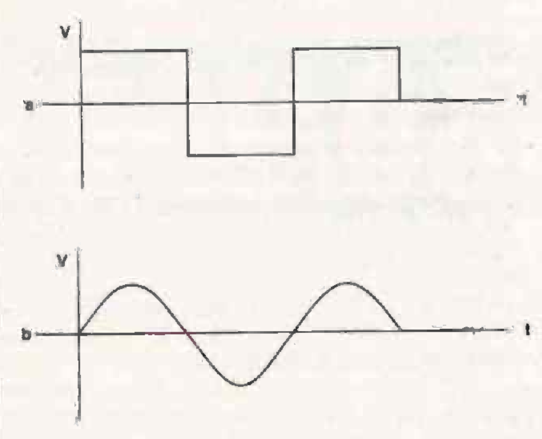


Fig.2 Voltage waveforms

The power transistors, Q3 and Q4 need fitting with small heatsinks which may conveniently be made from small pieces of 16swg (1.6mm) aluminium. If separate heatsinks are used then no isolating kits are needed, simply apply a small quantity of heatsink compound to the metal mounting tab of each transistor and bolt it to its respective heatsink, ensuring that the two cannot touch.

The fuseholder and preset, RV1 may be fitted next. If user adjustment of the output frequency is desired then an external potentiometer may be fitted as described under Modifications.

Assembly To Case And Interwiring

If a two part plastic case with aluminium front and rear panels is used as in the prototype then the PCB and transformer may be mounted in the bottom half of the case using countersunk machine screws and nuts. Use spacers or a couple of nuts to stand the PCB clear of the lower panel of the case.

Drill the mounting hole for SK1 in the rear panel of the case and de-burr it before fitting the miniature power connector. If the panel mounting option for RV1 has been chosen then the mounting holes for this will also need drilling in the back panel.

Prepare the front panel to accept the IEC 6 Amp socket (if used), S1 and D1 in accordance with Figure 5. The cutout for

HOW IT WORKS

An inverter works by converting the direct current (DC) from a battery into alternating current (AC), and feeding it into the primary winding of a step-up transformer. For AC applications the frequency is usually chosen to coincide with the local mains frequency of around 50 to 60Hz, although other frequencies such as 400Hz, commonly used in aircraft systems are not unheard of.

The usual mains electricity has a sinusoidal voltage waveform, as depicted in Figure 2a. This is normal for electricity generated in a rotating machine, such as an alternator. However, in electronics things are not always as straightforward as this and for reasons of simplicity and efficiency we often make do with a squarewave output (Figure 2b). This does not affect the vast majority of small appliances as the only major device which will not accept a square wave input is the induction motor, which is generally excluded from connection to this particular inverter by nature of its current hungry power requirements anyway.

The circuit used in the Mini Inverter is very simple and is based around stock parts, making it cheap and easy to build. Figure 3 shows its complete circuit diagram.

A CMOS multivibrator, IC1 generates the timing signals at a user adjustable rate, set by preset, RV1 in conjunction with fixed resistor, R2 and capacitor, C2. Any frequency in the approximate range 42 to 68Hz may be selected, thus covering the World's most common mains frequencies of 50 and 60Hz.

The multivibrator's outputs are used to drive two common emitter darlington pairs, with a phase difference of 180° between their outputs, swinging alternate ends of the transformer primary to ground while the centre-tap is held at +12V. This generates a low frequency square wave in the primary winding, inducing an alternating magnetic flux in the iron core and ultimately a higher voltage in the transformer's secondary winding due to the far greater number of turns on this winding. The load is connected across the secondary and experiences the equivalent of the full mains voltage.

Diodes D3 and D4 protect the power transistors and drive electronics from the effects of the high voltage spikes produced by virtue of the extremely rapid switching of the inductive primary winding. Capacitor, C1 provides supply decoupling and D1 in conjunction with the fuse, FS1 protects the circuit against incorrect supply connection.

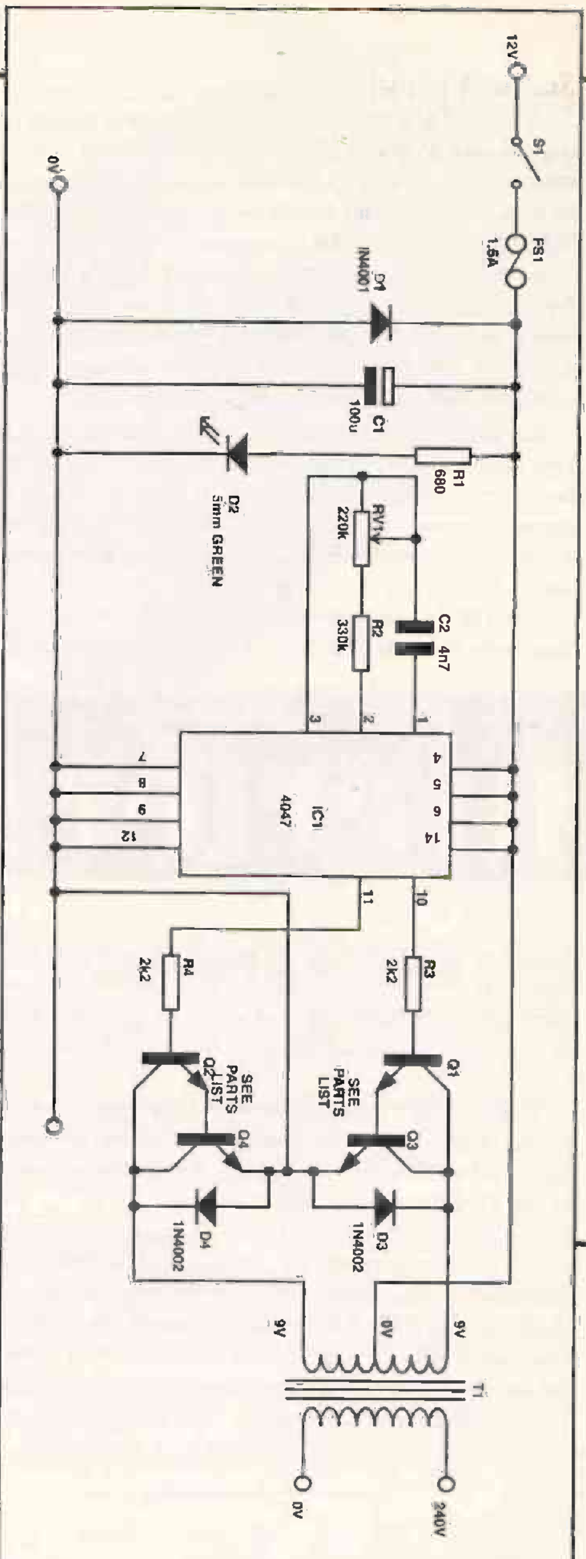


Fig.3 Circuit diagram of mini inverter

the socket may be made by drilling a 10mm hole at each corner of the cutout and then using a junior hacksaw to join up the four holes, finishing to size with a flat file. The other holes are simply drilled, with an anti- rotation notch filed for the switch, if necessary.

If front panel lettering is required apply it now and give the panel two coats of transparent lacquer, which should be allowed to dry before fitting any components to it. Fit the panels to the lower half of the case using the self tapping screws supplied with the case and make all the electrical connections between the various components in accordance with the interwiring diagram of Figure 5.

Fit a length of twin core flex to the DC plug, PL1, making the centre pole positive and fit a large pair of crocodile clips or a cigar lighter plug as preferred to the other end of the lead. Keep this lead as short as possible to reduce cable voltage drops (3 to 4 metres should be adequate in most cases). Any extension leads should be on the high voltage side, where currents will be lower, thus keeping power losses to a minimum.

Safety

The high voltage output of this inverter is at a fairly low impedance and is capable of giving quite a severe electric shock. It is essential to observe the same safety procedures which apply when working with the normal mains, particularly with the larger unit described later which is quite capable of delivering sufficient current to kill! If you are at all uncertain about working with mains voltages then do NOT attempt to build any of these circuits.

It is essential that mains rated wire be used for all 240 volt connections and the terminals on the mains socket must be properly insulated to reduce electric shock hazard. Take note of the earthing arrangements shown in Figure 6 as these are essential for safe operation of the completed unit and must NOT be omitted under any circumstances.

Setting Up and Testing

A 12 volt DC source capable of providing at least 2 amps (e.g. car battery) and a 4R7 2.5W wirewound resistor are the only items essential for testing the inverter. An analogue multimeter, although not essential, would be helpful particularly if fault finding becomes necessary.

Connect the 4R7 resistor in series with the inverter and battery and measure the output voltage of the inverter, which should be in excess of 200 volts. Allow it to run for a while and check that the power transistors do not get warm, switching it off immediately at any sign of a problem.

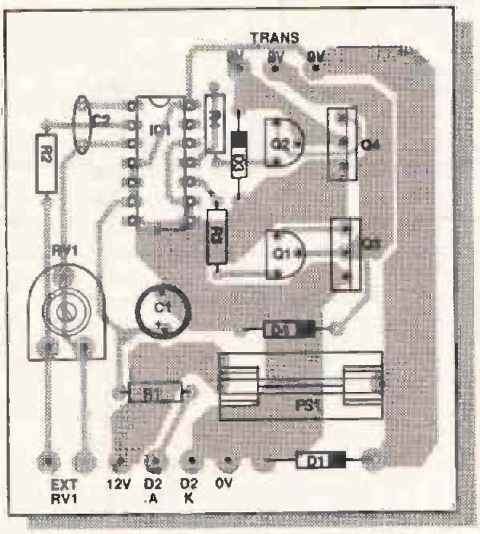


Fig.4 Component Overlay

If all is well at this stage disconnect the 4R7 resistor, reconnect the unit to the power source and measure the open circuit output voltage, which should be around 300 to 340 volts. Apply a small load, such as a 15 Watt soldering iron and check that the output voltage does not fall below 240 volts.

To set the output frequency connect a digital frequency meter between pin 10 of IC1 and 0 volts and adjust RV1 until the desired frequency is obtained, normally 50Hz or 60Hz.

If no frequency meter is available an oscilloscope may alternatively be used to set the period of the waveform to 20ms for 50Hz or approximately 17ms for 60Hz.

The above two methods of setting the frequency require access to some fairly expensive test equipment, but with a little ingenuity this may be avoided. A high impedance loudspeaker connected between Q1 collector and the positive supply rail will produce an audible note which may be compared with any accurately known 50Hz or 60Hz tone (e.g. a speaker connected across the output of a low voltage transformer plugged into the normal household mains).

If the frequency is unimportant set RV1 to give the highest output frequency as this will also produce the greatest efficiency and output voltage. The two higher power versions of this inverter are tested in a manner similar to that outlined above, with the following differences; a higher current supply and suitably larger loads are required.

Fault Finding

This circuit should prevent no serious problems if assembled on the cover PCB as shown. Solder bridges across adjacent tracks on the board are the most likely problem.

Check the fuse first as this may have failed if the unit was incorrectly connected to the battery. If this is the case the reverse polarity protection diode may have have failed to a short circuit and will also need replacing.

If the fuse fails a second time with the battery correctly connected check the orientation of all the diodes and replace any incorrectly fitted ones with new ones.

It is possible that the secondaries (used here as primaries) of the transformer have been connected in opposition, thus presenting a low impedance to the driver transistors. Check for this by removing the transformer from the circuit and connecting it to the mains in the normal manner. Measure its output across the ends of the centre tapped winding, which should produce around 18 to 20 volts AC. A reading of zero indicates that the connections to one of the windings have been reversed and will need swapping around.

Modifications

An external potentiometer may be fitted to the inverter to allow user adjustment of the output frequency and is connected as shown in Figure 7. The on-board preset shown in Figure 2 is then not needed and should be omitted if this modification is carried out.

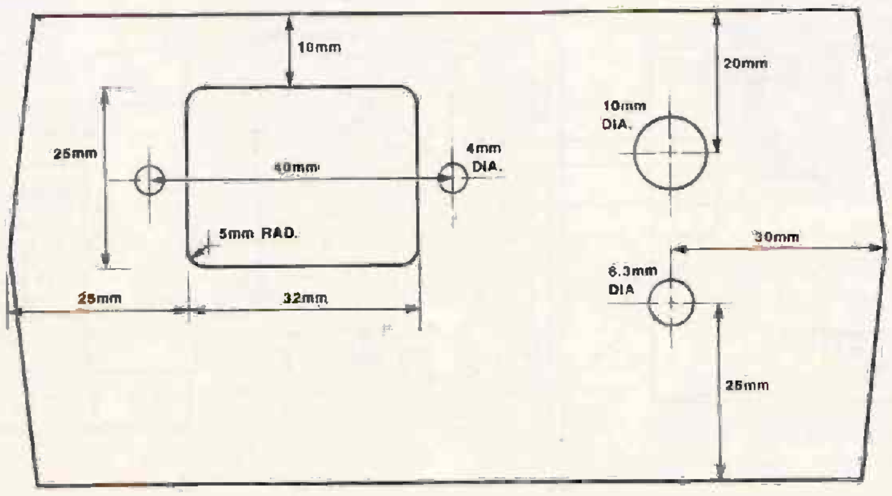


Fig.5 Front panel cutouts

PROJECT

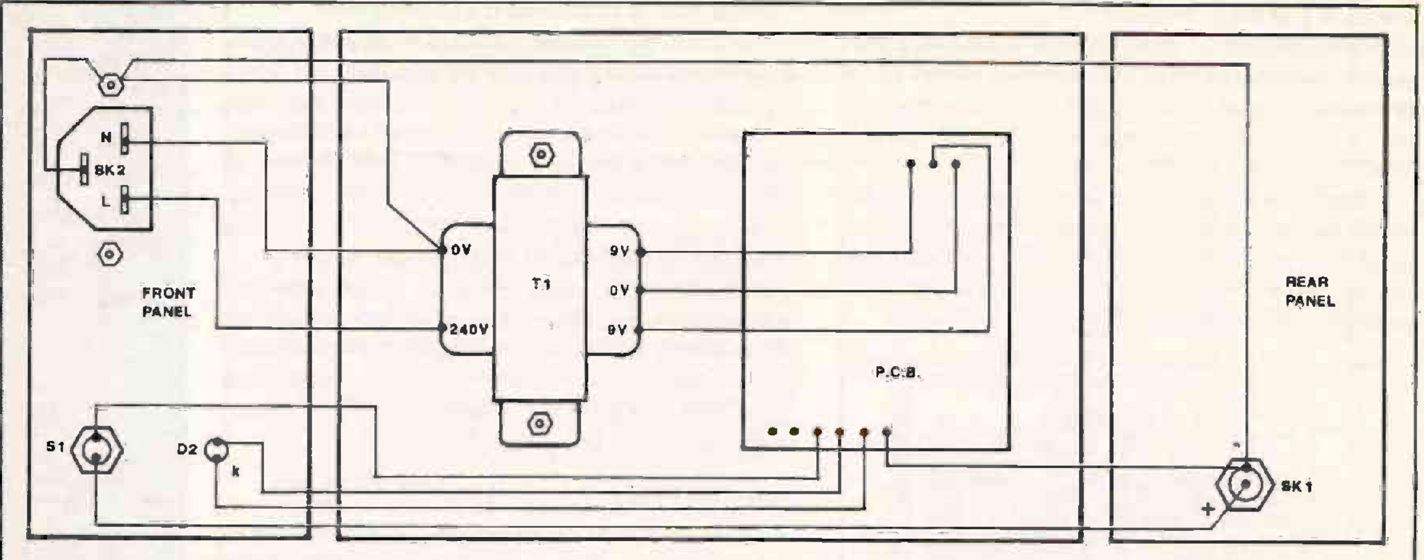


Fig.6 Case layout and interwiring

For an increased output power of up to 50 Watts replace Q3 and Q4 with TIP41 devices, uprate T1 to 50VA and FS1 to 3 or 4 amps. Fit a larger heatsink to the power transistors, using isolating kits and heatsink compound.

For adequate reverse polarity protection D1 will need uprating to at least 6 Amps, otherwise it will have to be replaced each time incorrect battery connections are made and it will fail to a short circuit. The large areas of copper on the PCB which carry the full input current to the inverter, would benefit from heavy tinning if continuous use at high powers is expected. All interwiring on the low voltage side should also be suitably uprated to cope with higher input currents of upto 5 Amps at full load.

For maximum output power the TIP power transistors may be replaced with TO3 packaged power darlingtons mounted off-board on a large heatsink, having a thermal resistance of less than 2°C/W. MJ4033 devices, having a current rating of 16 amps, may be used for Q3 and Q4 and should be fitted to the heatsink using isolating kits and heatsink compound. Connection to the PCB and transformer should be in accordance with Figure 8, using heavy connecting wire for all high current paths, indicated by the thicker lines in the drawing.

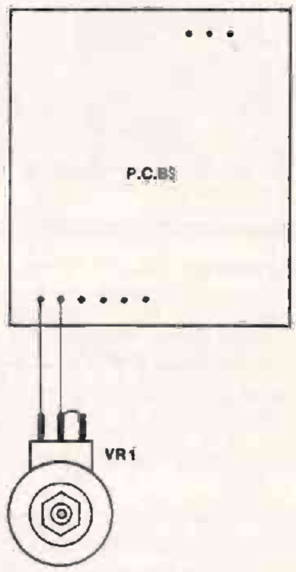


Fig.7 External frequency control wiring

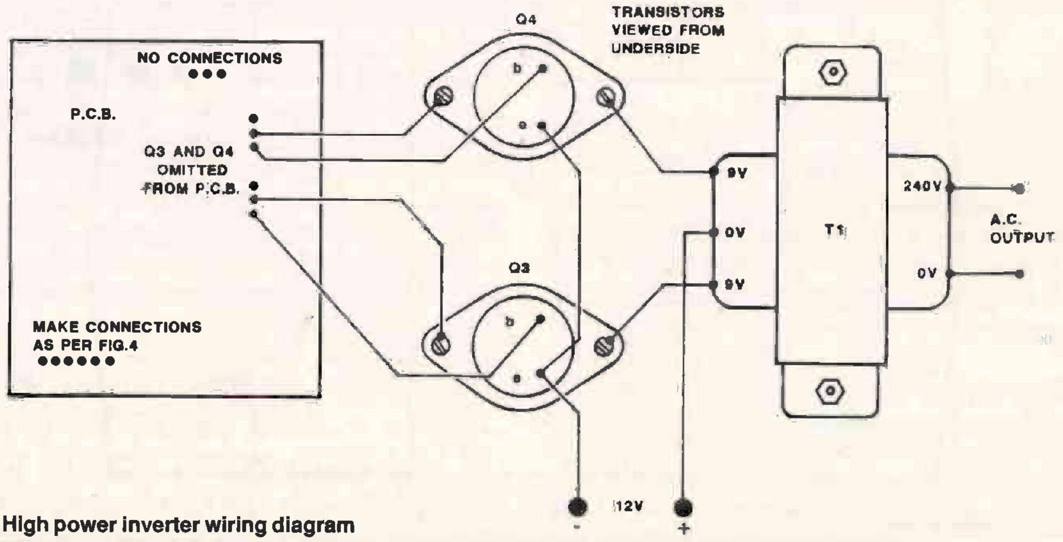


Fig.8 High power inverter wiring diagram

PROJECT

For a full 120 Watts rating a toroidal type transformer is to be recommended for its lower magnetizing current requirement, which is reflected in the inverter's lower no-load current and considerably greater part load efficiency. As an added bonus a toroidal device of this rating is very much cheaper than a conventional laminated transformer! A full load efficiency of around 80% can be expected.

PARTS LIST

RESISTORS (All 0.25W 5% Carbon Film)

R1	680	
R2	330k	
R3	2k2	
R4	2k2	
RV1	220k Sub-min Horiz Preset	

CAPACITORS

C1	100µ 25V Radial Elec	
C2	4n7 Polyester, 5mm Pitch	

SEMICONDUCTORS

D1	1N4001 (uprate accordingly for 50/120W versions)	
D2	5mm Green LED	
D3,D4	1N4002 (2 off)	
Q1,Q2	BC184L (2 off)	
Q3,Q4	TIP31	(2 off for 20W)
	TIP41	(2 off for 50W)
	MJ4033	(2 off for 120W)
IC1	4047B	

MISCELLANEOUS

T1	Mains Transformer	
	9-0-9V 20VA Rating	(20W)
	50VA Rating	(50W)
	120VA Toroidal	(120W)
S1	Push to Make Switch	(20W)
	5A Toggle Switch	(50W)
	16A Rocker Switch	(120W)
FS1	1.5A 20mm Quick Blow	(20W)
	3.15A 20mm Quick Blow	(50W)
	10A 1.25"	(120W)

PCB Mounting Fuseholder for FS1
(Panel Mounting Type for 120VA Version)
Large Crocodile Clips or Cigar Lighter Plug
Panel Mounting 6A IEC Socket Outlet and Plug to Suit
Panel Mounting DC Power Connector and Cable Mounting Plug
Ventilated Enclosure to Suit
Wire, Solder Tags, Crimp Terminals, Screws, etc.

BUYLINES

Ventilated enclosure is TEK K22 from West Hyde (Tel: 0453 731831) All other components are standard parts and were supplied by J.P.G. Electronics (Tel: 0246 211202), who can also supply a case if required.

AutoMate Anniversary Mixer

8a

This month, Mike Meechan presents some circuits which are guaranteed to raise the hackles and boil the blood of the anti-tone control brigade.

Although some of our readership has intimated as much, and despite some scurrilous rumours to the contrary, I have yet to secure a deal with Steven Spielberg as regards a blockbuster movie of the Anniversary AutoMate - with screenplay by Stephen King and a musical score by Andrew Lloyd Webber - but T-shirt sales are doing well, book rights have been agreed upon and the album will soon be released! Anyway, enough of the frivolity and wishful thinking and down to business.

The Equalizer

No, not a guest appearance in this column by Edward Woodward, scourge of wrong-doers. At long last, we can now present the equalization circuitry of the AutoMate and I hope that all will agree that it's been worth the wait. At this late (EQ) stage in the game, it might be worthwhile pointing out that the AutoMate EQ is a true parametric equalizer. The name parametric and sweep equalizer have, in many ways, become synonymous. This is a quite false axiom since a sweep equalizer offers control only of centre frequency and boost/cut, not the other parameter necessary - that of Q control - which yields the TRUE parametric equalizer. It is as well to point this out here and now - like can therefore be compared with like in the case of the AutoMate and any potential commercial competitors.

Future topics for exploration and vivizection - in the style of previous sections- will include dynamics and switching (in next month's issue), monitoring, panning, mixing and finally AutoMation. We shall then start to publish some overlays for the mono mic/line channel strip before briskly moving on to other modules in the series including the stereo line/RIAA channel strip, group module, master module etc.

For the present, we'll content ourselves woth looking at the comprehensive equalization circuitry of the AutoMate. Referring to the circuit diagrams of Figures 1 and 2, we should be able to see - after three months of intensive study of EQ and filter networks - that the featured circuits are a veritable smorgasbord of different types. This was flying somewhat in the face of popular fashion where conventional designs - for the parametric EQ at any rate - follow either one school of thought, the constant all-pass phase-shifting types (CAPS) invoked as variable and tunable admittances to ground or the other, state-variable method of implementation. I have used both types where I thought that the performance of one type in a particular aspect was superior to the performance of the other type in that same aspect. Sometimes, a slightly maverick approach to design is to be commended....

Figure 1 shows the High Pass Filter section. This is an outwardly conventional equal-component-type Sallen and Key HPF. Tacked onto the end of it is a reasonably meaty push-pull transistor stage which boosts current-sourcing capability by a good factor and means that long lines or jackfields can be driven with considerable ease. Feedback is therefore derived from the output of the two transistors and not from the op-amp. Referring to the discussion of some months previous, we now know that the Sallen and Key type of filter has reasonable responses in all of the important areas. Also, with the equal component type, the methods used to produce better out-of-band roll-off ie a Butterworth response means that 4dB of gain is introduced. This was why the previous Line Trim stage was made to sustain an overall 4dB loss in the 0dB setting. There is thus no overall gain (or loss) through the system with all level controls set for 0dB.

Fazed by Phase

In the second stage of the EQ, each of the true parametric sections is able to be tuned over a 20:1 frequency range, from 50Hz to 1kHz at the lower end - I've called this section, somewhat misleadingly, low -mid - and from 1kHz to 20kHz at the upper end. On the face of it, there is no direct overlap of frequencies. This is important since both of the state-variable sections share a common Baxandall-style summing stage. The one caveat, however, (with both filters able to be tuned to the same frequency) is that if both sections *are* tuned to a particular crossover frequency, or a very similar one for that matter, the available cut or boost ratio is altered - you can't simply just add 15dB of boost at 1kHz in one section and also boost it by the same amount in the other! This is because the two stages are summed, not multiplied so the maximum possible (if the op-amp can do so without clipping) is 21dB. The use of both the gyrated admittances and state variable in the same package meant that the EQ stage had an unattractive overall phase inversion.Again, there has been much subjective argument about the need to maintain faithfully the integrity of the audio phase, with an overall in-phase response from input to output - sounds better, old boy. I can't comment authoritatavely one way or the other but it is interesting to note that many of the most widely-used Japanese professional digital audio processors did, in fact, invert the signal phase of the signal. It is claimed that incorrect phase results in imaging that is perceived psychoacoustically as 'flat' and which sounds as if it emanates from a point near or behind the loudspeaker. Absolute phase, on the other hand, cause the image to tend to surround the listener and the depth and dimensional character of the mix are enhanced greatly. It makes one wonder just what absolute phase reference there is to believe in in many recordings. Phase is of particular importance with microphones, especially those arranged to capture a stereo source (where phase-reversed mics will cause images to wander) or where ambient as well as close-miking of the source is being done since mono will be affected, too, in this instance. Phase inversion can be used

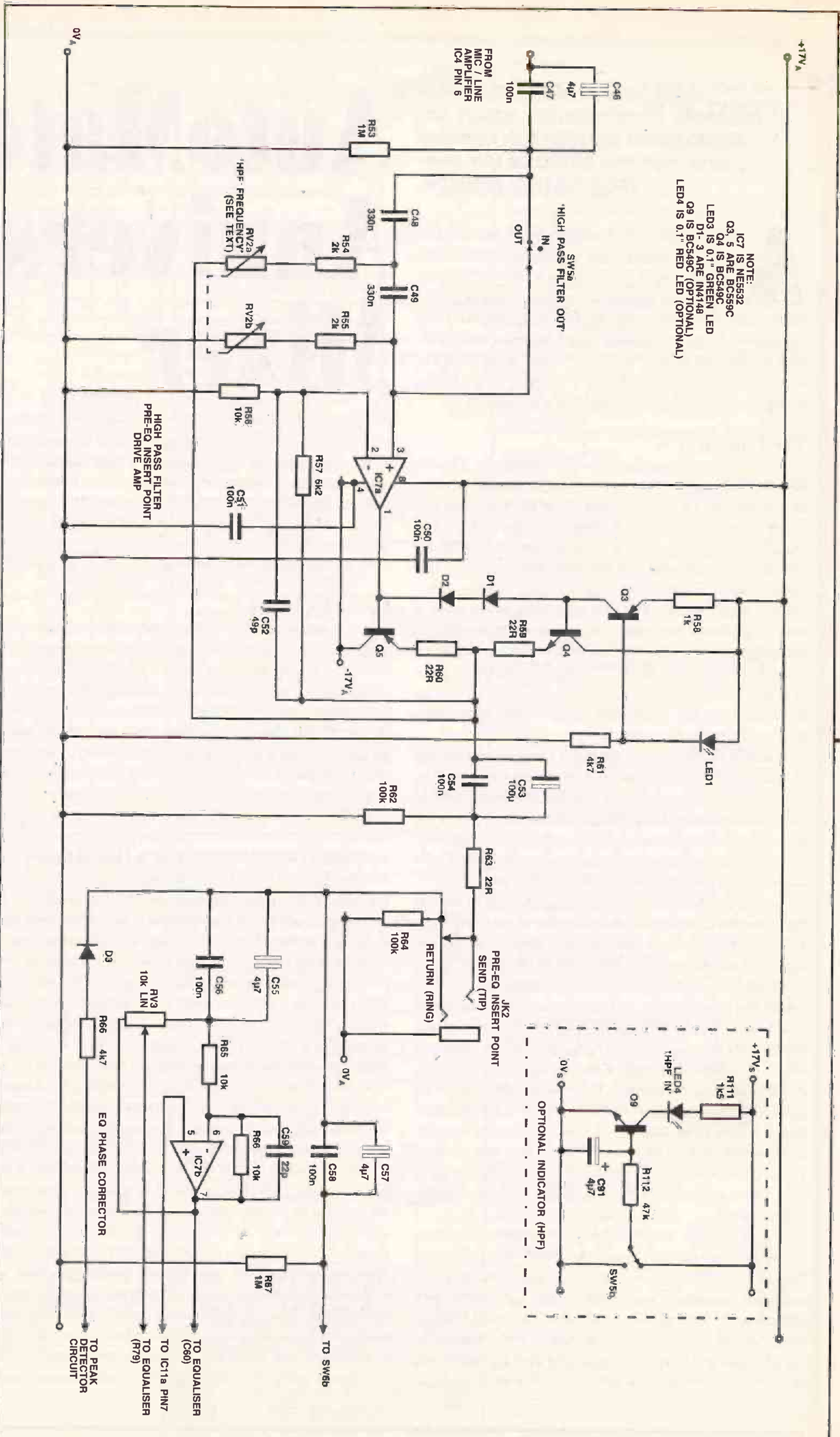


Fig.1 AutoMate switchable high-pass filter

HOW IT WORKS

HIGH PASS FILTER AND EQ PHASE CORRECTION

The High Pass Filter utilizes an equal component second-order Sallen and Key type filter. This gives a 12dB/octave roll-off and a flattest amplitude response while the feedback necessary to create this response gives 4dB of gain. Faster roll-off for out-of-band signals has been compromised for a better in-band response.
The unity gain type, would, in any case, be difficult to tune, because of the non-similar values of R's and C's.

R54 and R55 and the associated part of RV2 set the turnover frequency of the filter. The pot may be omitted and replaced by two discrete resistors chosen from the values given in the attached table (Figure 7). Whatever the case, the filter turnover frequency can be varied from about 20 to 300 Hz. As already mentioned, the resistors may be supplemented with a dual gang 20k linear pot, thus allowing operator fully variable control of the turnover frequency. As mentioned in the general text, the control law, ideally, should be anti-log in nature so in practise, the linear pot gives a slightly cramped, though useable law.

SW5 switches the filter in and out of circuit. Conventionally, and if the filter caused the signal to sustain no overall loss or gain, ie a unity gain as opposed to equal-component value Sallen-Key, the switch would simply and wholly bypass all of the filter circuitry. This is advantageous in that the signal is passing through one less stage of amplification, which can only be good from a sonic point of view.

However, because the filter is a flattest amplitude type, and so gives 4dB of gain which has had to be assimilated into the overall level architecture, simple bypassing won't do and with the filter out of circuit, there must still be 4dB of frequency-insensitive -flat - gain. This is achieved by shorting out C48 and C49. DC paths around the switch are maintained during the switching operation and no clicks are evident on the output.The output of IC7a drives a reasonably hefty pair of line-driving transistors - Q4 and Q5 - in push-pull configuration with Q3 behaving as a constant current source for these two. LED1 biases this transistor while overall feedback is provided from the node of R59 and R60 via R57. The C54/R62 combination AC couple and ground reference the output whilst R63 provides some protection against short-circuit or highly capacitive loads. C53 value was chosen so that there is no LF roll-off with the envisaged lowest load impedance of the FX unit - 600R - and the electrolytic is bypassed with non-polarized C54 to improve in-band response.

JK2 is the Channel Pre-EQ Insert point and comprises a 1/4" stereo jack socket with switched contacts. These are 'normalled' in the traditional way, providing an unbroken path for the signal unless a jackplug is inserted whereupon the signal travels out of the mixer through the 'tip' contacts. It then returns in processed form through the 'ring' contacts, with R64 providing a source impedance for any FX and ground-referencing the return path.

IC7b is the Insert Buffer/EQ Phase Corrector. Refer to Figure 4. With EQ inserted via SW6b, overall phase between the input of IC7b and the output of IC13b is unchanged. De-selecting the EQ takes the signal directly from the 'return' contacts of the jack to IC13.

One snag with the arrangement is the absence of the buffer when EQ is OUT but in practise this has proven not to be a problem with any FX units connected to the insert point. Again, each of the high-value polarized coupling capacitors have been bypassed.

LED 4 and associated components constitute an optional indicator operated by the second half of SW5's contacts and shows when the HPF is selecteed IN circuit. This is an important feature should the switch be part of RV2 since the pull on/pull-off operation needed to place the filter in circuit can be difficult to see at a glance when the control is buried amidst countless others. It can be omitted if so desired

creatively, too, to bring a vocalist to the front of the mix, for example, so that the listener is surrounded by vocals while the orchestra or backing instruments reside in the background. See Figure 3. We'll be looking more carefully at spatial positioning at a later stage.

From a purely practical point of view, absolute phase makes life easier for the designer if he knows that the output from each discrete stage should be in-phase with the input. This approach eradicates the need for individualism on particular cards or parts of the mixer - a killer in any modular system since they can then only be replaced by exactly the same type at a particular point.But this is to miss the main point. The problem of most concern here was that the signal was in-phase with the EQ bypassed and out-of-phase with the EQ in - a very unhappy state of affairs.

Consequently, I arranged for a compensatory phase reversal (transparent to the operator) to be introduced into the signal path whenever the EQ was placed in-circuit. The phase reverse amplifier (EQ absolute phase restorer) also serves as a Post-Insert Buffer Amplifier , although it can only be implemented as such when the EQ is in circuit. This is a slightly unorthodox arrangement and ideally, the buffer should have been present whether the EQ was in circuit or out. The original design configured this amplifier in an identical way to the one used in the phase switching arrangement of IC13a and associated components.

The amplifier became an inverter when EQ was IN and a follower when EQ was OUT. All was hunky-dory but for the clicks sometimes caused when switching EQ in and out of circuit (for purposes of comparison etc) with the fader open. It was thus abandoned. In any case, it makes for one less detrimental amplification stage when EQ is switched out. Further details on this are given in the How It Works section. The signal path in each of the two conditions will be shown next month.

Taking the Law into One's Own Hands

There are some other rather quirky-but-nice design features. Again, I was completely stymied in my efforts to locate suppliers of anti-log pots so some cunning was required to bend the law of the frequency-setting pots from easily-available linear or log to the ideal anti-log law required.

It is important in any variable control - pot - that the available control is not cramped at the extremes of rotation. Figure 4 shows rotation laws for various pots when used, as is a common requirement, as frequency-determining controls. The use of star-delta transforms - as covered by A P Stevenson in an article in the January 1992 issue of ETI - facilitates powerful manipulation wherein networks of one type can be converted into the corresponding equivalents of the other type ie from star to delta or vice versa. We can thus approximate various different laws using standard pots and pull-up or pull-down resistors from the wiper to another terminal. See Figure 5. Just such an approach is used commercially in the quest for an financially-viable but also, from the oft-despised subjective point of view, aurally accurate, panpot control law. (We'll cover the pan-pot debate at a later point in the series). This 'law-faking' approach was used at four different points in the EQ - in each of the frequency determining controls for the four different sections.

I suppose that, as in the case of the Mic Gain-setting

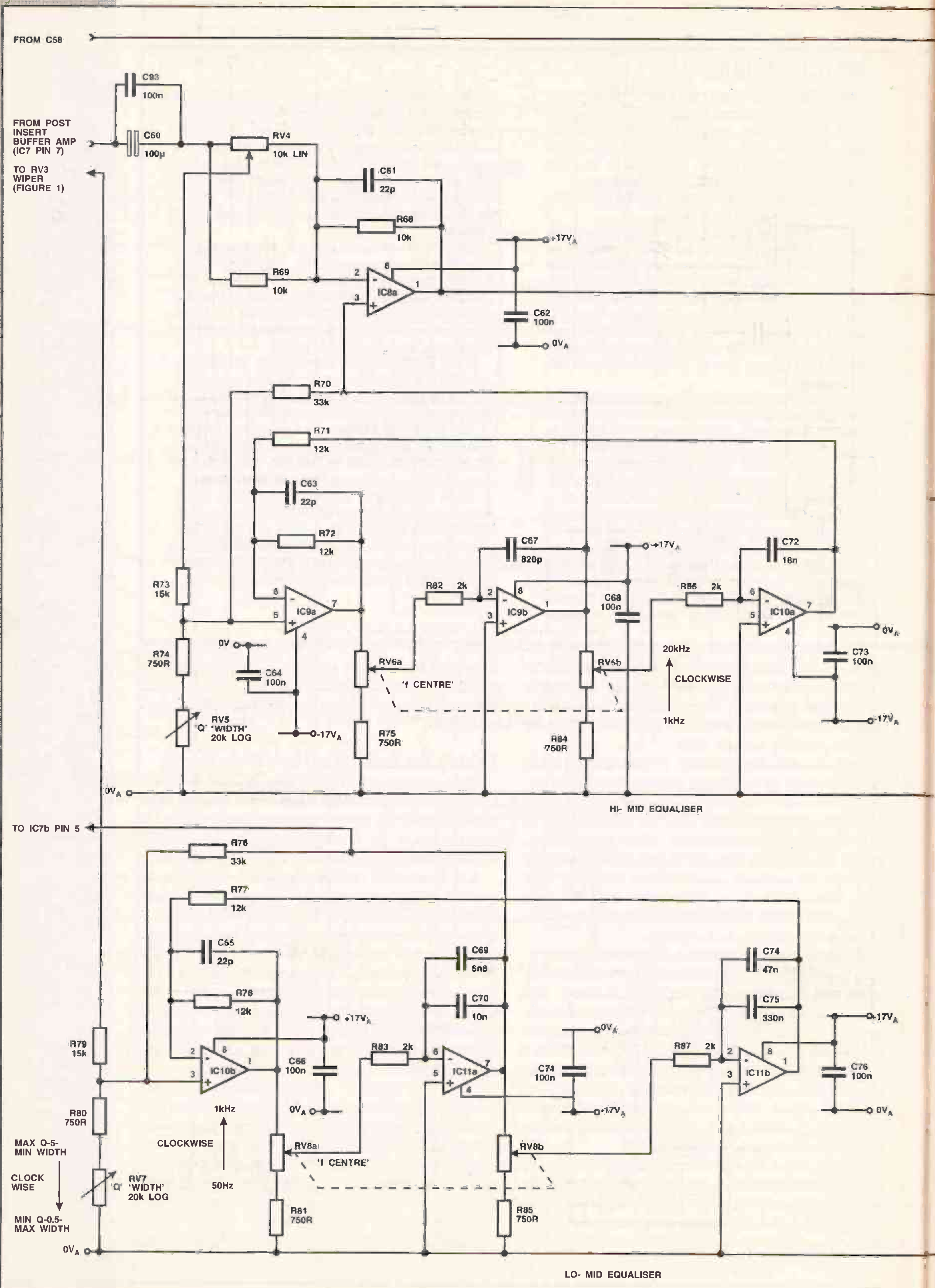
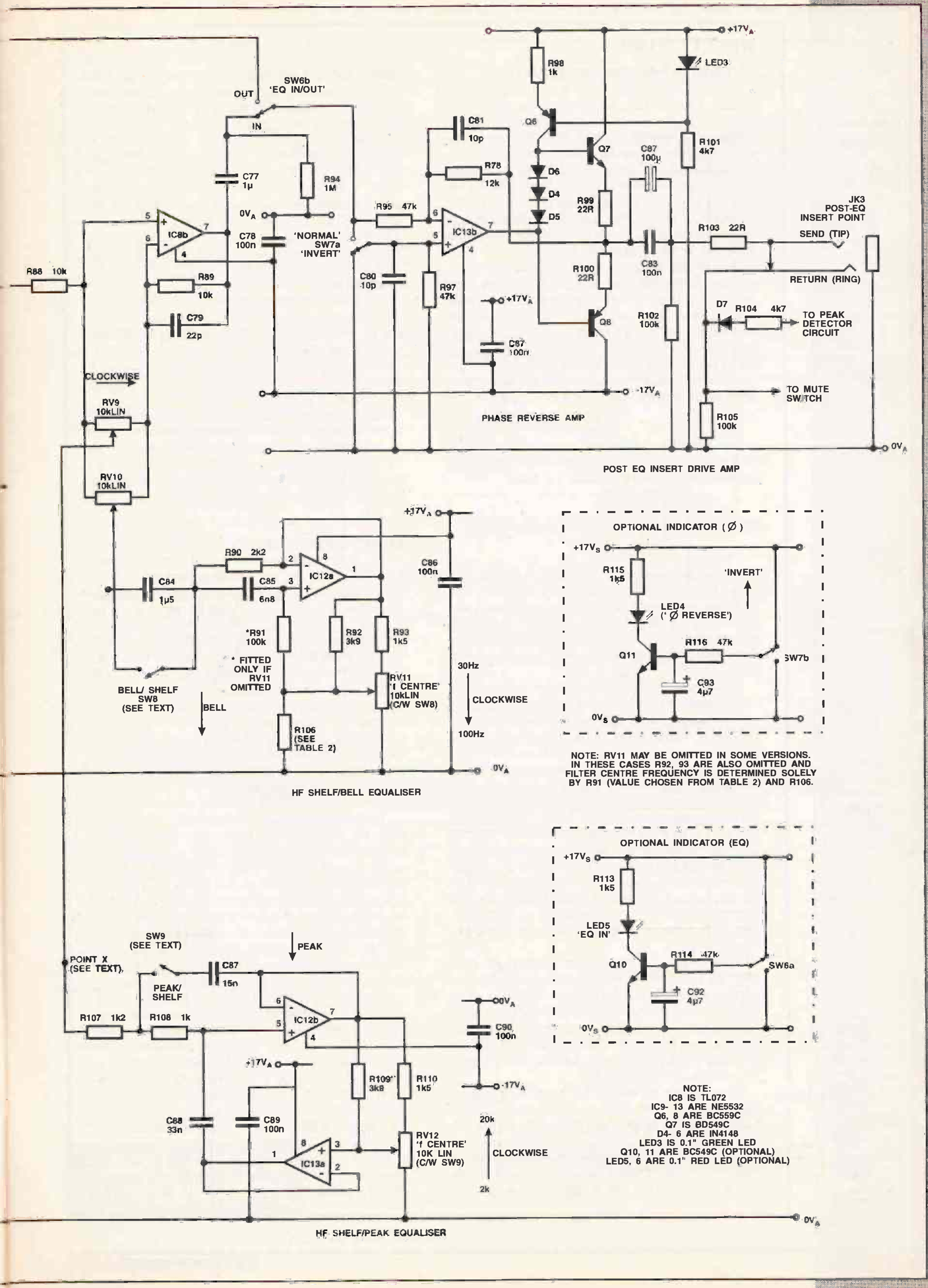


Fig.2 AutoMate 4-band equaliser


SW6b
'EQ IN/OUT'
OUT
IN
R88 10k
IC8b
C77 1µ
R94 1M
0VA
C78 100n
'NORMAL'
SW7a
'INVERT'
R89 10k
C79 22p
CLOCKWISE
RV9 10kLIN
RV10 10kLIN
C81 10p
R78 12k
R95 47k
IC13b
C80 10p
R97 47k
+17VA
C87 100n
-17VA
PHASE REVERSE AMP
R98 1k
Q6
Q7
D6
D4
D5
R99 22R
R100 22R
Q8
LED3
R101 4k7
C87 100µ
C83 100n
R102 100k
R103 22R
JK3
POST-EQ
INSERT POINT
SEND (TIP)
RETURN (RING)
D7
R104 4k7
TO PEAK DETECTOR CIRCUIT
TO MUTE SWITCH
R105 100k
0VA
POST EQ INSERT DRIVE AMP
R90 2k2
C84 1µ5
C85 6n8
IC12a
C86 100n
*R91 100k
* FITTED ONLY IF RV11 OMITTED
R92 3k9
R93 1k5
RV11
'f CENTRE'
10kLIN
(C/W SW8)
30Hz
CLOCKWISE
100Hz
BELL/ SHELF
SW8
(SEE TEXT)
BELL
R106
(SEE TABLE 2)
HF SHELF/BELL EQUALISER
OPTIONAL INDICATOR (Ø)
+17VS
R115 1k5
'INVERT'
LED4
('Ø REVERSE')
Q11
R116 47k
SW7b
C93 4µ7
0VS
NOTE: RV11 MAY BE OMITTED IN SOME VERSIONS. IN THESE CASES R92, 93 ARE ALSO OMITTED AND FILTER CENTRE FREQUENCY IS DETERMINED SOLELY BY R91 (VALUE CHOSEN FROM TABLE 2) AND R106.
OPTIONAL INDICATOR (EQ)
R113 1k5
LED5
'EQ IN'
Q10
R114 47k
SW6a
C92 4µ7
SW9
(SEE TEXT)
PEAK
POINT X
(SEE TEXT)
C87 15n
PEAK/
SHELF
R107 1k2
R108 1k
IC12b
C90 100n
R109 3k9
R110 1k5
C88 33n
C89 100n
IC13a
RV12
'f CENTRE'
10K LIN
(C/W SW9)
20k
CLOCKWISE
2k
HF SHELF/PEAK EQUALISER
NOTE:
IC8 IS TL072
IC9- 13 ARE NE5532
Q6, 8 ARE BC559C
Q7 IS BD549C
D4- 6 ARE IN4148
LED3 IS 0.1" GREEN LED
Q10, 11 ARE BC549C (OPTIONAL)
LED5, 6 ARE 0.1" RED LED (OPTIONAL)

HOW IT WORKS

AUTOMATE PARAMETRIC EQUALISER

The parametric section consists of two state-variable sections, identical in all respects but for the size of the frequency-determining capacitors. The state-variable has been discussed at length in previous parts of the article so we'll look only at those aspects of the design which set it apart from the bog-standard form. Only the high-mid equalizer as regards component numbering - will be investigated but as we've said, it is identical in electrical operation to the low-mid.Input signals are derived from the wiper of RV4 which is part of a conventional Baxandall-style ratiometric feedback/attenuation network. Resistor values are lower than is customary in this type of configuration to optimise noise performance.

From the wiper, the signal is injected into a reasonably conventional two-integrator loop state variable. The only quirks in the design which set it apart from other, more conventional types are all centred around the major frequency-determining components, RV6a and RV6b, R75, R82, R83 and R86, and C67 and C72. In straightforward textbook designs, both of the frequency-determining capacitors are kept identical in value. (It simplifies the calculations). Figure 9 wiil show a schematic diagram next month. Break frequency of the section can be determined quite simply from the equation:

$$f_{centre} = 1/2\pi C1R4$$

This is the simple expression and supposes that both C's are the same in value and that there is a single frequency-determining resistor per section. The full expression is as follows:

$$f_{centre} = 1/2\pi\sqrt{R6/R3C1R4C2R7}$$

With R3 equal to R6, the transfer function simplifies further to:

$$f_{centre} = 1/2\sqrt{1/R4C1R7C2}$$

In the AutoMate example, one of the capacitors is $\sqrt{22}$ times the value of the other ie scaled about the geometric mean value. From the equation, as in the simpler Sallen and Key types discussed some months ago, we can see the PRODUCT is important. So long as the product of the two calculates to be the same as the originally-needed pair of identical values of single capacitors, the break frequency remains the same.

In past issues, we have said circuits can be modified to realize LARGE Q values. Although it might seem strange now, it can be just as difficult realizing SMALL values with this manifestation of the state variable. This conventional state-variable with its single pot Q-adjust can't realize Q values much below 1. The devious business with the non-equal capacitors which was briefly outlined above becomes necessary. In fact, each capacitor has been removed from a middle value by a factor of $\sqrt{22}$, one being scaled up by a factor of $\sqrt{22}$ and the other scaled down although the product of the two remains constant. It is this product which determines the break frequency. Equal value capacitors mean that the lowest value of Q achieveable is unity. We really want Q's down to values of 0.5 to 0.2 and these measures provide this range for us. Current through each of the integrating capacitors, C67 and C71, is shared non-equally. Around the integrator loop, R70 can be assumed to be the Q-determining component. Changing the current through this alters the Q value to around the required value of 0.5.

Values for the $f_{resistor}$, $f_{capacitor}$ have been chosen to give a 20:1 range, from 50Hz to 1kHz in one of the sections and from 1kHz to 20kHz in the other. As stated, the complete inavailability of anti-log pots to the hobbyist constructor prompted the use of a three resistor network to fake the anti-log law required. An anti-log control law yields the correct characteristic which should be one of resistance value being inversely proportional to frequency ie as resistance drops, filter break frequency increases.

So the frequency determining pot has an almost linear frequency change:percentage rotation characteristic which is good from an operational viewpoint. Figure 4 shows the effects of using three pots - linear, log and anti-log - for the control of frequency. Figure 5 shows the transmutation between star and delta networks, how the value of resistors in each network relate to one another and specifically how these values relate to our required law-bending exercise. These resistor values have been chosen to compromise both good noise performance - values as low as possible but within the driving stage capability of the op-amp - whilst allowing the frequency determining capacitors to be of the polyester type rather than electrolytics etc. 10µ caps become horribly expensive and bulky. RV5 is the Q-determining pot, with maximum Q - corresponding to 5 - when the pot is at its minimum value. Again, this control should have had an anti-log law so that as the control is turned clockwise, the Q value changes progressively and smoothly from a low to high value. Wiring a log pot the wrong way round yields a control where WIDTH is smoothly increased as the control is turned clockwise. SSL use this approach on their desks, so we are in good company! Its electrical effect upon the circuit is to attenuate the signal returned via R70 and so alter the Q.

The phase switcher is straightforward. In the inverting state, SW7 grounds the non-inverting input of IC13b and it behaves as an inverting amplifier of gain -1. Switching SW7 to the NORMAL position connects the signal input to the inverting and non-inverting input. Amplification through the IC is now 2 (non-inverting) plus -1 (inverting) so the overall gain is non-inverting. R97 and C80 prevent any oscillation or bursts of noise from the output as the switch contacts change over while each side of the switch has a DC path to earth to avoid clicks when EQ is switched in and out of circuit.

In addition, there is an insert point drive amp, comprised of Q6 - the constant current source - and Q7/Q8, the push-pull output stage. This is identical in operation to the line driving stage attached to the HPF op-amp output and reference is made to this.

LF AND HF EQUALISER

Both of these circuits could be termed 'unusual'. A gyrator - IC12a is used to synthesize an inductor to create a conventional shelving bass control. R90,91,92, and 93 with C85 (and C84 when in-circuit) set the turnover frequency with the network able to be supplemented by a 10k linear pot (RV11) so the operator can have fully variable control of this frequency. The table shown in Figure 7 gives component values for the range of turnover frequencies between 30Hz and 100Hz. Switching capacitor C84 In or Out of circuit using SW8 achieves a bell or resonant type of response rather than the shelving response yielded when the capacitor is shorted out. Again, the switching operation can be combined as a pull on/push off switch integral to RV11 if this is fitted or from a separate switch. Refer to the schematic shown in Figure 10 next month. The network transfer function is as follows:

$$f_{centre} = 1/2\pi\sqrt{1/C84C85R90R91_{effective}}$$

A variable bootstrapping arrangement appears on the output of the op-amp. A linear pot is used which, with the law-faking resistors R91,92 and 93 and the bootstrapping technique, yields a very usable law with frequency rising logarithmically with pot rotation. In this way, Q varies as frequency is increased, with larger Q's -smaller bandwidths - at the lower end of the frequency range and the opposite as frequency is increased. This yields an audio characteristic which is subjectively very powerful and useful. Q is around the 1.5 mark at 30Hz and about 0.47 at 100Hz. It alters because the ratio of resistance:reactance changes with frequency, in effect making the network more 'lossy' at higher frequencies. C84 value has been chosen so that it swamps C85 and, also, the desired frequency is affected with the in-circuit resistor values. All of the impedances are quite critical, compromised in such a way that there is a reasonable cut and boost ratio to the required frequencies and little effect on the others ie those in the upper-mid and HF parts of the spectrum. The responses in Figure 11 next month, show the lazy Q value at the 100Hz control setting (with maximum boost) and means the stage has a lot of effect on frequencies extending into the lower mid region. Circuit impedances mean that even at HF, the response does not fall to unity. The worst case deviation in this design is in the order of plus or minus 1dB. When we consider there is a 15dB change to the frequencies at the lower end of the spectrum, the subjective effect upon HF is minimal.

control on the input amplifier, I could have used a multi-way switch coupled to a precision resistor string. This would have resticted flexibility (only discrete values of break frequency would then have been available) and added cost so I thought it better to stick with the preferred arrangement wherein some operational ease is sacrificed - the control law is very slightly cramped at one end of its rotation - but fully variable control is realized.

Admittedly, the star-delta arithmetic does becomes a little tedious but at the risk of sounding sanctimonious or just plain patronizing, to those 'in the know' or with very smart friends (most definitely the author's case), there do exist certain key values which can be used to yield the important law-faking curves. This alleviates calculator-induced insomnia!

Unfortunately, this law-fiddling approach can only work where the network is a three terminal type - this technique could not therefore be used in the Q-determining pots in the parametric sections. A reverse-connected log pot was therefore used and yields a workable compromise although WIDTH is increased as the pot is rotated clockwise compared to Q in conventional, commercial designs using anti-log types - one example of the maverick approach - but in operational use, no problems have been forthcoming. There is nothing to stop enterprising individuals who *do* manage to track down dual-gang anti-log pots at reasonable prices fitting them to this stage.

Where fully-variable operator control of the optional parts of the equalizer - High pass Filter and LF and HF Equalisers break frequencies - is NOT required, the respective pots can be replaced by resistor or resistors in the cases of the dual-gang types.

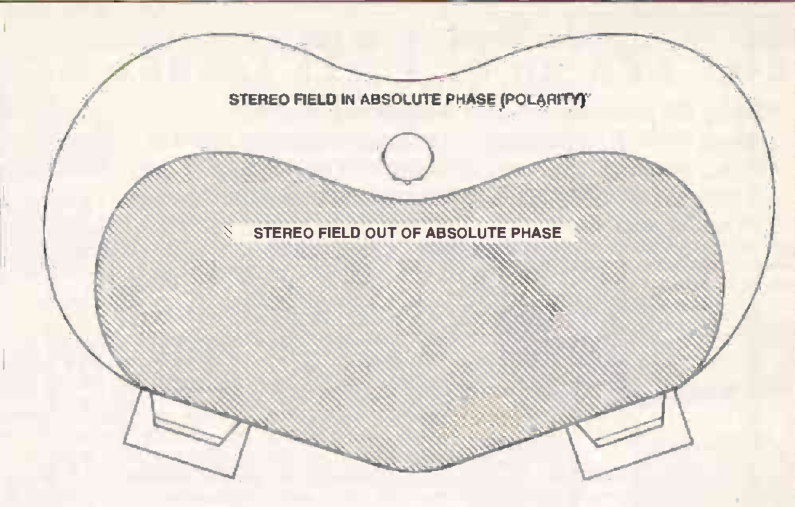


Fig.3 The subjective effect of absolute phase

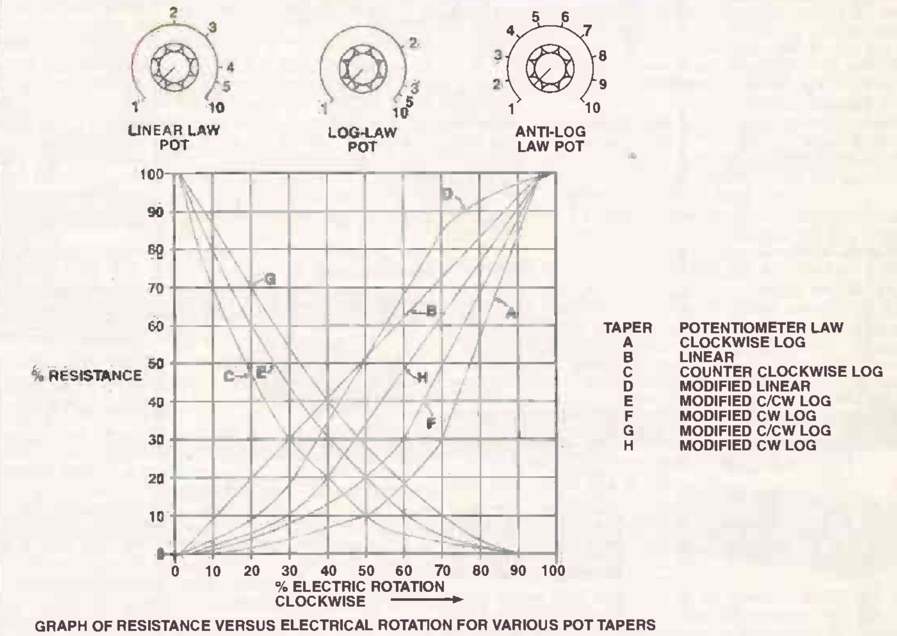


Fig.4 Examples of different control laws acheived by using linear, log and anti-log potentiometers to vary frequency

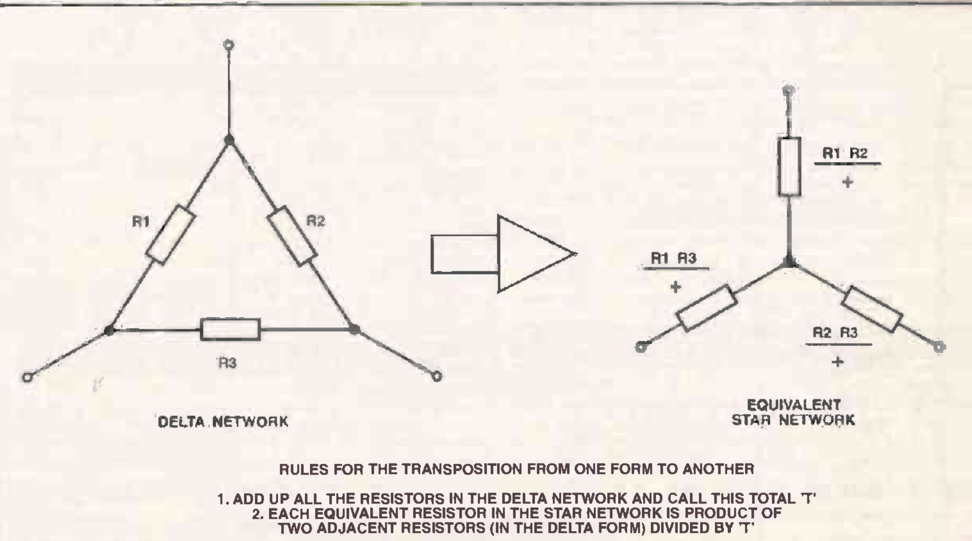


Fig.5 Practical example of the star/delta transform

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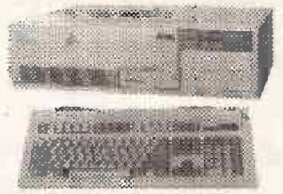

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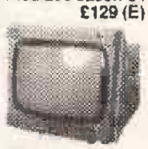

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Digital Circuit Tester

Daniel Brook constructs an invaluable piece of test equipment

In theory it should be easy to test digital circuits as any point can only be at one of two voltage levels, and for simple circuits the theory holds true. All that is required is a logic probe to display the high/low status of the point being tested.

However, simple gates rapidly get built up into counters, microprocessors etc. with buses of logic signals, and in these situations it can be difficult and/or impractical to test the system using only a single logic probe to find the value of a word on a typical 8-bit bus would require eight tests and a calculator (or a good memory and head for figures!)

Even using eight logic probes together, you would still have to convert the binary word to a base more manageable by the human brain.

The solution to this problem is BUSTEST. This project has eight TTL logic inputs, and will display the value at the inputs on three 7 segment displays. The display is switchable between octal, decimal and hexadecimal number bases, each of which can be useful, depending on the situation.

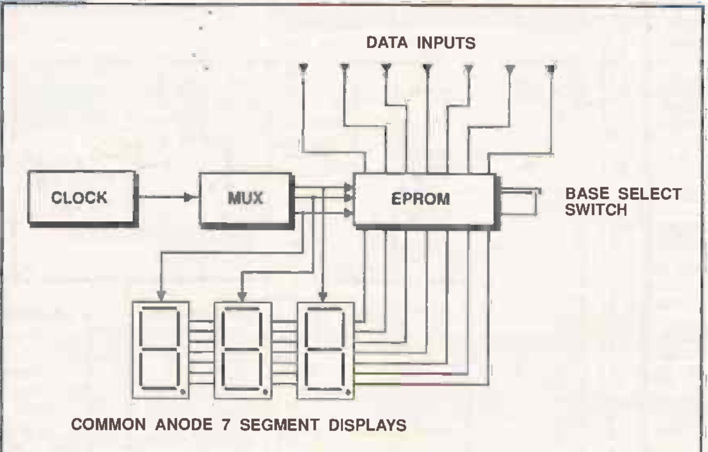


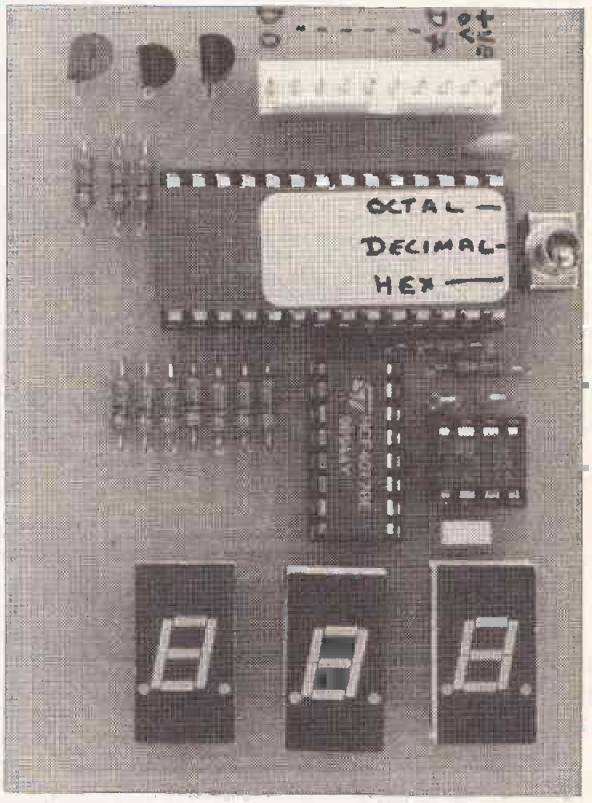
Fig.1 Block diagram

Design Considerations

The unit must be fairly compact as it is a piece of test gear, simple to use (but still useful), and reasonably cheap. Also it must be 5V TTL compatible as most complex digital systems fall into this category.

The obvious solution to the problem would seem to be to use a 7-segment display driver IC such as the 4511, but closer investigation shows that this approach won't solve the problem. This is because the 4511 and similar drivers only convert the 4 binary inputs to a single decimal digit, according to the BCD (Binary Coded Decimal) system, which isn't acceptable for this application.

More expensive driver ICs are available that will control



a number of digits, but these are designed to be used with microprocessors, and most will only produce output in one number base (usually hex or decimal).

Solution

The solution presented here uses an EPROM and a simple multiplexer circuit to directly drive each of the three digits that make up the display (see Figure 1). The EPROM acts like a look-up table to display the correct number in each display, according to the word on the input pins. By choosing a large enough EPROM, there is provision for switching between octal, decimal and hex number bases.

EPROM

The EPROM required is a 2764 device which needs to be programmed. Rather than present a lengthy hex dump of the EPROM contents, which would require a tedious amount of (error prone) typing in, I present a BASIC program. The program (Figure 4) was written in GW BASIC on a PC clone, and generates a binary file called 'BUSTEST.BIN'. This file contains the required EPROM contents, which can be loaded into a programmer and then used to blow the EPROM.

Alternatively, I can supply pre-programmed EPROMS (See Buylines).

Construction

Construction is fairly simple. Start first with the resistors (note that R6 and R7 are mounted vertically), then the IC sockets, capacitors, the connector (if required) and the switch. The switch used is a small PCB mounting SPDT device with on-off-on action. i.e. the moving pole can touch either, or neither, of the two throws. This provides the switching between the three number bases.

Next fit the displays, which may be socketed if desired (remove pins 4,5 and 12 from a 14 pin DIL socket), and then the ICs. Note that IC2 is a CMOS device so take anti-static precautions when handling it.

Finally, you will need to connect some test leads (see Figure 3). Mini probe clips on short lengths of wire are ideal for general purpose use, or you can make up custom leads to suit your requirements. It is advisable to at least colour code the power leads, if not the test inputs as well. If you have fitted a connector to the PCB the leads will have to connect to the other half of the connector (the socket). Alternatively, solder the leads to PCB pins, or directly to the pads. The unit wasn't designed to be cased, although small boxes are available should you wish to enclose the unit. One final touch, whether you decide to case the unit or not, is to put a piece of red filter in front of the displays to improve their readability.

Testing

Before connecting up the circuit, check the board for solder shorts, make sure the components are in the correct

HOW IT WORKS

IC1,R1,R2 and C1 form an astable oscillator, running at approximately 42kHz. This clock output is fed into IC2, a decoded decade counter. Three outputs from the decade counter switch on the displays via resistors R3-5 and transistors Q1-3 (see circuit diagram, Figure 2). To turn on a segment or segments in any particular display, the EPROM must sink current through the required segment and resistor. R8-14 limit the current through the LED segments and EPROM pins to about 5mA, but TTL can sink 16mA max, so this is within limits.

The EPROM can only light segments in one display at any one time, but cycles through all the digits so quickly (as determined by the clock) that persistence of vision makes us beleive that all the digits are on together.

The segments the EPROM tums on are determined by the 'look-up tables' programmed into the EPROM. The part of the table that is 'looked at' is, in turn, determined by the EPROM address. The address is partly made up from the input signals (D0-D7) which connect to A0-A7. The next two address bits, A8 and A9, select the table for the desired number base. Both lines are normally pulled high by R6 and R7, but one or other or none of the two can be set low by switch SW1.. When they are both high, decimal is selected. When A8 is low, octal is selected, and when A9 is low, hex is selected. The final three bits of the address come from the counter, IC2. When A11 is high, the EPROM outputs the code for DISP3. When A10 is high, the code for DISP2 is output, and when A12 is high the code for DISP1 is output.

IC2 outputs Q1, Q3 and Q5 control address lines A11,A10 and A12 respectively. IC2 outputs Q0,Q2 and Q4 are not used so that there is a gap between one display turning off and the next turning on.

Output Q6 resets the counter to begin the cycle again.

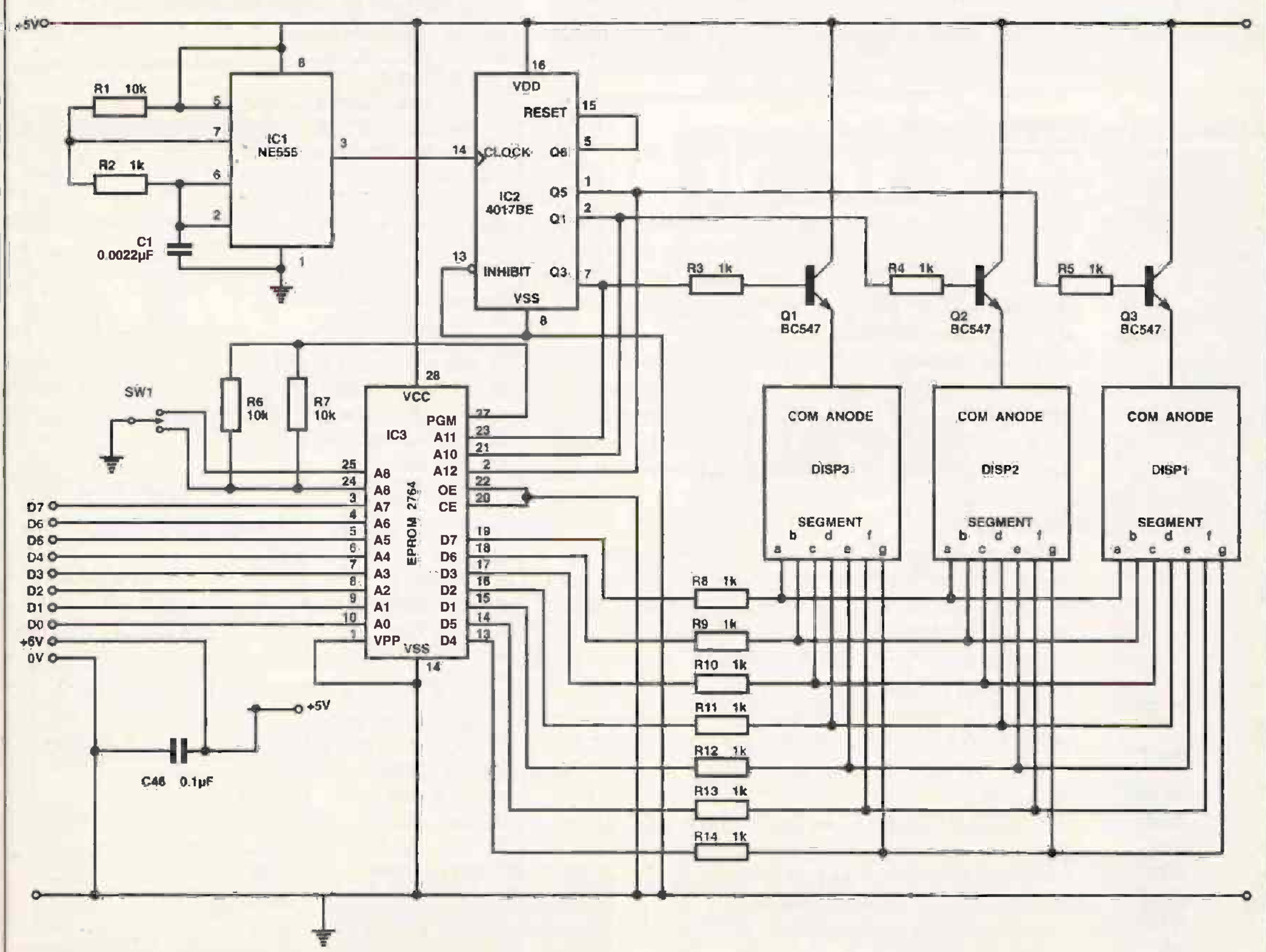


Fig.2 Complete circuit diagram

places and that IC's are the right way round in their sockets.

Assuming that all is okay so far, connect the power leads to a 5V DC supply, and ground all of the inputs. Flicking the switch between octal and decimal should produce three zeros, whilst in hex only two zeros should be displayed.

Now connect the inputs to +5V. The display should show 377 for octal, 255 for decimal and FF for hex.

If the unit has worked so far, it is unlikely that anything is wrong, but to satisfy yourself you may wish to apply various words to the unit and check the output.

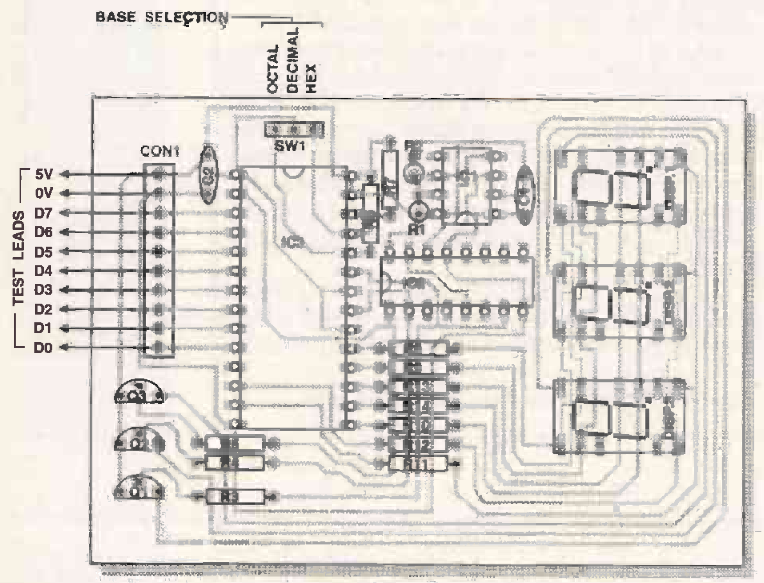


Fig.3 Component overlay and lead connections

If the unit has not yet shown signs of life, switch off and recheck the component positions and solder joins. If you have a 'scope, check there is a clock output from IC1 pin 3 and that this reaches IC2 pin 14. Also check that pins 1,2 and 7 of IC2 are being pulsed regularly.

If the unit still doesn't work, it is likely that the EPROM has not been programmed correctly or is of the wrong type - it must be a standard TTL 2764, NOT a CMOS version. If you programmed your own EPROM, check that you have entered the program correctly, then erase and reprogram the EPROM.

In Use

Operation of the unit is very straight-forward. Remember to always connect the power supply lines before connecting any of the inputs D0-D7. D0 is the least significant bit (LSB) and D7 the most significant bit (MSB). The inputs should be connected to the circuit under test bearing this in mind, otherwise the output will make no sense.

If less than 6 bits are being tested, unused lines should be grounded (these will be at the MSB end of the inputs).

I will now briefly mention the merits of each of the three number bases:

Octal digits map to 3 binary digits, enabling easy conversion back to binary if required.

Decimal is the easiest base for us humans to manipulate, as it is the one we are most used to.

Hexadecimal digits map to 4 binary digits. With this in mind, it is possible to monitor two words of up to 4 bits, with a separate digit displaying the value of each word. When used in this way, the left-hand digit shows the value on D4-D7 (D4 is LSB, D7 is MSB), and the right-hand digit shows the value on D0-D3 (D0 is LSB, D3 is MSB).

Program for Digital Circuit Tester

```
10 CLS
20 REM Program to build EPROM file for use with BUSTEST project.
30 REM Written in GW BASIC by D. BROOK  21/5/92.
40 OPEN "BUSTEST.BIN" AS #1 LEN=1
50 FIELD #1,1 AS DGC$
60 FOR LOOP=1 TO 8192
70 LSET DGC$=CHR$(255)
80 PUT#1,LOOP
90 NEXT
100 PRINT "CREATED EMPTY FILE"
110 REM Read "character codes" for 7 segment displays into array DG(n)
120 REM where n is the value (0-15) of the corresponding character.
130 DIM DG(15)
140 FOR LOOP=0 TO 15
150 READ DG(LOOP)
160 NEXT LOOP
170 REM Do the MAJOR loop 3 times (for octal, decimal, then hex data).
180 FOR MAJOR=1 TO 3
190 IF MAJOR=1 THEN PRINT "FILLING IN OCTAL DATA"
200 IF MAJOR=2 THEN PRINT "FILLING IN DECIMAL DATA"
210 IF MAJOR=3 THEN PRINT "FILLING IN HEX DATA"
220 READ NUMBASE,LPA,LPB,LPC,MULB,MULC
230 REM Constants for loop set up.
240 REM Begin the MAJOR loop:
250 FOR DGTC=0 TO LPC
260 FOR DGTB=0 TO LPB
270 FOR DGTA=0 TO LPA
280 BASEREC=((DGTC*MULC)+(DGTB*MULB)+DGTA+NUMBASE)+1
290 REM Base record number set up.
300 REM Output code for digit A to the file.
310 LSET DGC$=CHR$(DG(DGTA))
320 REC=BASEREC+4096
330 PUT#1,REC
340 REM Now output for digit B.
350 LSET DGC$=CHR$(DG(DGTB))
360 REC=BASEREC+1024
370 PUT#1,REC
380 REM Now output for digit C.
390 LSET DGC$=CHR$(DG(DGTC))
400 IF MAJOR=3 THEN LSET DGC$=CHR$(255)
410 REC=BASEREC+2048
420 PUT#1,REC
430 REM Check if loop should end (i.e. all 256 (including 0) records
output).
440 IF ((DGTC*MULC)+(DGTB*MULB)+DGTA)=255 THEN
DGTC=LPC:DGTB=LPB:DGTA=LPA
450 NEXT DGTA
460 NEXT DGTB
470 NEXT DGTC
480 NEXT MAJOR
490 CLOSE
500 PRINT "          ****** FINISHED FILE CREATION ******"
510 REM Character data (0-15):-
520 DATA 16,182,40,34,134,66,64,54,0,2,4,192,88,160,72,76
530 REM Constants for OCTAL:-
540 DATA 512,7,7,3,8,64
550 REM Constants for DECIMAL:-
560 DATA 768,9,9,2,10,100
570 REM Constants for HEXADECIMAL:-
580 DATA 256,15,15,1,16,256
```

Fig.4 Basic Program

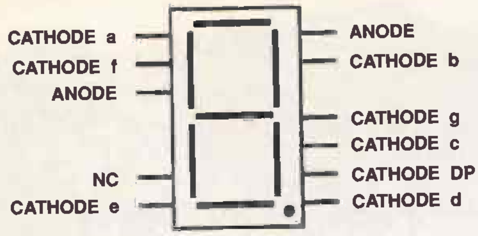


Fig.5 Display Pinouts

BUYLINES

The 7-segment display is available from MAPLIN (Telephone 0702 55416]), order code FR36P. Other types may be suitable - check the pin connections with Figure 5.

The switch used in the prototype is marked RS, but may be available from other suppliers. MAPLIN can supply a switch with suitable action, but it will not fit on the PCB.

For a pre-programmed EPROM, send a cheque for £6 to: Daniel Brook, 119 Hale Drive, Mill Hill, London NW7 3EJ.

PARTS LIST

RESISTORS (All 1/4 Watt, 5% or better)

R1,6,7	10k (3 OFF)
R2-5,8-14	1k (11 OFF)

CAPACITORS

C1	2n2
C2	100n

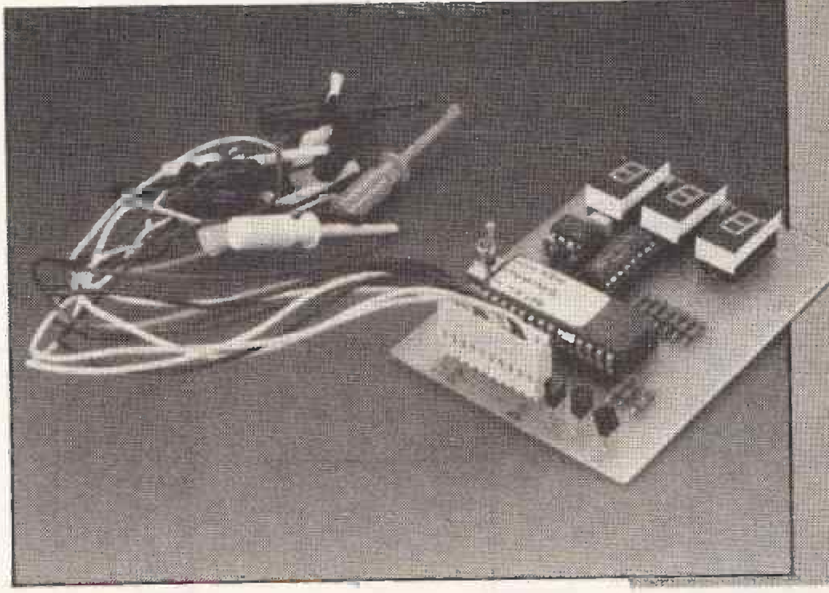
SEMICONDUCTORS

IC1	NE555
IC2	4017BE
IC3	Programmed EPROM 2764 (not CMOS)
Q1-3	BC547 (3 OFF)
DISP1-3	common anode 7seg display (3 OFF)

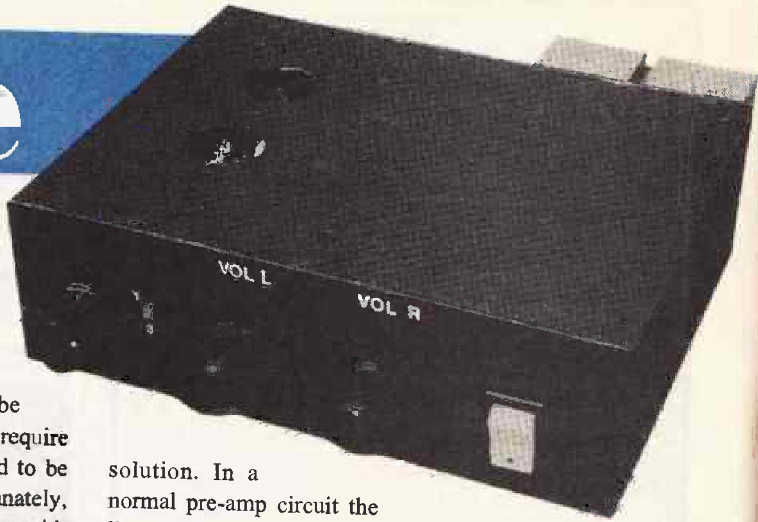
MISCELLANEOUS

SW1	SPDT Toggle switch ON-OFF-ON (See text)
CON1	10 WAY PCB mount plug (If required)

PCB, IC sockets, probe clips, wire, plug to suit CON1, display filter, case



The ETI Line



A hybrid line amplifier
by Jeff Macaulay

With the rapid demise of vinyl records the role of the preamplifier in an audio system is being re-evaluated. Most sources currently available and those likely to be encountered in the future are 'flat'. That is to say they require no frequency response equalisation but merely need to be matched to the power amplifier's input. Unfortunately, speaking from experience, I have yet to find two sources with the same output level or impedance charactaristics.

Output levels can vary from 50mV or so to 1V, a twenty to one range. Moreover the electronics providing the signal most definitly work better when fed into a high impedance. Even CD players operate better into such a load since the now traditional 10k passive pot can upset the operating mode of the final op-amp in the player. Shifting the output into class B with it's associated distortion.

With this in mind the question arises,how can one mix and match these sources with the existing power amps without compromising the input signal? The simplest solution is to produce a really high quality line level stage with switched gain and a high input impedance. At the output end of the circuit we require both a low impedance drive and a high overload level for driving the amp.

Placing a high impedance pot between the source and amp can provide an increase in performance but only when the signal level is already adequate.

Furthermore a pot in this position will mean that the signal to noise ratio of the output will depend on the slider position.The separate line amp is an altogether better solution. In a normal pre-amp circuit the line level amp is already in evidence. However most of these are not 'state of the art' and this fact prompted the design described here.

Before I delve too deeply into the actual mechanics of the circuit it is useful to look at the problem in more detail and the solutions used. First let's really get down to basics. I have

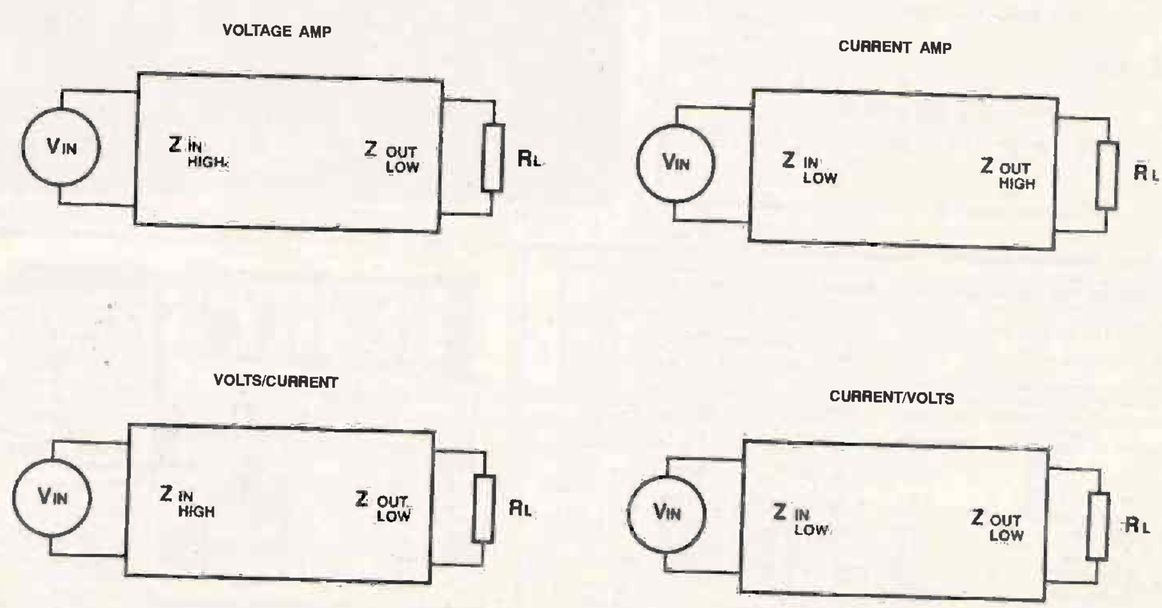


Fig.1 Basic Amplifier Types

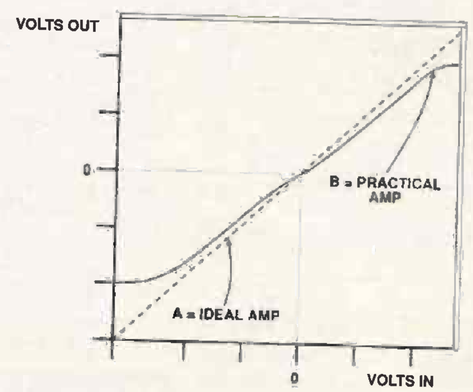


Fig.2 Real and Ideal amplifier transfer characteristics

written on this topic before but it bears repeating. An amplifier, regardless of the technology employed produces an enlarged copy of the electrical signal presented to it's input. To do this it modulates an external power supply and thus doesn't contravene the laws of physics.

In actual fact there are only four basic types of amplifier and these are shown in Figure 1. The difference between them is defined by their input and output impedances. Figure 1 shows the possibilities as black boxes. Figure 1a shows the voltage amplifier. In order not to load the input voltage provided by the source the input impedance must be as high as possible, preferably infinite. On the output end we want a voltage output which is independent of the load impedance. This requires zero output impedance.

Figure 1b shows a current amplifier. Here we are unconcerned with the voltage provided by the source but we need to take maximum current from it. In consequence the input impedance must be very low, preferably zero.

Turning to the output we need here to provide a current output independent of the load impedance. For this reason the output impedance must be high, preferably infinitely so.

The other two amp types shown are rather oddities but very useful nontheless. Figure 1c shows a voltage to current converter, high input and output impedances whilst Figure 1d shows the opposite. A current to voltage converter. Here the input impedance is low as well as the output impedance.

For our application we need Figure 1a. A voltage amplifier. Figure 2 shows the ideal input output charactaristics of such an amp. As you might expect this is a straight line whose slope is proportional to the voltage gain. Curve b gives a more realistic transfer charactaristic which gently curves. What can be done to minimise the non linearity? First we can restrict the output voltage to small level. As John Linsley-Hood once remarked in these pages a small enough section of any curve approaches a straight line. The curve assumes a class A output stage. If we were to operate in class B the non linearity would increase with decreasing signal level.

Curve B also illustrates the linearity conundrum faced by designers. If we restrict the output level sufficiently distortion reduces approximately in proportion. Theoretically with zero out we have zero distortion. However although this is a sure fire way of reducing non linearity of all kinds it leads us into unacceptable noise

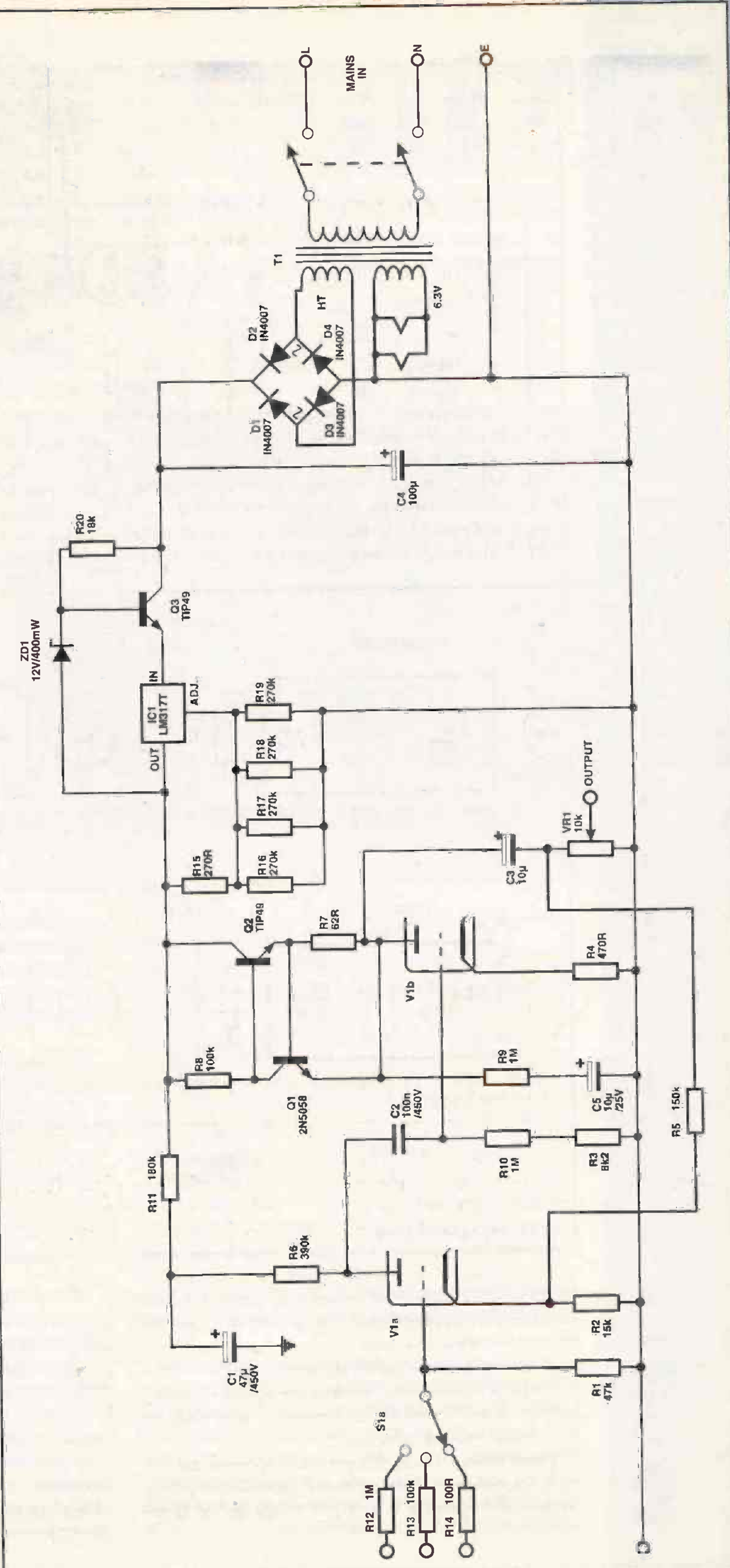


Fig.3 Circuit of Hybrid line amp (R12, 13 & 14 are off-board components)

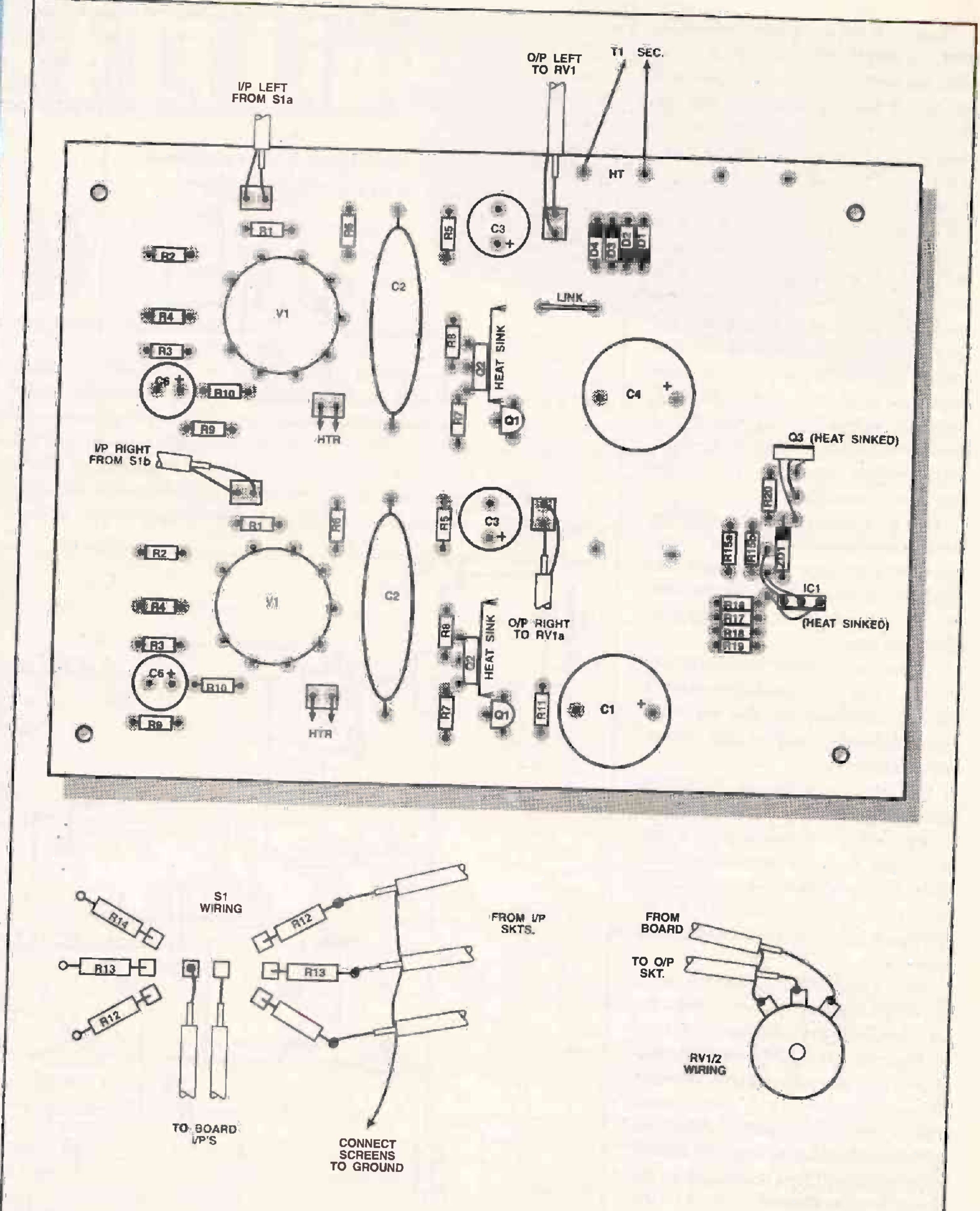


Fig.4 Component Overlay

levels. An alternative is to build an amplifier capable of huge signal excursions. This achieves the same results by the back door, so to speak.

This is essentially the reason that a high overload ratio is of vital importance when seeking to design for maximum linearity. Too often this aspect of design is relegated to the back burner and high overall linearity is sought by other means. In particular the overuse of negative feedback. Feedback has been given a bad name in some quarters recently. Certainly if an attempt is made to rescue a poor design by this means it is possible to run into difficulties.

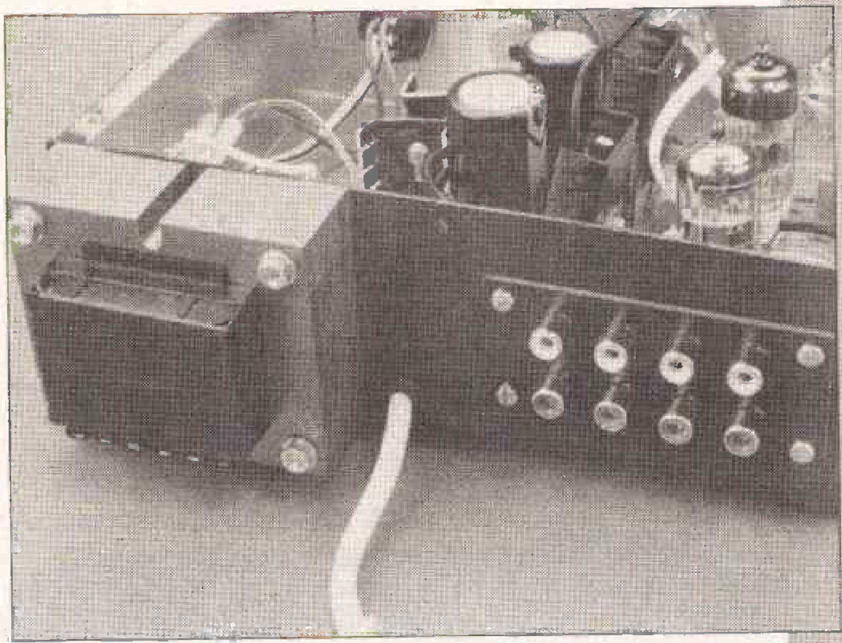
If on the other hand the design is made linear to start with and has an adequate bandwidth negative feedback will improve matters both objectively and subjectively.

Anotber factor which has an important bearing on the final performance of any amp is the power supply to which it is attached. If the voltage level varies with the drive level, sadly a common occurance, the transfer charactaristic can look more like an ellipse than a straight line with attendant dire sound. Again, if ripple, RF noise on the supply line are allowed to reach the output the sonic consequences are disasterous.

Please note nothing which I have described involves any form of metaphysics, super components, grain orientated wire, just simple physics! Having described the problem I will now present my solution. I don't beleive that it's the ultimate circuit, there's simply no such thing but it's the best sounding line amp that I've ever designed or used. The basis for the circuit is a single dual triode valve. I've used one per channel.

The particular valve features a low anode impedance, wide frequency response and large signal swings at adequate current for the application in mind.

The circuit is shown in Figure 3 of one channel, the other being identical. Being a valve circuit it uses a high operating voltage. This need not be dangerous providing that simple safety rules are applied. I'll come back to this aspect of things later in the article. The circuit acts as a super buffer with high input impedance and programmable gain via SW1. Output impedance is less than 100R so that long cables can be driven with ease.



The circuit configuration employed uses a series feedback connected pair of triodes. In many ways this is a classic valve circuit dating back to the 1940's. It's virtues are many with very few vices. Implemented with high performance RF triodes it has a bandwidth that extends well above 20kHz before the application of feedback. Distortion levels, with a standard line level output, 775mV, are well below 0.1%, again before the application of negative feedback.

One of these days the semiconductor industry will provide a device with the virtues of a valve. The average valve is ten times more linear than an equiverlent transistor stage and has an input impedance of approximately 100 Megohms. Although VFET charactaristics come closest they haven't yet cracked the problem of large input capacitances which tends to negate the advantages of the high DC input impedances of these devices. All this leaves the valve as the premier device for this particular application and this is why they are being used.

Astute readers will however notice the presence of semiconductor devices in this circuit . These are not however used directly in the signal path but are rather employed in a supporting role. To provide the output stage with a constant current source. This enables the amplifier to provide far larger symetrical signal swings than would be available with a simple resistor anode load. If a resistor were to be used it would appear to be in parallel with the load reducing the signal swing.

The Circuit

Turning to Figure 3 the signals are applied to the voltage divider resistors selected by SW1. The reasoning behind this is to provide the amp with a uniform input voltage of about 70mV. Regardless of the actual input level. R1 maintains the input impedance constant at 100k. Signals from the input attenuator are directly applied to the grid of V1a. One half of the dual triode. This is operated with a low level of anode current to ensure that the overall feedback loop connected from the output to the cathode resistor R2 won't load the output stage unduly.

The valve is used in the common cathode mode, analogeous to the common emmitter mode in a transistor amplifier and thus gives a fair measure of voltage gain. The valve operates very much like a J-FET. To provide correct bias the grid voltage need to be negative with respect to the cathode. In fact the stage will only work correctly when the grid is negative, distortion levels increase dramatically if the grid is taken positive. Luckily setting the correct anode current can be achieved by selecting an appropiate sized resistor for the cathode circuit, R2.

The output signal from the valve is generated across R6. R11 and C1 form a very effective decoupling filter which removes any noise and ripple from the supply voltage. The signal is coupled to the other stage, built around V1b, via the DC blocking capacitor C2. A good quality polypropolene type is used here for it's wide frequency response.

The output stage itself requires some explaining. As I mentioned earlier I decided to use a constant current source for the anode load of this stage. This prevents loading but it also defines the anode current. Because of device to device variation it is necessary to provide a DC feedback loop around the stage. This is the function of R10, R3 and R9. R10 and R11 provide shunt feedback to stabilise the operating point. C5 completely removes any AC signals fed back by R9 by decoupling the junction of R10 and R3 to ground.

The anode current of V1b is set by the resistor R7 which is in the constant current source formed by Q1,Q2,R7 and R8. The operation of this is quite conventional. On switch on, R8 biases Q2 hard on. It's collector current increases until approximately 0.6V is generated across R7. This then turns on Q1 which stabilises the current to a level defined by 0.6/R7 amps. With the component values used this is 12mA/channel.

Lastly the amp's output voltage is supplied to the outside world via the DC blocking capacitor C3 to RV1. Overall negative feedback is applied to the cathode of V1a via R5. The voltage gain being set by the ratio of R5 to R2.

Power Supply

The most difficult area of valve design is the power supply. Apart from the fact that some of the electrolytics are

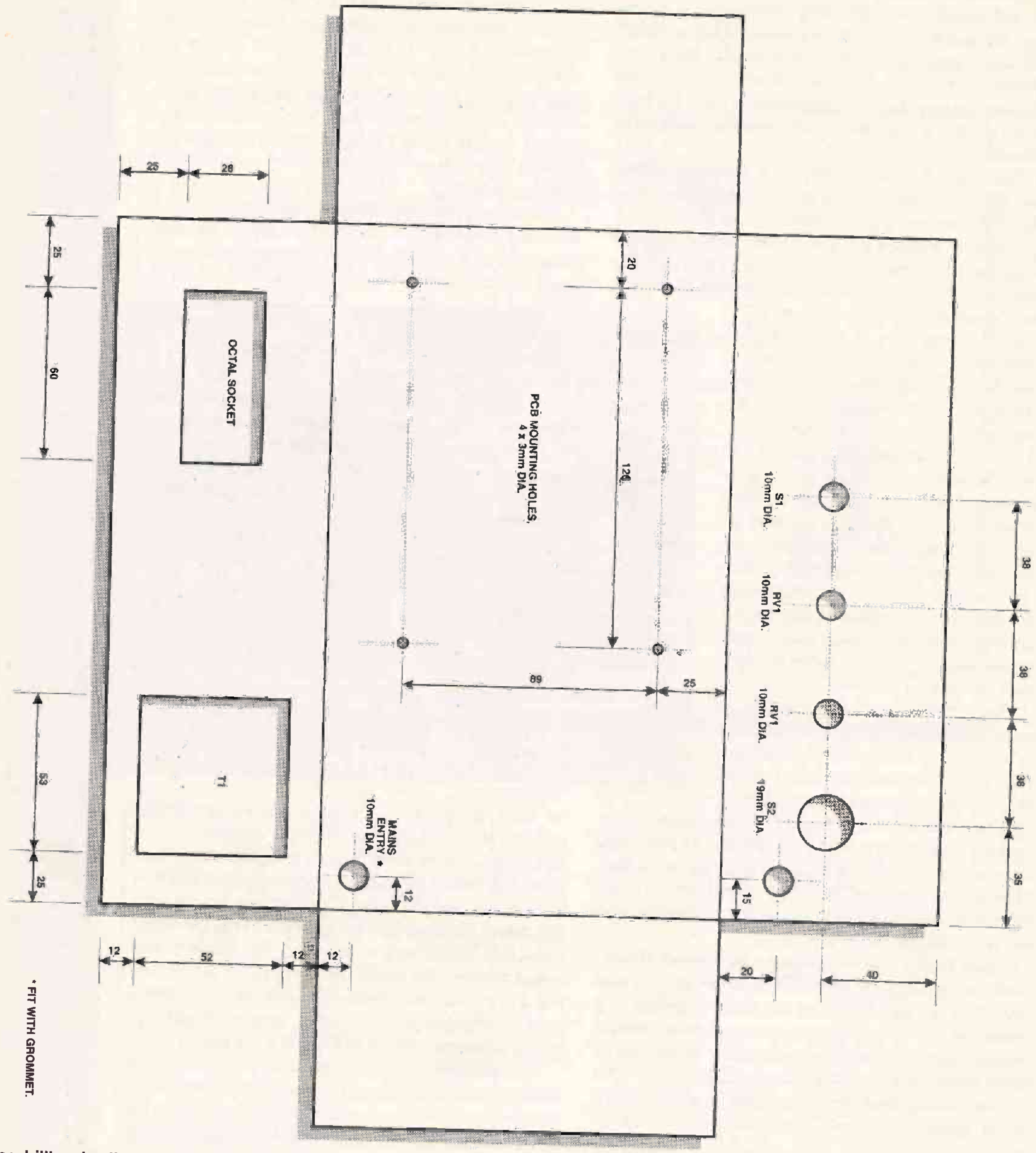


Fig.5 Case drilling detail

hard to find resistors tend to pose a problem as well. At high voltages surprisingly large levels of power dissipation occur. Put into simple language things can tend to get hot!

Large electrolytics of adequate voltage rating are thin on the ground and so other methods of smoothing the power supply must be sought. The most obvious answer is to use a floating voltage regulator of the LM317 type. These work well but have a low output impedance which requires care while commisioning. Furthermore they cannot stand more than 40V between the input and output terminals and will turn themselves off if adequate heatsinking is not provided.

The circuit diagram of the power supply is also shown in Figure 3. Here the HT voltage is full wave rectified by D1-4 and the resulting raw DC is smoothed by C4. To avoid overdissipation of IC1, the 317T regulator, Q3 is used as a 'power dump'. This component is biased from ZD1 and R21 and prevents high voltages being applied across the chip. Advantage is taken of the current flow through R14 to provide on indication via LED D9. IC1 needs to float and this is achieved by utilising the fact that the adjust pin must be

1.25V below the output for proper operation.

R15 sets the quiescent current of IC1 at approximately 4mA and the adjust pin is lifted of ground by this current flowing through the parallel resistors R16 to R19.

Construction And Testing

Most of the components are mounted on the PCB panel, see overlay. The most important thing to watch is that you have inserted the electrolytics the correct way round. If anything is liable to produce problems a reversed electrolytic will. None of the other components require commemt, Just follow the overlay. The two Q1's and IC1 require mounting on a heatsink. Small finned types are used for these devices. Note the two way PCB mounting plugs. Use Veropins for the HT input as these are added to the circuit last

Having completed the board attention can be turned to the mechanical aspects of the design. Figure 5 shows the mechanical drilling detail of the unit. Once the holes have been drilled the case can be finished to taste. I chose to spray mine matt black. Legends were then applied with white rub down lettering and fixed with clear spray varnish. Both the latter items were obtained from my local art shop.

Having finished the case the inevitable self adhesive rubber feet were applied to the bottom of the case. Now the real work can commence! Fit the transformer and PCB into the case and also the pots and sockets.

Note that the heater and input wiring, shown in Figure 6 terminate in 2 way PCB plugs that mate with the sockets on the board. In the first instance dont wire the HT leads in.

The reason is that to ensure safety it is important that the valve heaters light up. With the valves on the HT supply is rapidly discharged by the circuit's current when the power is removed. Otherwise a potentially dangerous HT voltage will linger across C4.

Testing the unit consists of two stages. First with the HT supply from T1 and the mains earth lead unconnected switch on the unit. After a few seconds the valve heaters should start to glow. If not switch off and find your wiring error. Assuming all is well here the second stage of the testing can commence. First a number precautions. When testing the HT rail switch your testmeter to a range which will clearly show 300V DC. Ensure that you have made the connection between system earth and the case. Lodge the negative testmeter probe securely in the case so that it makes a connection with the metal work. Second always keep one arm behind your back when testing.

Attach the HT leads to the Veropins on the board. Take a deep breath and switch on. Take the positive test lead and hold it against the metal tab of IC1. Keep the other hand behind your back! You should read 300V, a few volts either way is inconsequential. remove your test lead and switch off. Reapplying it to IC1 tab should show the voltage decaying rapidly. In any event don't touch the circuit until this voltage has decayed below 100V.

Having got this far the next stage is to actually try the unit out. First connect the mains earth, your inputs and outputs.

Power up again. After a few seconds warm up sweet music should emmanate from your system! If you have wired the circuit up as described no further problems should be encountered and all that remains is to enjoy!

PARTS LIST

RESISTORS

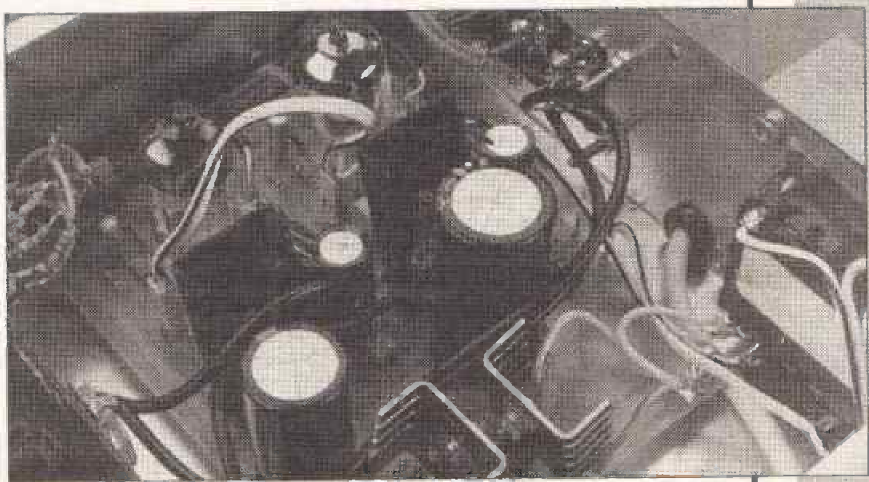
R1	47k
R2	15k
R3	8k2
R4	470R
R5	150k
R6	390k
R7	62R
R8,	100k
R9,10	1M
R11	180k
R12	1M
R13	100k
R14	100R
R15	270R
R16,17,18,19	270k
R20	18k
RV1,2	10k log pots

CAPACITORS

C1	47µ/450V
C2	100µ/1000V
C3	10µ/450V
C4	100µ/450V
C5	10µ/25V

SEMICONDUCTORS

V1	CV2493
Q1	2N5058
Q2,3	TIP49
D1-4	1N4007
IC1	LM317T
ZD1	12V/400mW
D5	Panel LED



MISCELLANEOUS

B9A PCB valve base
4 small heatsinks
T1 220V 150mA 6V 1A secondary transformer
PCB
Case
4P 3W rotary switch
Knobs
Octal phono socket

Specifications

The following measurements were made on the prototype unit, loaded with a 10k pot

S/N ratio	-101dB unweighted below 775mV (input shorted)
THD	<0.005% at 1kHz, 775mV out
Frequency response	-3dB at 0.8Hz and 150kHz
Clipping level	+39.5dB above 775mV (74V RMS)

Automatic Audio Response Measuring System

2

Ralph Mantel continues his report from Germany on a convenient way to check the response from a loudspeaker.

The complete circuit diagram from MEPEG is shown in Fig.8a and b. The complete system, with the exception of the mains transformer, is constructed on a single eurocard.

As stated MEPEG uses a parallel (centronics) port and the loudspeaker output of the PC. The loudspeaker output is used solely for generating the measuring signal. All control functions are achieved solely through the parallel port.

Construction

The construction of the boards should not cause any problems, only the connections to the PC tone generator should perhaps be described in some detail.

The loudspeaker output from the PC tone generator should be connected to the 9 pin Sub D socket on the rear of

HOW IT WORKS

IC1 is a low noise input amplifier with an amplification of 1 for normal use and 30 for microphone use. The amplification is automatically controlled by the computer via relay RLY2. R5, ZD1 and ZD2 provide over voltage protection up to 70V. Direct connection of the microphone is via a XLR socket. The microphone used is an asymmetrical electret condenser microphone which requires a DC voltage to function correctly. This voltage is fed to the microphone via R1/R2. Inserting the microphone plug in the XLR socket on input 2 shorts pin 1 with pin 2 via a bridge in the socket. The signal therefore is imposed on the DC supply line and fed to the input amplifier. If required, input one can be used to observe the microphone input signal using an oscilloscope. Resistor RCal is used as a calibration resistor during impedance measurements (e.g. TH/SM parameters) and is connected using RLY1 automatically by the computer when required.

IC2/IC3 form a zero loss full way rectifier which rectifies the AC input voltage to a DC voltage. IC2 works as an inverting one way rectifier, the negative half waves of the input signal being short circuited by D4. The circuit is then extended using IC3 as a sumator. Here, the negative half wave and the 'complete' signal voltage via R13 are added together to form our full way rectifier. The resulting DC voltage is integrated by C10 and using P2 this DC voltage is set to the same level as the effective input signal level. The selection of the OPs is very critical as the circuit must work over a large voltage range linearly and without loss. The accuracy of this circuit is dependent primarily on the diodes used and the slew rate of the OPs. IC4 works as a normal inverter. IC5 and IC6 work as an V/F converter (Voltage/frequency-converter)[6]. The voltage on the inverting input of IC5 is converted into a proportional frequency in the ratio of 1 to 2; i.e. an input of 1000mV would result in a frequency of 2000Hz on pin 3 (output) of IC6. The resolution would be 0.5mV. Pin 3 of IC6 is an 'open collector' and is connected directly to pin 10 on the parallel port. This pin carries 5V under 'no signal' conditions. Every negative pulse (change from +5 to 0) on this pin starts a system interrupt in the computer. The time between two interrupts is exactly the period of the input frequency. The time is measured by the computer using an assembler routine. The computer therefore has the value of the input signal as a proportional frequency (Fig. 9). The advantages of this so called serial A/D conversion are a)the accuracy over a wide range and b)the high resolution (see Table 1) for a relatively low cost.

Measuring signal generation is achieved using the computers internal sound generator. For our circuit the signal to the normal internal loudspeaker is diverted to IC7. The connection is, however, made by RLY5 and only after the system has been switched on. When the measuring system is switched off the loudspeaker is available for normal use by the computer. Both generator outputs carry a DC voltage. The plus pole also carry's the generator square wave signal on top. This square wave is directed through IC7 to IC8. This IC works as a frequency divider and reduces the generator frequency by a factor of 10. This frequency is fed to pin 1 and 13 of IC8 and is used in the frequency range <150Hz. for controlling the Phase Locked Loop (IC9,IC10) i.e. for signal generation. From 150Hz relay RLY3 switches the original frequency back in to pin 14 on IC9. This process is necessary in the lower frequencies in order to obtain a sufficiently high resolution. For example a computer is not able to generate a frequency of say 20.47Hz so this frequency is generated from 204.7Hz divided by 10. IC9 and IC10 work as a Phase Locked Loop (PLL) and form the actual sine wave generation part of the circuit. The detailed function of a PLL cannot be described here. However sufficient to say that IC9 compares the signal from the PC on pin 14 with the signal from IC10 (VCO) on pin 3. According to the frequency difference (phase difference) between these two signals there appears on pin 13 an 'error signal' which is then integrated via a low pass filter (R32, C22, R33) and is used as a control signal for IC10. In other words the square wave signal from the PC fed to pin 14 of IC9 is used to generate a sine wave of the same frequency at pin 2 of IC10. Every frequency change at pin 14 IC9 has an equivalent frequency change at the output of IC10 (pin 2). Further, pin 1 of IC9 contains a 'lock' signal which is used via pin 12 of the parallel port to signal that the PLL is locked on. i.e. a check is made to ensure that the output of IC10 is similar to the input of IC9 (pin 14); if this is not the case, the program gives an error message.

The capacitors on IC10 pins 5 and 6 control the frequency range of the VCO. In the range 20-150Hz both relays are de-energised i.e. C26 is in circuit. In the range 150-1500Hz RLY3 is switched by the PC and C25 is then in use. The other contacts on RLY3 switch the input frequency on pin 14, IC9 as already described. From 1500Hz RLY4 is activated and connects C24 in series with C25 resulting in a drop in the total capacity. By this method the VCO is kept in its optimal voltage range. Trimmers P6 and P7 are used to fine tune the form and symmetry of the sine wave output signal. By careful adjustments it is possible to obtain a distortion figure of <1%. A description of remaining components around IC9 and 10 is not necessary for an understanding of the overall circuit.

The output frequency on pin 2 of IC10 is connected via IC11a to the various outputs. P8 sets the signal amplitude. IC11b via R106 provides a constant current output which is essential for all impedance measurements e.g. Thiele/Small. The output via R106 will generally be used for all other measurements that do not require a powerful output. The power output is achieved using IC12 and can be used for example to directly drive a loudspeaker. Specifications can be seen in Table 1.

PROJECT

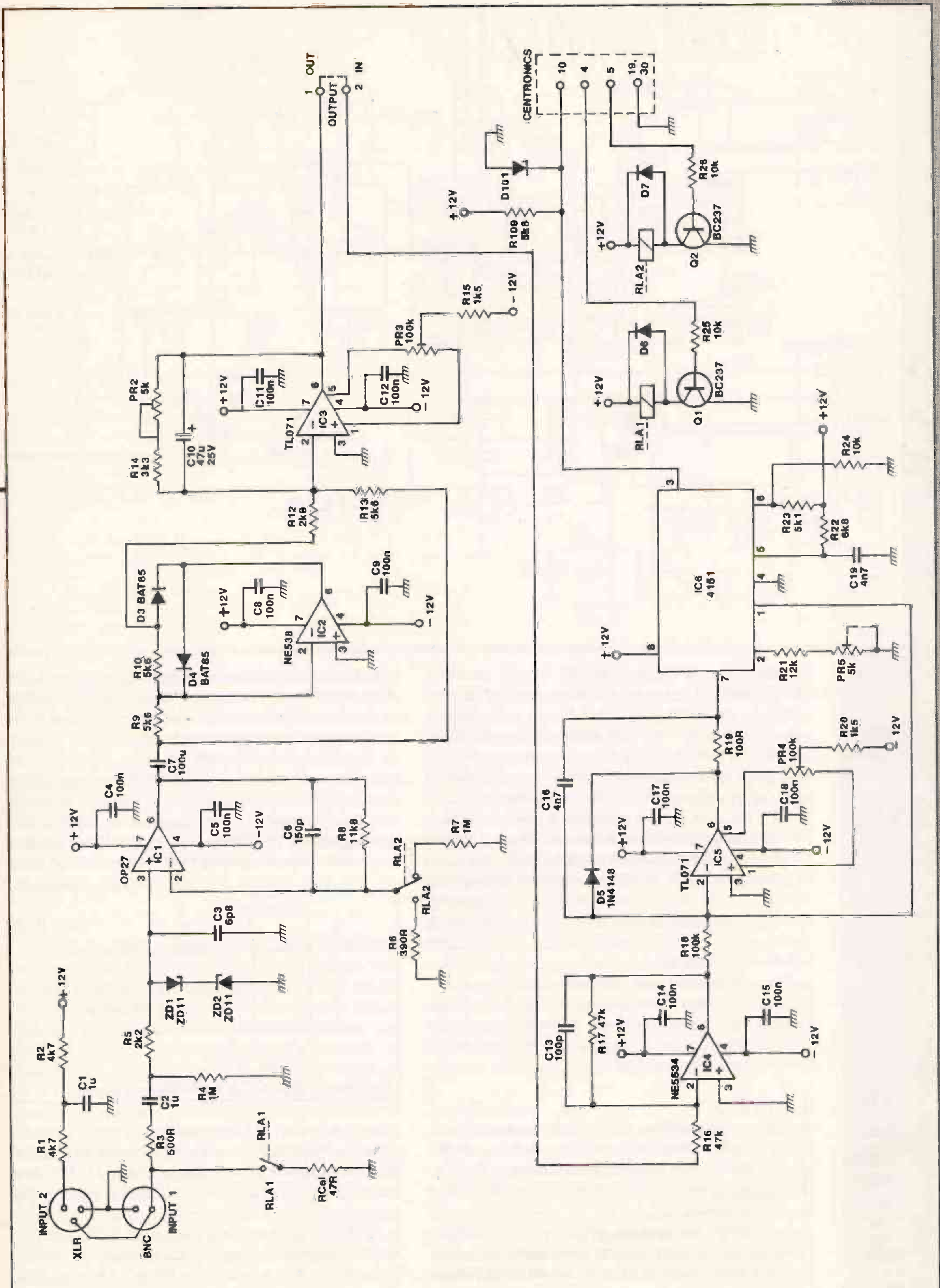


Fig.8a & b Complete circuit diagram of system

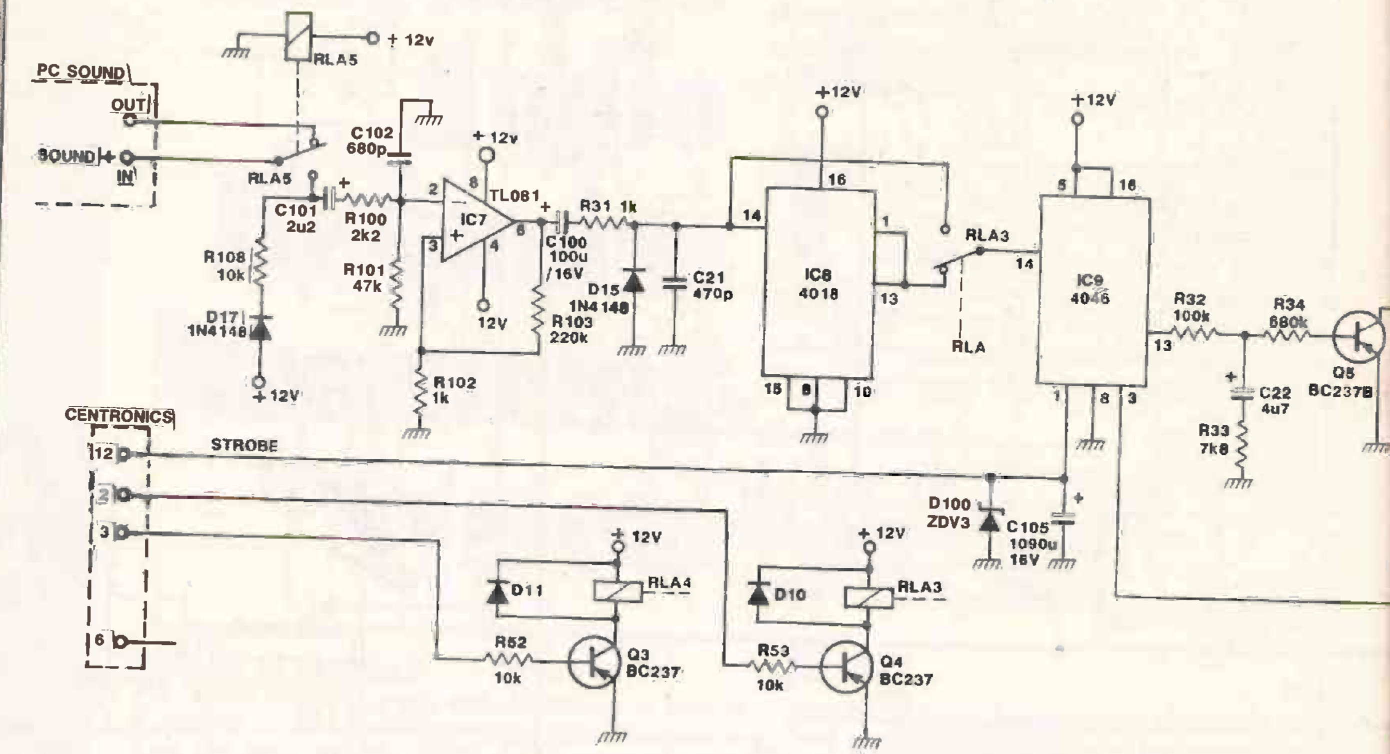


Fig.8b

the computer as shown in Figure 10. The PC speaker is usually connected to the motherboard via a 4 pin plug. Pin 1 carries the signal (positivepole) and pin 4 is the negative pole. Normally it is a simple matter of de-soldering the positive wire from the loudspeaker and connecting this wire to the Sub D socket. The return connection from the generator card (+out) is only needed when the loudspeaker is to remain in use. If this is the case the connection is then to be made to the de-soldered connection on the speaker as shown in Figure 10. If the speaker plug is not marked + and - the signal carrying pin can easily be determined by connecting one of the wires up and testing to see if the signal generator card functions. If this is not the case simply swop the wires on the speaker connection over and retry. This trial and error method will not damage the circuit.

The connection between MEPEG and the PC is via a 25 pin Sub D plug, i.e. a normal parallel interface configuration. The individual pin connections are shown in Figure 8a/8b.

The connecting cables from the two interfaces should have a maximum length of 2m.

Adjustment

Before any adjustments can be made the circuit board, must be working satisfactorily and be connected to the PC. Also the software must be installed and running on the PC as the programm is used in the adjustment process. (See section on software installation).

A voltmeter, oscilloscope and if available distortion measuring equipment are necessary for adjusting the system.

With output 2 connected to input 1 adjustment of PR6 and PR7 can be made. The programm must firstly be started with <MEPEG> and from the main menu <begin> selected. We then arrive in the measuring menu and should then select No. <6 -Voltmeter>. The programm then asks :

Do you use measuring microphone(y/n)?

To which you should answer <n>.

If the circuitry is functioning, MEPEG generates a 1kHz signal and the programm is in voltmeter mode. If the card is not correctly connected to the PC an error message will most probably appear. The amplitude of the sound wave signal at output 2 is set to 5Vpp using PR8. Trimmer PR7 is set to

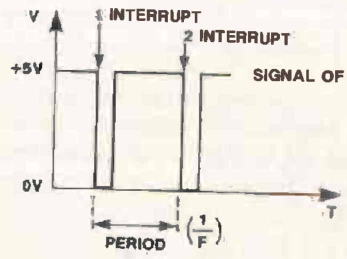
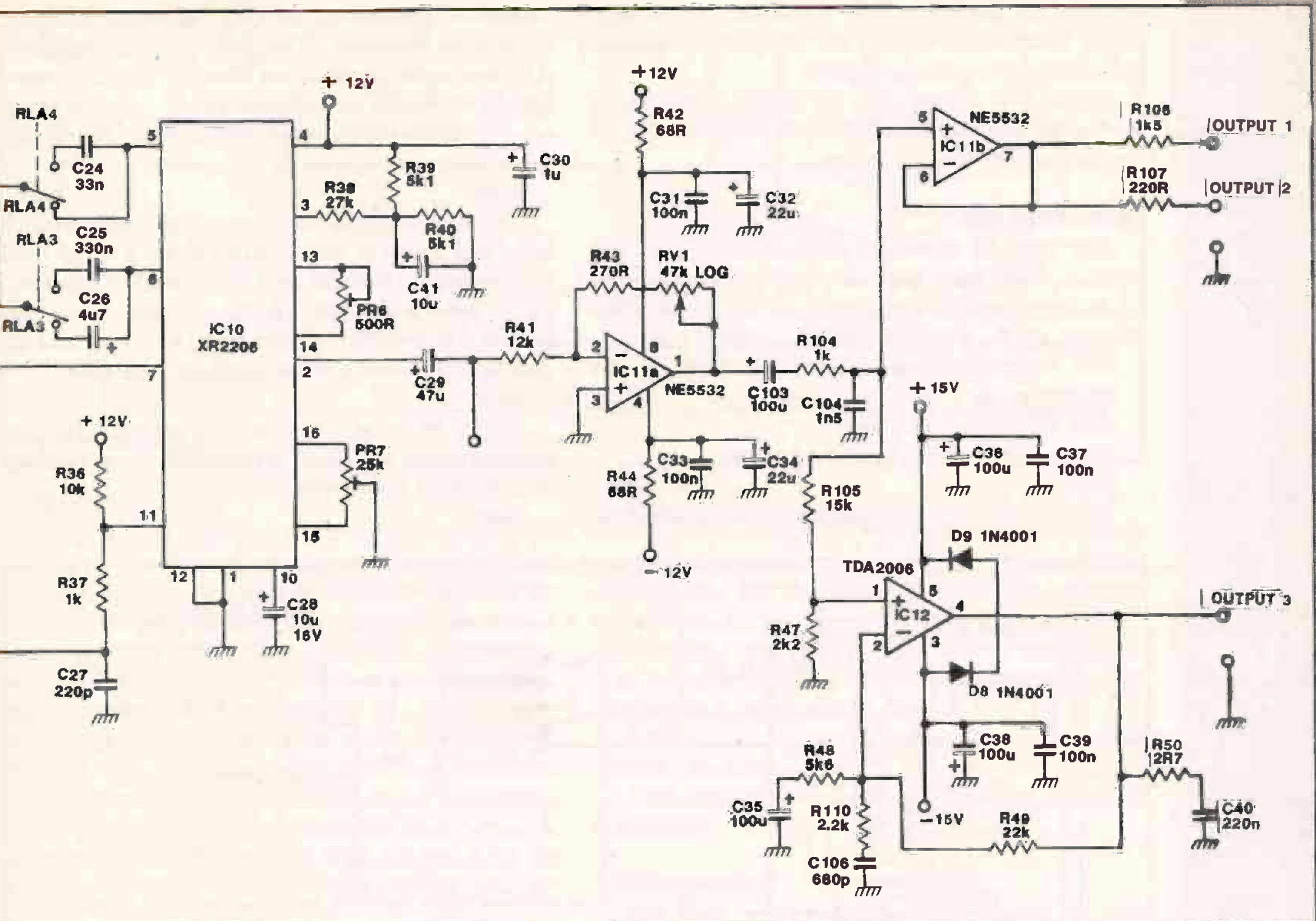


Fig.9 Input signal as a proportional frequency

midway and using PR6 the signal is adjusted to minimum distortion. If distortion measuring equipment is not available the adjustment must be made 'by eye'. Set PR6 to 200 ohms and using PR7 adjust the wave for optimal symmetry using an oscilloscope.

With the help of a voltmeter adjust the 1kHz signal on output 2 to 1000mV (output 2 still connected to input 1). Then adjust the output of IC3 to 1000mV DC using PR2. (Remember to change the voltmeter range from AC to DC!).



Now disconnect the generator signal from input 1 and short circuit it to earth. Using PR3 adjust the output of IC3 to 0mV (Offset). The generator output 2 is then again connected to input 1. The generator signal should now be adjusted to 10mV. Now adjust trimmer PR4 until the measuring bar on the screen <Vmess> also shows 10mV. Then using the voltmeter set the generator signal to 4000mV. Then adjust PR5 until the screen measuring bar shows 4000mV. On completion of these adjustments MEPEG is calibrated and ready for use. Now press <Esc> to leave the voltmeter mode and return to the main menu.

Software

No great computer expertise is required to use MEPEG. As mentioned in the introduction the majority of functions are fully automatic, only measuring functions and parameters need be entered by the user. The programm catches most errors which occur due to incorrect use or incorrect entries. Problems with the hardware are also detected e.g. measuring beyond the allowed range or PLL not locked on, all of which could lead to inaccurate results. The program works with a temporary store which is able to store up to 30 measured curves and associated data. This temporary store, unlike many other programms, is held on the Hard/Floppy drive. This has the advantage of not occupying valuable memory and also should the system crash the data is not lost. The temporary store is cleared before and after each session.

The minimum configuration for the use of MEPEG is an IBM* or 100% compatible AT computer running DOS 2.0* or higher with an EGA or VGA graphic card. Colour or monochrome monitors may be used although by colour the associated graphic card should have at least 128Kb of memory. A parallel interface, LPT1, on port &H378 is also required. If a second interface is available it is possible to measure on LPT1 and print on LPT2. If this is not the case measurement and printing are both via LPT1. The software has been tested on several different IBM compatible computers with the above configuration and should therefore run on most PCs without problem.

The following files are contained on the original disk;

Setup.exe	Program to set the hardware configuration
Compen.dat	Compensation file for the microphone
Ralf.exe	File for main Program
Runmepeg.bat	Batch file for system startup
Mepeg.exe	Main program

Several demonstrations are also available.

The DOS routine 'Graphics' is used to enable screen hard copies to be printed. Runmepeg.BAT loads 'Graphics' before starting the main programm. Hardcopies are therefore available on all printers this routine supports; typically Epson or IBM compatible 9 or 24 pin dot matrix.

Installation

All important settings with regard to hardware and the installation of the software are carried out by the programm <SETUP.EXE>. Insert the disk in drive <A> or <B> and start the installation by typing SETUP and pressing 'return'. (For safety reasons only use the original disk for installation purposes !!). The setup program is self explanatory and requires no further explanation. When all the necessary parameters have been entered the system software is automatically installed. 'Setup' suggests < C:\MEPEG > as target directory, but this can of couse be changed by the user. Finally 'setup' writes a further file 'setup.dat' in which all the necessary parameters are stored.

NOTE: it is essential that the SETUP is run before starting the main programm. The main programm will not function correctly if this is not done.

Main Program

After succssful completion of the installation we find ourselves in the chosen target directory. All data operations i.e. the storing and loading of curves are carried out in this directory. The temporary store is also contained in here.

With <Mepeg> we start the main program and come to the main menu.

Main menu Functions

The menu contains the following functions:

Begin

With <B> for Begin a measuring sesson is started and the

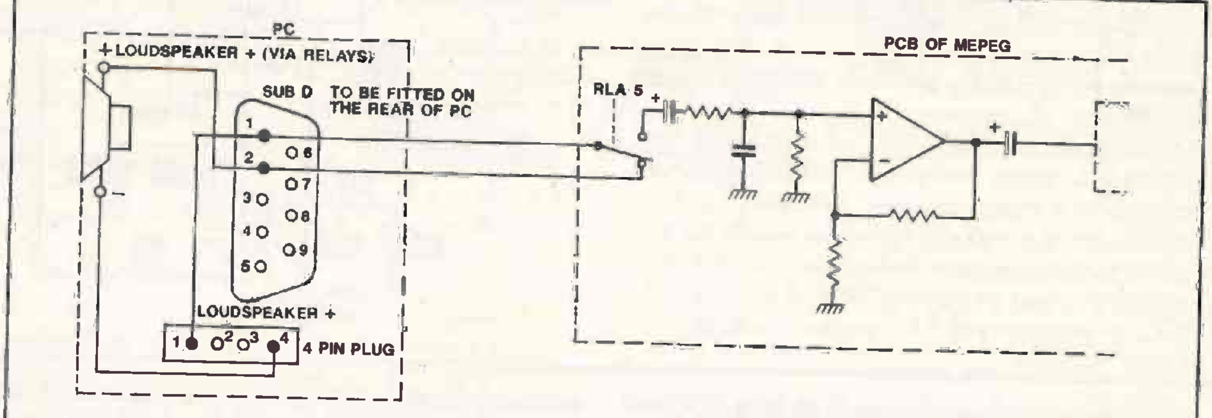


Fig.10 PC connections via sub D socket

measuring menu appears in which measuring functions can be selected and parameters entered. If the temporary store contains a curve the following message is given:

Do you want to enter new Parameters (y/n)

If this is answered with <N> then the existing functions, parameters and reference values are kept and used in the new session. By a series of measurements (e.g. sound level measurement) this eleviates the need to enter the values every time.

Then the measuring procedure is immediately started.

If the question is answered with <Y> then the user can enter new parameters etc.

The measuring menu then appears offering the following functions:

1-Level measurement	
2-Spl measurement	Sound level measurement
3-Nearfield measurement	Near field measurement
4-Impedance measurement	Impedance measurement
5-Th/Sm measurement	Thiele/Small Parameter measurement
6-Voltmeter	Voltmeter mode
7-Generator	Computer controlled sine wave generator

The individual measurement functions and their properties have already been described in part 1. Depending on which function is chosen the user is asked for certain parameters. The requests are clear and require no further explanation. (Function 1-3 ask for a 'reference frequency'. As already explained, using this frequency the system calculates the '0 Decibel line reference value'). After all entries are complete the measurement procedure starts. The user can follow the measurment on the screen.

Load

<L> for load, shows the contents of the current directory and allows files to be loaded into the temporary store. Only MEPEG files i.e. files with the *.MPG extension are shown. The last curve to be loaded using this command is the 'actual' curve and is immediately available for use. i.e. it does not have to be recovered from the temporary store again.

Save

<S> for Save, saves curves and their associated data to the current directory. File names can be specified by the user and are given the *.MPG extension.

Quit

<Q> for Quit to exit MEPEG. The contents of the temporary store are deleted and all unsaved curves are lost. MEPEG does however check if the user wants to save any data before leaving the program!!

Plot diagram

<P> for Plot diagram plots a curve on the screen. The curve can be either from the last measurement or from disk. On the lower right of the screen is a small menu with the following options:

Copy

<C> for Copy sends a hard copy of the current screen to the printer

Text

<T> for Text enables the user to add a comment to the diagram (up to 28 characters).

Res

<R> for Resolution enables the scale of the Y axis to be changed. See Table 1 for the various possibilities

Gcrv

<G> for Get curve allows different curves to be loaded from the temporary store either into the current diagram, for comparision purposes. If several curves are shown in the same diagram the parameters shown apply the last curve to be loaded.

Esc

With Esc the current measurement functions can be interupted i.e. to leave the graphic mode.

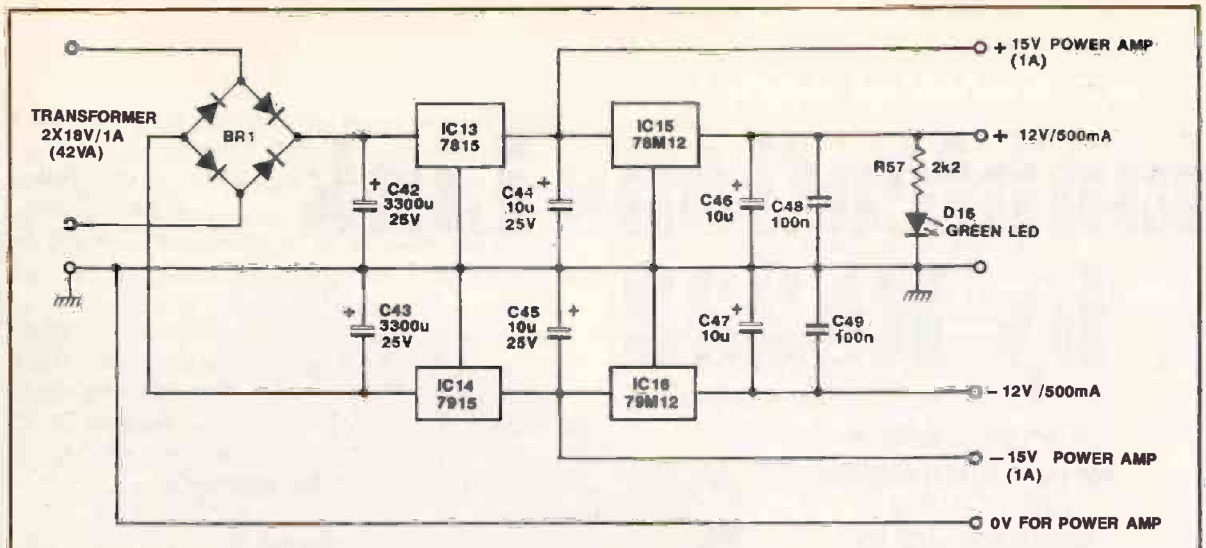


Fig.11 Power supply

Difference

<D> for Difference it is possible to calculate the difference between curves currently in the temporary store. The available curves are shown in a window on the left of the screen and can be selected using the cursor keys. The selected curves are shown in the window on the right. The difference calculation is only possible with curves which have been measured under the same conditions i.e. with the same measuring functions and parameters. During this process the origional cuves remain unchanged. After every difference calculation the user is asked if he wishes to save the resulting curve in the temporary store. If the answer is yes the user is prompted for a name for the curve. If the user answers no, the cuve is nevertheless saved in the temporary store under the filename "Nname".

Average

<A> for Average calculates the average of the curves currently in the temporary store. The usage is the same as for 'Difference'.

Octave

<O> for 1/3 octave calculates the 1/3 octave response curve from a sound level or level curve measured in High resolution mode. During this process the origional curve remains unchanged. Again, see 'difference' for use of this function.

Get curve

<G> for Get curve loads a chosen curve from the Temporary Store. This replaces the curve currently in use. (NB. the curves in the temporary store are saved in the current directory with the file extension *.STR. In the event of a possible system crash the files can be found here !!).

New

<N> for New deletes all the curves currently in memory and the temporary store and re-reads the compen.dat and setup.dat files. This function is used primarily by a "Renew" of the temporary store. A renew is automatically requested by the programm when there are more than 30 curves in the store. Before this is carried out there is of course the possiility of saving one or more curves.

* IBM is the recognised Trademark of International Business Machines

* MS-DOS is the recognised trademark of Microsoft Corporation

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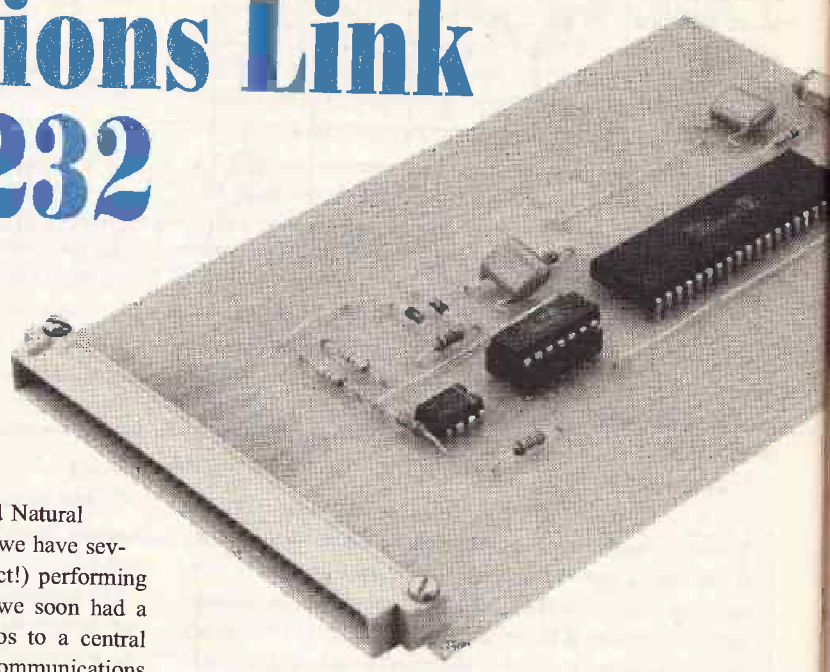
Acknowledgement: Thank you to C.A Taylor for his support through this whole project.

Communications Link by RS232

A project where 'Device Shall Speak Unto Device'. Commentary by Keith Garwell



At the Newchapel Observatory and Natural Sciences Centre, Stoke on Trent, we have several small micros (Dragons in fact!) performing various jobs round the site and we soon had a requirement to pass data from these micros to a central machine. Unfortunately the micros had no communications interface.

Due to my general interest in electronics I often thought it would be useful if I could couple my own IBM PC look-alike to other equipment. To digitisers, controllers, and because of an interest in amateur theatre even to a theatre lighting system.

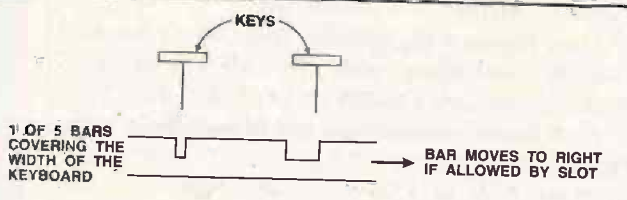


Fig.1

However to me the PC is an expensive device and I am rather loath (though a competent computer engineer) to meddle with or modify its innards.

A certain amount of cogitation later I concluded that the serial interface on the PC was the best means of connection provided that the speed at which data had to be passed was not too large. There was then no need to modify anything and the serial interface is well protected, electrically, from accidents. It also has the advantage that only three wires are needed between the PC and the device in question. From this came the idea of adopting a standard for myself and the Centre and producing a 'standard' interface board. The end product enables 240 bytes of data per second to be sent in either direction.

The serial interface is known as RS232 and there is a complete official specification for it. Which is perhaps a roundabout way of saying it's quite popular and there are many instances of it. It also means that, in this case, whatever applies to an IBM PC or look-alike will also apply to any other computer fitted with this interface.

The Early Years

The origin of RS232 is ancient and goes back to the days when the only means of communication was by way of a morse key, sounder, battery, and a single wire with earth return. For further information see any wild west film!

With the diversification of business the morse key became too slow and so ways of speeding up communication

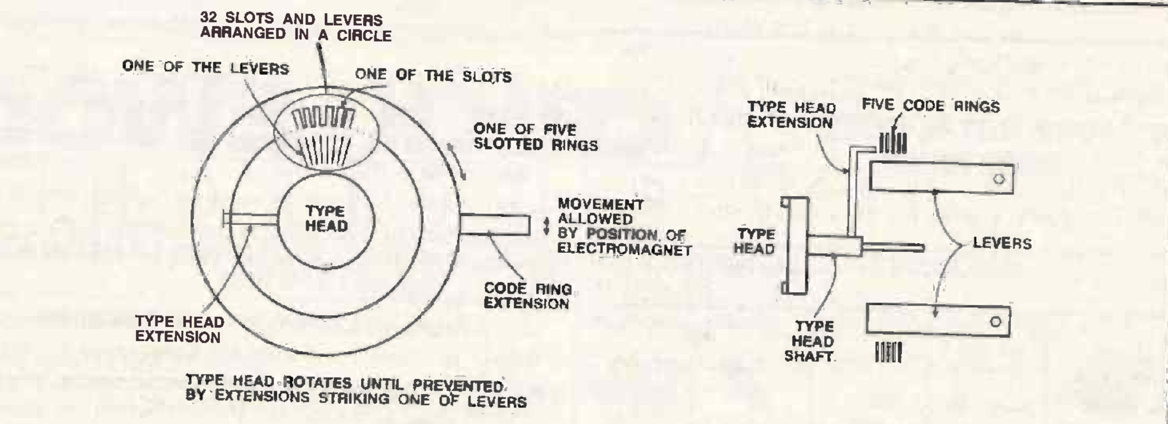
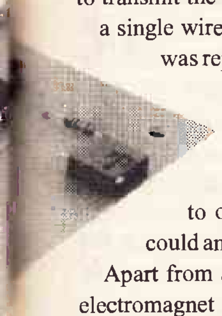


Fig.2a & b

PROJECT

developed. In the first instance the morse dots and dashes where punched onto paper tape by operators working together. The paper tape was then used by mechanical senders to transmit the information at a much higher speed, still via a single wire and earth return. At the far end the sounder was replaced by a mechanical device which wrote or punched the data onto paper tape again.



Meanwhile back at the ranch the typewriter had appeared. So why couldn't the pressing of keys at one end of a line be made to operate the type at the far end. Eventualy it could and became the world famous Creed teleprinter.

Apart from a pair of contacts at the sending end and an electromagnet at the receiving end the device was entirely mechanical. The mechanics in principle were relatively simple but in practice exceedingly intricate. Very briefly, at the sending end pressing a key released five bars running the length of the keyboard and which carried a code for each key one of which is shown in Figure 1. The final position of the ends of the bars corresponded to the key code. Following this action a set of cams rotated once causing the code at the bar ends to be applied to a pair of contacts in sequence. Thus five consecutive makes/breaks identified the character. The completed rotation of the camshaft restored the bars to their original position ready for the next key to be pressed.

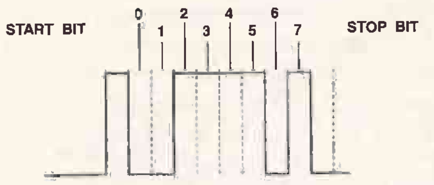


Fig.3 C no parity

To complete the sequence and to start the mechanism at the far end, before the five codes were sent, a start break was performed. (The contacts at the transmitter were normaly closed so that at rest current flowed through the line. This enabled the operators to check that the wire was still intact before sending the message). To ensure the receiver mechanism was always given time to complete its task a delay was inserted between each character by the transmitter equal in duration to at least the length of a data bit. Nowadays known as the stop bits.

At the receiving end an electromagnet responded to the interruptions in the line current. The first break started a camshaft rotating. During this rotation the following five bits of the code either allowed or inhibited a small rotation of five rings. See Figure 2a for the face view and Figure 2b for the side view. The rings had slots on their inner edge which corresponded to the key codes. Because of the rotary movement, at one particular point in the circle the slots all lined up allowing a lever to move outward into the slots. Figure 2b. The lever stopped the type head rotating so that the correct character was aligned with the paper and on the next rotation of the mechanism the character was pressed against the paper. The characters received were thus printed one step behind the characters being sent.

Each character was therefore represented by a code consisting of start bit, five data bits and two stop bits. To allow for all letters of the alphabet plus numbers and punctuation two special shift characters were used. After sending one of these characters all the printed characters changed until the second character was sent.

Later to increase the distance over which messages could be sent the single battery system was replaced by a dual positve and negative supply with change over contacts at the transmitter and a polarized electromagnet at the receiver. Other enhancements included electromagnetic repeaters and with the advent of amplifiers, voice frequency keying.

The teleprinter was the mainstay of the telegram service in the 40s printing onto a sticky paper tape which could be stuck onto a telegram form.

During WW2 a page printing version was very popular with the meteorelogical service as used by the forces. An American version was produced known as a Teletype which employed a different mechanical system (presumably to avoid infringement of Creed patents). It took up less table space than the Creed machine and became popular with early computer systems particularly as the computer operators machine.

The start bit, 5 data bits, and stop bit system of serial data transmission was soon adopted as a standard. To extend the print repertoire the number of data bits was extended, and error detection added. Thus was borne todays RS232.

Todays RS232

This is a more sophisticated system having more data bits to extend the available codes plus if required a bit intended to enable errors in transmission and reception to be detected.

As before the start bit is just that, it indicates the start of the character and can be followed by either 5, 6, 7 or 8 data bits. These in turn can optionally be followed by the error detection bit, known as the parity bit. Finally either 1, 1.5 or 2 stop bits. One and a half bits sounds odd but in fact means a duration of 1.5 bits.

Now let's look at an example in further detail. The letter C can be represented by the binary code 01000011. The data is sent in reverse order to how it would normaly be written ie with the least significant bit first. A dual voltage supply is used and the quiescent condition is negative.Figure 3 shows how the C would appear on an oscilloscope in the normal sense with positive at the top using eight bits, one stop bit and without parity. (Let's not complicate the issue too soon).

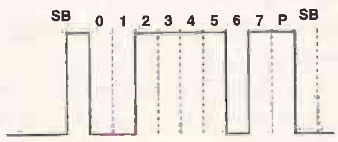


Fig.4 C odd parity

The start bit is thus positive going followed by the first data bit which is a 1 and is thus negative. Then the next data bit a 1 also. Next the four zeroes as positive then bit 7 a 0 and finaly the stop bit which returns the line to its original condition as negative.

Just to sidetrack the issue for a moment. Why did I choose 01000011 to represent the letter C? Answer. For the very good reason that the most commonly used character code is the ASCII code. In which the initials stand for American Standard Code for Information Interchange. Strictly speaking this code is a seven bit code but is frequently used as an eight bit. The eighth bit being used for special purposes. For instance in the IBM PC and all its look-alikes the eight bit is used for special characters such as foreign language characters and graphics characters ie. characters used for drawing.

Error detection and parity

With RS232 a parity bit is available and follows the most significant bit of the data. Parity can be either odd or even and it works like this.

The parity bit is generated by the electronics in such a way that the number of ones in the combined data plus parity is either odd or even.

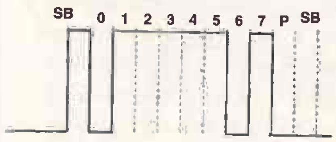


Fig.5 A odd parity

As an example again suppose the letter C is being sent represented by eight bits. If parity is declared as odd then in the case chosen the ninth bit, the parity bit, would be a 0 ie. in the nine bits there are 3 ones and the remainder are zeros. See Figure 4.

If the letter A was being sent the parity bit would be a 1 because the eight bit code for A is 01010001 which only has two ones. See Figure 5.

At the receiving end the electronics will count the number of ones in each character as they are received. If parity is odd then the ones count for each complete character received must be odd also. If this is not so then an error signal is given.

Reception And Stop Bits

At the receiver, the electronics will detect the leading edge of the start bit. It then waits for one and a half bit times before strobing the input. The strobe should therefore come exactly in the middle of the first data bit. It then waits for one bit time and strobes again putting the second strobe in the middle of the second bit and so on as shown in Figure 6. After the 8th strobe the electronics is reset during the stop bit to wait for the next start bit.

It is important to appreciate that although the start bit must not occur before the expiration of the stop bit time ie. there is a minimum delay before the next character - there is no maximum delay.

The stop bit is intended to prevent characters running in to each other and to allow time for the electronics and the line to recover before the next character.

Baud Rates

Although we have just been discussing duration of the pulses or bits the more usual consideration is frequency. RS232 allows for a wide variety, from 100 bits per second to 9600 and the bit rate is termed as so many Baud. After a well known character who was big in data transmission!

The standard Baud rates for RS232 are 110, 150, 300, 600, 1200, 2400, 4800, and 9600. The actual rate at which characters are sent will depend on the Baud rate and the number of bits per character. For instance 1200 Baud, 7 data bits, no parity, and one stop bit will give 1200/9 or 133 characters per second. 1200 Baud, 8 data bits, parity and 2 stop bits would be 1200/12 or 100 characters per second.

The shape of the pulses will be distorted by the electrical properties of the connecting line and these in turn will depend upon the length and type of line. The Baud rate chosen is therefore a trade-off between freedom from errors and the time available for transmission.

There is also a further point of significance, namely the accuracy of timing of the electronics. Consequently RS232 links are usually crystal controlled. From Figure 6 it can be seen that for 8 bits no parity the permissable error before the 8th bit is misread is plus/minus 0.5 after an interval of 8.5 which is 1 in 17 or just under 6%.

Plugs and Sockets

As well as standardising the methods of transmission the plug and socketry is also included in the specification. The standard is a 25 pin D type connector which at the processor is male ie. its a plug. The pin out of which is as follows. (The pins not mentioned are not used).

1. Frame or screen.	
2. Tx	Transmit, the serial ouput.
3. Rx	Receive, the serial input.
4. RTS	Request to send.
5. CTS	Clear to send.
6. DSR	Data set ready.
7. Signal ground	The common line.
8. DCD	Data carrier detected.
20. DTR	Data terminal ready.
22. RI	Ring indicator.

It will be seen from the above that only three connections are actualy needed for the data exchange. Pins 2 and 3 data transmit and receive, and pin 7 the common line which is ground, 0 volts, or earth, call it what you will.

The remainder are handshaking signals intended for use principly between a computer and a modem. Modem stands for modulator/demodulator and is a device which at the sending end converts the DC signals to voice frequencies suitable for sending over a telephone line, radio link etc. Thats the modulator. At the receiving end the voice frequencies are converted back to the DC signals. Thats the demodulator.

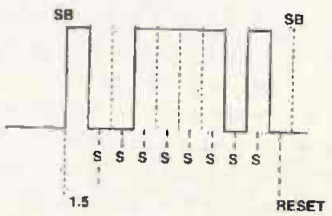


Fig.6 C No parity

An alternative connector frequently used these days particularly on physicaly small machines eg. portables, is a 9 pin D type connector. The pin-out is usualy as follows.

1. DCD
2. Rx
3. Tx
4. DTR
5. Signal ground
6. DSR
7. RTS
8. CTS
9. RI

The Chips

The chip chosen to convert the parallel to serial data and vice versa is the IM6402, readily available and compatible with industry standards. These devices are known as UARTs ie. Universal Asynchronous Receiver Transmitters. The data bits, commonly known as the word length can be 5, 6, 7 or 8 bits. Parity can be odd, even or none, and there can be one, one and a half or two stop bits. The chip is a 40 pin DIL. As well as its use as a terminal unit for equipment of all sorts it can also be used in conjunction with a microprocessor for which reason it is possible to switch all its output signals to a high impedance state.

Figure 7 shows the pin layout with names and I am sure a quick run through their purpose will do no harm. Starting at pin 1. High level is +5 volts, low level is 0v.

1 VDD the positive supply 5 volts.
2 NC not connected.
3 VSS the negative supply, ground or 0 volts.
4 RRD Read Register Disable. A high level on this line forces the receiver outputs to a high impedance state.
5-12 RBR8 to RBR1 the Receive Buffer Register ie. the receiver output. The least significant bit is RBR1.
13 PE Parity Error a high level on this pin indicates a parity error has been detected.
14 FE Framing Error a high level indicates an invalid stop bit.
15 OE Overrun Error a high level indicates receive data not read soon enough.
16 SFD Status Flags Disable a high level applied to this pin forces the status lines PE, FE, OE, DR and TBRE to a high impedance state.
17 RRC the Receive Register Clock, this input should be driven at 16 times the Baud rate.
18 DRR (N) Data Received Reset a low level here clears the receiver output.
19 DR Data Received a high level indicates a character has been received.
20 RRI Receive Register Input ie the incoming serial data.
And going back up the other side -
21 MR Master Reset a high on here resets everything except the receive buffer register.
22 TBRE Transmit Buffer Register Empty ie ready for the next character.
23 TBRL (N) Transmit Buffer Register Load a low here trans fers data from the input terminals to the buffer register.
24 TRE Transmitter Register Empty a high indicates data has been sent.
25 TRO Transmitter Register Output ie. the serial data.
26-33 TBR1 to TBR8 Transmit buffer register ie. input to transmitter.
34 CRL Control Register Load a high level here loads the control register.
35 PI Parity Inhibit a high level selects no parity.
36 SBS Stop Bit Select a high selects 1.5 stop bits for 5 bit data and 2 stop bits for all others. A low selects 1 stop bit.
37&38 CLS2 and CLS1 Character Length Select. The appropriate combination of levels on these pins select 5, 6, 7 or 8 data bits.
39 EPE Even Parity Enable a high level selects even parity providing pin 35 is low. Low selects odd parity.
40 TRC Transmitter Register Clock this should be 16 times the transmitter Baud rate.

The remaining 3 chips used are quite common and familiar to most I would imagine.

The clock oscillator is a TLC555 the CMOS version of the 555 and is used to generate both transmitter and receiver clocks.

A 4011 CMOS quad NAND gate is used for generating some of the control signals, see 'How it works'.

A CA3401 op-amp is used for converting the 0v and +5v signals to -12v and +12V.

The Power Supply

The power requirements are quite small. About 10mA at 5V for the chips and the same for the ± 12 volt supplies for the line driver. The smallest commonly available mains transformer is usualy 100mA which is rather more than enough! In fact remarks about sledge-hammers and nuts would be justyfied. So before embarking on a power supply for the conversion board (just CB in future) consider any options such as sharing a supply. Another option is to run from a single 12V supply. See below.

Conventional power

If a mains supply is going to be used to drive the RS232 board only, then the simplest arrangement is shown in Figure 9. Using a 12-0-12 transformer with half wave rectification to produce a peak output of 12 x 1.4 ie. approx 17 volts. This leaves plenty of headroom to drive two 100mA 12V regulators eg. μA78L12 and μA79L12. In addition the +5V (μA78L05) comes off the +12V. Don't forget the capacitor on the negative rail is upside down ie. its positive leg is connected to 0V.

The current output of such a simple arrangement can be full wave rectification and using larger capacitors. The new configuration of transformer secondary, diodes and capacitors is shown in Figure 10 otherwise its the same as Figure 9.

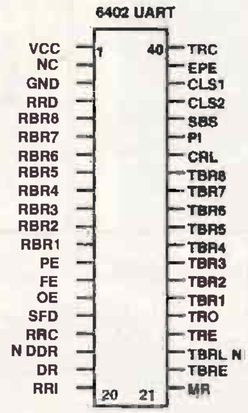


Fig.7 6402 UART Connections

DC to DC convertors

Because the current consumption of the board is so small there are alternatives to conventional power supplies. Indeed in my case the boards are all run from a +12 volt battery supply. This involves DC to DC conversion.

Various DC to DC voltage convertors are available. The RC4190 micropower switching regulator will convert almost anything to anything! (Maplin UR15R). The TBA820 (Maplin WQ63T) which we all know is a small audio power amplifier can also be configured as a voltage convertor. Figure 11 shows how to use it to generate ≈12 from +12. This is how we use the device. The 5V comes off the +12 via a 100mA regulator as before. In Figure 11 the TBA820 operates as a high frequency (40kHz) square wave power oscillator. At pin 5 a peak to peak voltage of 12V is available which is inverted by the the two diodes and capacitor following. The diodes in these circuits are all 1N4148.

Building the Conversion Board

Assembly (Refer also to the copper design and component placement)

Immediately it's decision time. How is the board to be fitted with plugs and sockets? It's easy for plug and socketry to cost as much as all the electronics put together so it's as well to give some consideration to the problem.

As we made several of these boards for various purposes we decided on a 'standard' board which would be fitted with

HOW IT WORKS

The Conversion Board

Our general requirement for RS232 links was fairly specific. It had to be as simple as possible and of course reliable. No great distances are involved, 100 metres being the absolute maximum. The final choice was 2400 Bd, no parity, 8 data bits and 1 stop bit. At 2400 Bd this allows a character rate of 240cps. As there is no allowance for any sort of retransmission or handshaking parity would be pointless as nothing could be done if a parity error did occur. 8 data bits was the maximum possible and allowed for the transmission of standard 8 bit bytes. This format has proved very reliable in practice. Its not at all uncommon to transfer 20 to 30Kbyte chunks of data, and touch wood so far without error.

Sending

Figure 8 shows the schematic with data flow as far as possible from left to right. The P numbers on the lines are the pin numbers on the board connector. First the transmit side, 8 bit data input to serial output which is suitable for converting standard Centronics printer data to serial data. At the top left the 8 data lines T1 to 8 go to pins 26 to 33 on the 6402 IC. TXS is the line which strobes the data in, and would be connected to the Centronics strobe line. Busy is returned by inverting, via IC4, the signal on pin 22 of the 6402 which is transmit buffer empty, the inverse condition will be transmit buffer full which gives busy.

On the output side the serial data is on pin 25 of IC1. This is inverted by connection to the inverting input of the op-amp IC3. The non-inverting input of which is reference to the mid point of the 5 volt supply by the two 470R resistors. The supplies to IC3 are +12 volts on pin 7 and -12 volts on pin 4. Pin 6 therefore gives an inverted version of the serial ouput at ±12 volts. The 3k3 resistor just acts as a current limiting resistor to the serial output TX OUT.

Receiving

In the case of the receiver serial data appears on the left at RX IN. By means of the 10k resistor and the two clamping diodes the input is restricted to 0 volts and +5 volts. This is inverted by another section of IC4 to feed the serial input of the 6402 at pin 20.

The 8 bits of serial data will appear in parallel on pins 5 to 12 of IC1 thence to R1 to R8 of the output highway. The data ready signal appearing at pin 19 is delayed by the resistor capacitor combination R6 and C1 and inverted by another section of IC4 to generate the data received reset signal at pin 18. This signal is also provided at the ouput as RXDR receiver data received. Working in this way data received at the serial input appears on the parallel highway and remains there until the next character is received.

Clock generation

At the bottom of Figure 8 and to the left is the clock generator. This is a CMOS 555 IC2 in a standard arrangement generating a nearly symetrical square wave. The 10k preset potentiometer allows for setting the frequency (see setting up and testing). The clock generator runs at 38.5kHz which is 16 times the Baud rate.

Miscellaneous

At the bottom and to the right. A 100n capacitor is connected across the 5 volt power supply rails. The forth section of IC4 is spare its inputs connected to 5 volts to hold the ouput down to 0v. These connections can be cut if the NAND gate is required for any purpose.

Finally the following pins set the operational parameters for the 6402. Pin 35 to 5V to give no parity. Pins 37 and 38 to 5V to give 8 bits. Parity is not being used but pin 39 must be connected somewhere and its convenient to connect it to +5V. Pin 36 is connected to 0v to give 1 stop bit.

Pins 13, 14 and 15 are not used and not connected.

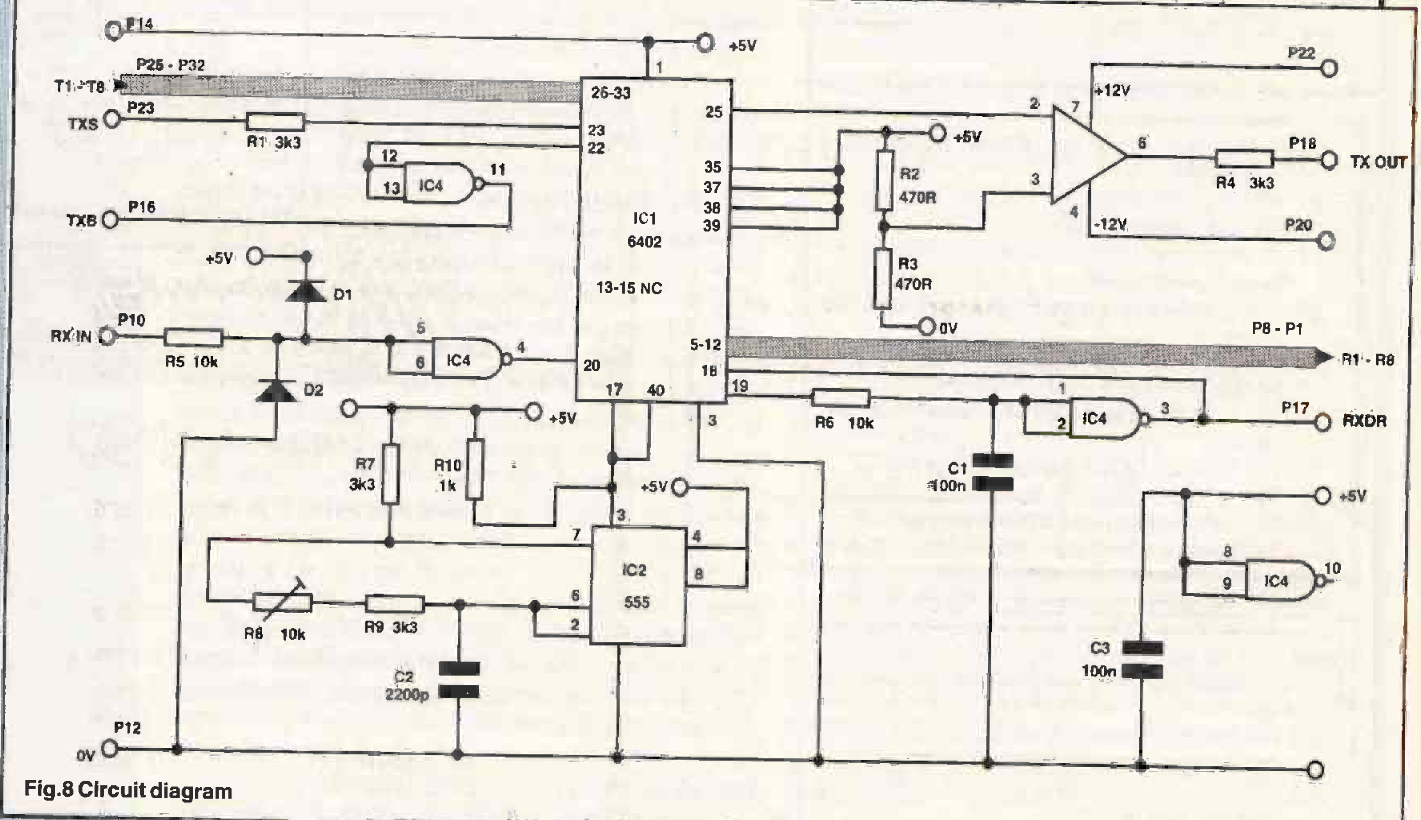


Fig.8 Circuit diagram

a multi-pin plug. The components list identifies this item and the pin numbers are shown on the board schematic drawing. (Numbered P1 to P32). A corresponding mother board is fitted with the mating 32 way socket at one end and a convenient board for the purpose is a 39 way by 39 holes, 4 x 4 inches. Maplin JP49D. We also run ours from a single 12V supply, so additionaly we build a small power supply board which connects with the 12V and 0V and carries a 5V regulator and an inverter for the -12V based on the TBA820 mentioned earlier. This power supply board is built on a small piece of strip-board and connected to the mother board via gold-plated PCB connectors. Maplin WQ15R and WQ16S.

This arrangement is very convenient and flexible. Additional boards for other circuitry can be made and fitted via the same style of 32 way plugs and sockets or such other sockets as necessary wired from the mother board. However this is a bit over the top if the board is dedicated to converting a Centronics printer output to RS2322 with its own power supply. In which case it would be easier and cheaper to mount the conversion board along with its power supply and wire it directly to the board along with a Centronics socket and RS232 socket. (See later under usage for pin connections).

So, if you are going to fit the 32 way plug, do it first. The end of the PCB will need trimming to make a good fit. To do this temporarily insert the pins in the board. The plug should be on the same side as the other components. Mark the piece to be trimmed with pencil and mark the fixing holes. Then remove the plug and saw off the unwanted portion of the PCB with a fine hacksaw. A Junior is the easiest.

Fit and solder the remainder of the components with the exception of the 10k preset. The 4 links can be bare or covered wire. Bare is obviously cheaper unless you would have to buy some specially in which case use covered! The diodes must be the right way up. Facing the component side of the board with the plug on the right, then the left hand diode should have its band at the top and the right hand diode its band at the bottom.

The 10k square 22 turn Cermet preset is actually intended for vertical mounting but is best fitted on its back with the adjusting screw at the outside edge of the board. Only two connections need be made using the centre lead and one of the others. Bend them to fit the holes marked 1 and 2 on the placement drawing and leave the other lead alone. Glue the preset to the board using 'UHU', 'Clear Bostic' or similar adhesive. Hold it in place until the glue sets with a paper clip, clothes peg, or whatever is handy. This done, the board is ready for testing.

Part 2 Next Month

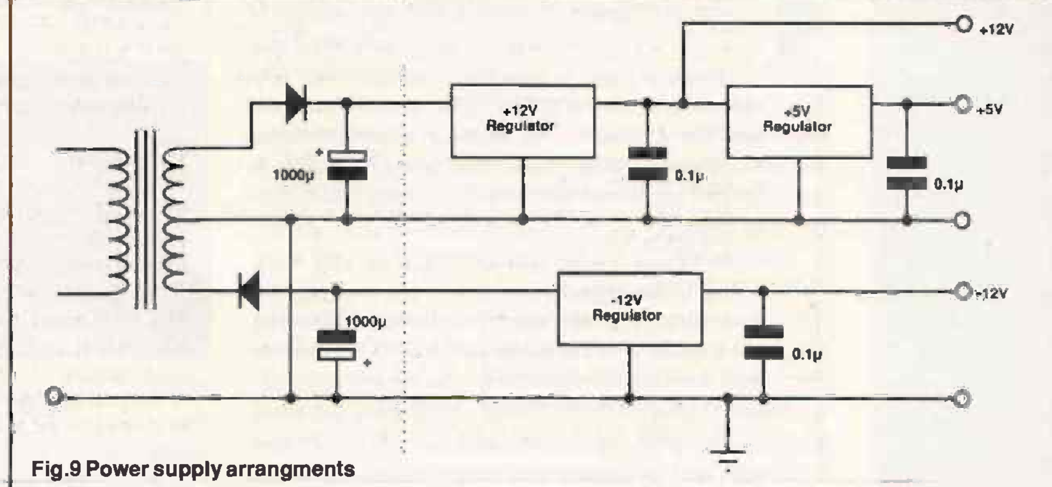


Fig.9 Power supply arrangments

The Greening of the Car

by Douglas Clarkson

The car is probably a superb example of something that 'just happened' - meaning it was a process of social and economic change which from very humble beginnings developed in an unpredictable way to become a very major element in the economies of the developed world. The car has become an indispensable element of modern life but in seeking to provide freedom to the individual, it is becoming a collective problem in relation to use of resources and pollution of various types.

Car manufacture has been an industry sector which has received a lot of encouragement over the years from governments. They have been encouraged to set up new production facilities - manufacturers have been quick to do so. Governments have been unenthusiastic to restrict the role of the car in respect of environmental factors - they sense this as an adoption of principles of economic downturn. Manufacturers like to consider that they adopt an 'everything we do is driven by you' attitude towards car development. The customer gets precisely what they want - nice wheel trim - reclining seats -electric power windows - nippy acceleration and a top speed of 120 mph.

The private individual and environmental pressure groups may identify features that they wish to be included in car design -but have little in the way of collective 'clout'. Environmental groups have a role in influencing public opinion and to focus on the 'green' car lobby.

Since the energy crisis of the early 1970's, pressure groups have been steadily growing. Although the USA took little part in the early technology of the car, it has in fact forced the pace of key elements of 'green' car policy which relate to emission levels as outlined in Figure 1. This is because the USA was the first to witness high levels of car exhaust pollution.

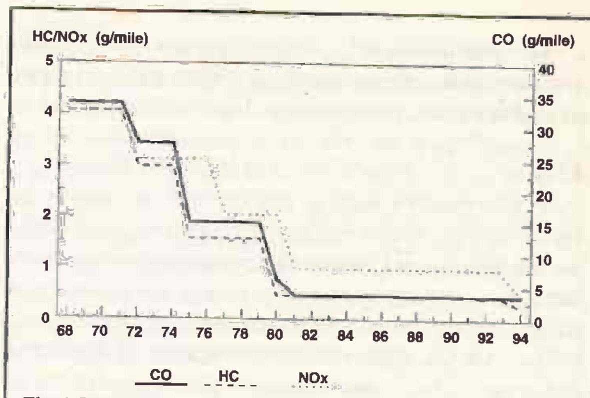


Fig.1 Sequence of US emission standards which have been introduced to date.

Aspects of Emission Control

The topic of emission control deals with one specific undesirable feature of the car. While it is a useful and necessary step forward, it is not the end point of the process of a 'green' car policy. It is appropriate, however, to examine the various types of offending emissions from cars and see how they can be minimised.

Lead in Petrol

Petrol is normally produced by refining crude oil. In the internal combustion engine, fuel tends to ignite before the gas mixture is fully compressed. This is because the work done in compressing the gas is transferred as thermal energy to the gas molecules themselves (adiabatic compression). The use of Lead Tetra Ethyl prevents this pre-combustion and provides a more efficient combustion of the petrol/air mixture.

Year	Amount of lead (thousands of tons)
1982	6.8
1983	6.9
1984	7.2
1985	6.5
1986	2.9 (unleaded available)
1987	3.0
1988	3.1
1989	2.6

Table 1: Variation of lead released in UK on yearly basis

The total amount of lead released is probably still moving downwards. While this is the overall picture, it does not take into account instances of high deposition in inner city areas where traffic densities are alarmingly high. If the UK was divided into a 100 by 100 grid, there would be some squares with alarmingly high lead concentrations.

There is regional variation within the EEC however, on the level of uptake of unleaded petrol. Within (West) Germany the level is approaching 80%, within France around 25% and within the UK around 40%. Interestingly, the significant early days of the car unfolded in Germany.

The bulk of the research into lead uptake in the population has been undertaken by the academic community and not by government agencies. Lead and its effect on individuals is a very complex field. Lead compounds were removed from petrol in the USA during the 1970's. The levels of lead in the general USA population was observed to fall. At the same time, the level of 30 micrograms per decilitre which was once considered 'safe' has been identified with neurobehavioral defects in children and increased blood pressure levels in adults.

There is also evidence that lead which has accumulated in the bones can be 'leached' out as a result of changed metabolic conditions. Thus it may be the case that lead accumulated in the bones of a pregnant mother can be released with potential toxic effects on both the fetus and the mother. There is also indication that increased levels of lead is associated with cardiovascular diseases.

All in all, and perhaps later rather than sooner, lead from petrol is a diminishing but still relevant concern.

Carbon Monoxide

Carbon monoxide is a product of incomplete combustion which reduces the ability of the bloodstream to carry oxygen. If sufficiently high levels are breathed in, the consequences can be fatal. The invisible gas is heavier than air and it can accumulate when stagnant air masses are in contact with cold ground surfaces. The pollutant is a greater risk to individuals who already have an impairment of their heart/lung system - eg angina sufferers or chronic bronchitics. The level of 9.5 parts per million over an 8 hour period is generally taken as a level which if exceeded can result in adverse effects for high risk individuals and also impair the performance of 'normal' individuals - cause drowsiness or loss of concentration.

Ozone

While there are worries about ozone depletion in the upper atmosphere there are also worries about environmental pollution caused by ozone. Ozone is considered to inflame and scar the airways of the lung - bringing about a reduction of lung capacity which is both short term and long term in its effect. Indeed, in the worst affected areas of California, reductions in lung capacity of some 50 to 75% have been observed in some individuals. During most normal activities, such a loss of capacity may not be noticed though this will significantly reduce the level of exercise that the individual could sustain.

In the USA the 'threshold' level is considered to be 0.12 parts per million.

Children would appear to be more vulnerable to air pollution in general, because they tend to breath more through their mouths. The human nose, it appears, is able to remove up to 90% of pollutants from inhaled air. Confirmation of the reduced lung capacity of children due to Ozone pollution was obtained when a study of children who grew up in the Los Angeles basin revealed that they had a reduced capacity of between 10 and 15% when compared with equivalent children in a 'clean' environment.

Paradoxically, athletes who on average breath more than the average individual can damage their lungs when they exercise in an ozone rich environment. There is also some evidence from animal experiments that ozone can impair the immune system.

In the USA the top of the poll of worst offenders in 1989 was, not surprisingly, Los Angeles with a tally of 137.5 days in which the level was above the 0.12 ppm standard.

If in the UK, freedom of information is not a problem, where are the comparable statistics for UK ozone level pollution?

Oxides of Nitrogen

Nitric oxide and nitrous oxide are formed during the combustion process. Where they are present in high concentrations they can appear as a yellow-brown hue in the sky. They are considered to be respiratory irritants and cause lower resistance to infection.

Fine Particulates

Everyone will be aware that exhausts from vehicles discharge smoke particles into the atmosphere. In relation to air pollution this aspect is termed - 'fine particulates'. It has been shown that such particles can lead to lung cancer and contribute to respiratory illness. Medical researchers consider that this form of pollution in association with other agents may be responsible for the rise in incidence of asthma within the population in the UK.

Carbon Dioxide

The role of carbon dioxide as a polluter is constantly under review in an assessment of how it will influence global warming. This 'pollutant' is very much for the collective health of the planet and not the immediate health of a cyclist pedalling through rush hour traffic in London. In various ways, government in the developed world have pledged to establish emission by the year 2000 at 1990 levels.

This policy pledge will certainly be the final hurdle to cross to perfect the ultimate non-polluting mode of transport. In the short term it relates to making vehicles more fuel efficient and in the longer term finding alternate fuels and developing radical new technologies to source energy.

Hydrocarbons

Fuel for the internal combustion engine does not completely burn. Unburnt hydrocarbons are released into the environment and react with other pollutants and sunlight. Surprisingly large volumes of hydrocarbons are also released into the atmosphere by spillages at petrol stations. There should perhaps be notices of petrol pumps warning customers to minimise any spillages.

Table 2 shows the relative contributions of road transport in the UK to various emissions. Power stations produce an equal amount of nitrogen oxide emissions and industry is responsible for around 52% of hydrocarbon emissions. Thus road transport is not wholly to blame for poor air quality in the UK.

Emission	% Emission by road transport (UK)
Carbon monoxide	85
Nitrogen oxide	40
Hydrocarbons	28

Table 2: Relative contribution of road transport to major emissions.

Catalytic Clean Up

Assuming that the legacy of lead pollution is if not altogether vanquished then on the wane, attention is focusing on the key pollutants of carbon monoxide, ozone and oxides of nitrogen. One solution has been to try and develop 'lean burn engines' where the pollution problem would be treated at source - within the engine itself. While progress has been made in this regard - most manufacturers have opted for a 'bolt on' catalytic converter 'cure'.

Various catalytic converters have been developed. The two way (oxidation) catalyst of Palladium and Platinum treats only the two pollutants carbon monoxide and hydrocarbons. The unit requires to be heated initially to over 300°C - necessitating location of the unit close to the engine.

The open-loop (unregulated) three-way catalyst is primarily intended as an 'aftermarket' device which does not integrate with the engine or the fuel system of the car. A platinum catalyst oxidises hydrocarbons and carbon monoxide while a Rhodium catalyst reduces oxides of Nitrogen to simple atomic nitrogen.

The closed-loop (regulated) three way catalyst functions in a more complex way. In this system the air fuel ratio is maintained at a value of 14.7 to 1. This allows for optimum oxidation of hydrocarbons and carbon monoxide and in addition ensures optimum removal of nitrogen oxides. This control system is usually only available on more expensive cars with complex engine management systems.

Cars equipped with catalytic converters run the risk of 'poisoning' them with leaded fuel which acts to block the pores of the active surfaces. Consequently, the fuel inlet ports of such cars are restricted to accommodate only the slimmer nozzle of unleaded petrol pumps. There is also typically a small loss of engine performance associated with a catalytic converter -typically around 3%.

Action on Emissions

The initiative for cleaning up the car has mainly stemmed from directives in the USA where pollution in Southern

California has been an acute problem for over 30 years. Figure 1 shows the sequence of US emission standards which have been introduced to date. The reduction in emission levels is largely achieved through the use of more efficient engines and catalytic converters.

More recent legislation in the USA will further reduce nitrous oxide emissions by 60% (to 0.4 g/mile) and hydrocarbons by 40% (to 0.25 g/mile). These changes were initially scheduled between 1994 and 1996, though California and various other states will implement them from 1993.

The anticipated expansion of cars in the Los Angeles area would, around the turn of the century, continue to cause pollution problems even with the more stringent emission levels. Rather than lower emission levels still further based on conventional car technology, future plans relate to the phasing out of all polluting vehicles. In this process the following categories of vehicle are specified:-

TLEV - transitional low emission vehicle
LEV - low emission vehicle
ULEV - ultra low emission vehicle
ZEV - zero emission vehicle

Between 1994 and 2010 it is proposed to change the mix of these vehicles so that there is a steady progression towards ZEV types of transportation. This focuses attention on what will be on the streets of Los Angeles in 2010. The question also arises - what will be on the streets of Europe at this time? There is no comparable plan such as the TLEV to ZEV transition which is scheduled for California. Based on the low of precedence, the standards about to be introduced in the EEC in 1993 are almost identical to those introduced in the USA in 1983 - a response time of some 10 years. Various member countries, such as Denmark and West Germany, however, accepted this deadline 'ahead of time'.

Table 3: Typical use of energy within an internal combustion vehicle. Only a relatively small part goes to propel the vehicle.

Function	Percentage Loss
Alternator/cooling fan	9%
gearbox	6%
differential	4%
drivetrain	5%
rolling resistance	18%
air resistance	40%
direct drive	18%

People, however, are only beginning to look at the environmental impact of the car. Progress is being made. The phasing out of lead in petrol is a blessing - but one which should have come sooner. The reduction of emissions from car exhausts is also good - although it will be some time before the benefits of this filter through to the general public as the 'fleet average' levels diminish to safer levels. It is particularly surprising, that the effect of such emissions on the health of the population seems to have been researched at a level out of all proportion to its importance. Why is this?

Reducing CO_2 Emissions

General Aspects

Attention is now being directed towards the ultimate greening of the car - the reduction or the elimination of Carbon Dioxide emissions in order to slow the effect of global warming.

There has been a significant switch in emphasis recently to view the carbon dioxide emissions as the most sinister in the long term. While some governments remain on the sidelines to wait and see how new technologies emerge, others are taking an active part in developing solutions which could in the not too distant future reap immense commercial rewards.

In this initiative, there are a range of options ranging from stabilising or reducing emissions to establishing zero net emissions. Within Europe, Germany has adopted the more ambitious plan than the UK of reducing CO_2 emission by 25% between 1990 and 2000. By comparison, the UK has plans only to stabilise emission between 1990 and 2005.

The drive towards more fuel efficient cars is certainly a step in the right direction - and fuel economies of cars are generally rising. In the USA the so called CAFE scheme (Corporate Average Fuel Economy) has raised its standards averaged over groups of manufactured cars from 18.0 US mpg in 1978 to 27.5 USmpg in 1990. Various Bills in the US, however, to improve on this rating have been defeated.

Diesel engines offer the best fuel efficiency. Urban cycle efficiencies of 48.6 mpg can be achieved for cars such as the Rover Montego 2.0 DSLX Turbo. Public worries about pollution, however, still limit their widespread uptake by the public. It is likely, however, that fuel efficiency figures will continue to rise based on 'incremental' development. More fundamental advances may also help achieve improved performances. It seems unlikely, however, that even significant rises in fuel efficiency will diminish total levels of CO_2 emissions since road traffic is itself rising rapidly - both in the developed world and also in the developing world.

There is no doubt that the real underlying need for fuel efficiency is the need to reduce CO_2 emissions. The countries in the world such as Germany who have taken a more progressive line on meeting targets for reducing such emissions have at the same time provided a real market stimulus for developing the technologies to meet the perceived challenges.

Vehicle Design

Table 3 shows typical way in which energy is consumed in petrol driven vehicles. Usually only some 28% of energy in the petrol is converted to power at the crankshaft.

This indicates that some 42% of the energy available for mechanical motion is dissipated in losses within the vehicle (gearbox, drivetrain etc). There would seem ample opportunity to reduce this figure using technology of new materials and engineering.

For many years engineers have been trying to develop continuously variable transmissions which would provide improved fuel efficiency. Recently a device described as an infinitely variable transmission (IVT) has been developed by Epilogics Inc. in Los Gatos, California. Rotary motion on one side is converted to oscillatory motion and back to rotary motion at the output shaft. Such a system of continuous gearing is being investigated by various companies in the USA. It is known, that the motor racing industry is keenly aware of the potential benefits of such technology. It is possible, this technology will first be proved on the Grand Prix race tracks of the world before it is available for the family car.

The coefficient of aerodynamic drag (Cd) is an indication of the level of air resistance of a specific design. Citroen cars have a history of low Cd values. The Citroen Activa prototype has a Cd value of 0.25 while most modern cars have values of around 0.32.

Vehicles of smaller mass will accelerate more rapidly (acceleration is force divided by mass). Thus a vehicle with a

5% reduction in mass will have a similar improvement in acceleration performance and contribute to improvement in fuel economy. There has been a tendency, however, to increase the weight of modern cars with the array of refinements and adornments which now accompany most cars.

Alternative Fuels

The use of fuels produced from crops such as sugar cane and sunflower seeds has been undertaken in countries such as Brazil and South Africa for reasons of economic necessity. It is unlikely, that such methods of production would contribute any useful amount of fuel to the world economy.

The use of Hydrogen has long been considered as an alternative fuel. The only product of its combustion in air is water. The hydrogen can either be provided in liquid form or stored in a metal hydride cartridge which releases the gas when it is heated. A development car produced by the Sanyo Electric Company in Japan has created a car which uses a phosphoric acid fuel cell which runs off hydrogen and air. Solar radiation or the output from the fuel cell can directly charge the nickel cadmium batteries which in turn drive a brushless DC motor. The energy density, of such a hydrogen fuel cell is about 3.6 watts per pound which is less than one third than that of current lead acid battery technology.

In the USA, the American Hydrogen Association lobbies for the increased use of hydrogen in the energy infrastructure of the world. The president of this group, Roy McAlister, Professor of Thermodynamics at Arizona State University anticipates that in the future solar power will be used to produce Hydrogen from sea water - apparently the Saudi Arabia plan to produce 25% of the world's energy requirements from Hydrogen.

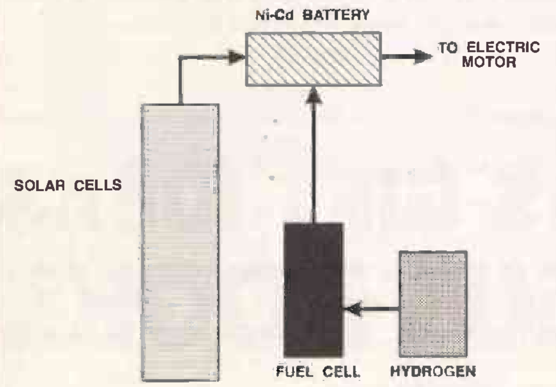


Fig.2 Design of car with integral fuel cell and Ni-Cd batteries.

One of the schemes which is being evaluated in the USA is one which involves the use of Methanol in a mixture 85% methanol and 15% petrol (M85). The value of methanol as a 'greenhouse friendly' gas, depends very much on its origin. Methanol can in fact be synthesised from a range of feedstocks such as natural gas, coal, sugar cane or even wood. Natural gas is in many respects a waste product of oil extraction when it is flared off at sites too remote for pipeline collection.

The use of methanol, would require some changes to both systems of distribution and use within vehicles. M85 has less calorific value than petrol. About one gallon of petrol is equivalent to 1.6 gallons of M85. This will require that fuel tanks in vehicles should be larger and also the distribution system for the fuel will need additional capacity compared with petrol. The M85 mixture, however, has a tendency to corrode present fuel system components.

Battery Technology

There is no doubt that technology is inching towards battery vehicles which can draw on non polluting sources of power. The fundamental breakthrough in battery storage technology, has yet to be announced. It may be, that such a breakthrough has already taken place and that the ink is nearly dry on the patent applications.

There is no doubt, that relatively large sums are being spent on developing battery technology. In the USA the major motor manufacturers General Motors, Ford and Chrysler have formed a co-operative group to develop battery technology. There is also intense activity in Japan and Europe.

The types of battery currently being developed include Nickel-Cadmium, Zinc-Bromine and Sodium-Sulphur. The Sodium-Sulphur battery which is being developed by ASEA-Brown Boveri (ABB) of Switzerland and Chloride in the UK has the advantage of four times the energy density of lead acid batteries. One drawback, however, is that the chemicals require to be at temperatures between 299°C and 329°C. This requires that some of the energy stored in the battery is required to bring the battery to its optimum operating temperature.

One major development in electric vehicles was that of the 'Impact' sports car developed by General Motors. While using conventional lead acid batteries, the car used a compact and efficient DC to AC voltage converter which allowed use of more efficient AC motors. The 'Impact', is still created in the traditional image of the car - stylish, assertive and trendy. Table 4 indicates the performance of a range of electric cars. The 1990's will no doubt see increasing numbers of electric vehicles on the road.

There is increasing interest in utilising solar energy as the energy source for powered vehicles. The World Solar Challenge which was first run in Australia in 1987 between Darwin and Adelaide proved that solar powered vehicles need to be taken seriously. The winner of the race was the General Motors SunRacer which completed the distance at an average speed of 66 kmh and which achieved a top speed of 113 kmh. This success was due in part to the use of a high efficiency 'Magnequench' electric motor manufactured by GM Delco Remy division.

Make	Range	Top Speed	Acceleration
GM Impact	192 km	160 km/h	0-50 km/h in 4.2 secs
Volkswagen Jetta CitySTROMer	120 km	105 km/h	0-50 km/h in 12 secs
BMW 3-series	115 km	100 km/h	0-50 km/h in 12 secs

Table 4: Performance of various electric cars

The race was subsequently held again in 1990. The winner this time was an entry from the Biel School of Engineering in Switzerland. Their vehicle used high efficiency solar cells and were developed at the University of New South Wales using a laser technique to etch the cell surface and so increase its active area.

By the late 1980's, efficiencies for Silicon cells and those made using Gallium Arsenide were in excess of 20%. Subsequently a Gallium Arsenide device which operates in conjunction with a focusing element has achieved an efficiency of 37%. To provide an element of historical perspective, efficiency values were around 1% in the 1930's and 6% in the mid 1950's.

Assuming a vehicle surface area of 5 square metres on a partially sunny day with a solar radiation of 0.5kw/m² and with cells with 30% efficiency, there would be approximately 0.75kW of power available. For a vehicle of 1000kg and assuming 75% efficiency in the electric motors, this will produce speed of about 35kmh in 10 seconds. Such vehicles, must surely operate with significant battery reserves within the vehicle to augment conditions of poor solar radiation.

In fact it makes more sense to use the larger surface areas of the roofs of domestic houses to capture solar energy than the relatively small area of a motor vehicle. Where such areas can be utilised for solar power collection values of areas can be quite significant eg around 20 square metres. Assuming 6 hours of sun on average at 0.5kw/m² and at 30% collection efficiency, this equates to 65MJ of energy or 18kWh (kilo watt hours). The cost of this amount of energy through the National Grid is £1.33 at a cost of 7.37p/kwh. Already in Switzerland, this process of charging vehicles from solar panels on buildings is becoming common.

Reference should also be made to 'flywheel technology' where the energy of a spinning disk is used to propel a vehicle. Such devices usually operate within a vacuum environment and utilise ultra low resistance bearings. The materials used require to be ultra strong to prevent fracturing due to the large centripetal forces. While such vehicles have been demonstrated, no major car manufacturer has so far adopted this method of energy storage.

Summary: Due to a combination of technological advance and the need to reduce car emissions still further (particularly CO_2), the 1990's will no doubt see the beginning of the end of polluting vehicles. The whole process, however, will need a switch in investment on a colossal scale if this is to come about. With the public increasingly willing to be responsible in their use of the resources of Planet Earth it should be increasingly easy to convince the industrialists that the models in their showrooms are going to experience major changes in design and function. Why not write to them and communicate your views to them?

Further Reading:

The Green Car Guide, Paul Nieuwenhuis, Peter Cope and Janet Armstrong, Green Print, 1992.

Useful addresses:

Air Resources Board, PO Box 2815, 1102 Q Street, Sacramento, CA 95814, USA.

Electric Vehicle Association of Great Britain Ltd., 13 Golden Square, Piccadilly, London, W1R 3AG.

Electric Vehicle Council, 1111 19th Street NW, Washington DC 20036, USA.

Energy and Environment Research Unit, Faculty of Technology, The Open University, Milton Keynes, MK7 6AA.

General Motors Environmental Activities, 30400 Mound Road, Warren, Michigan, 48090-9015, USA.

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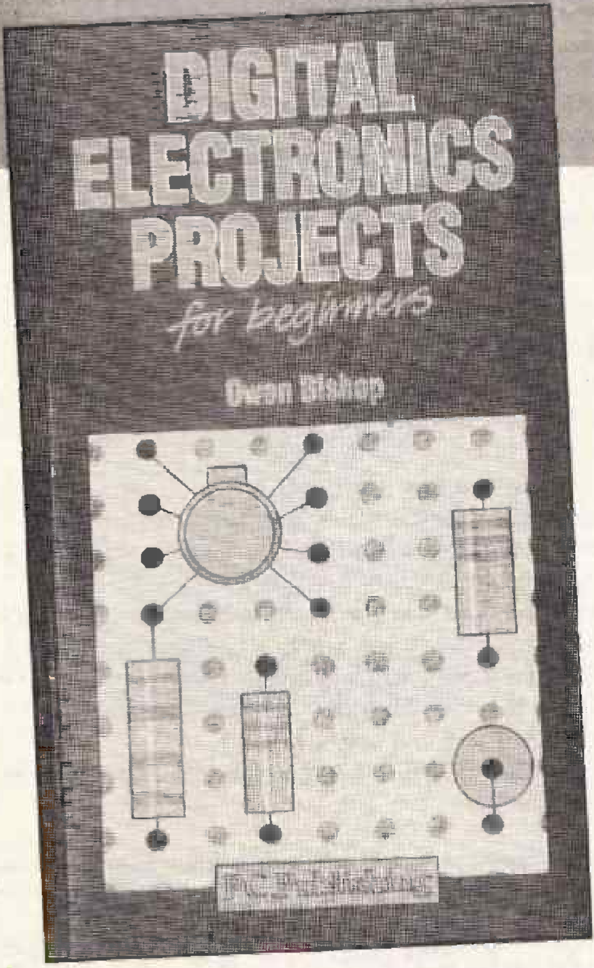

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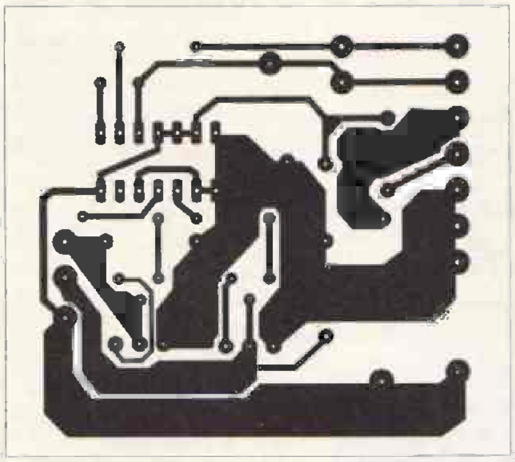
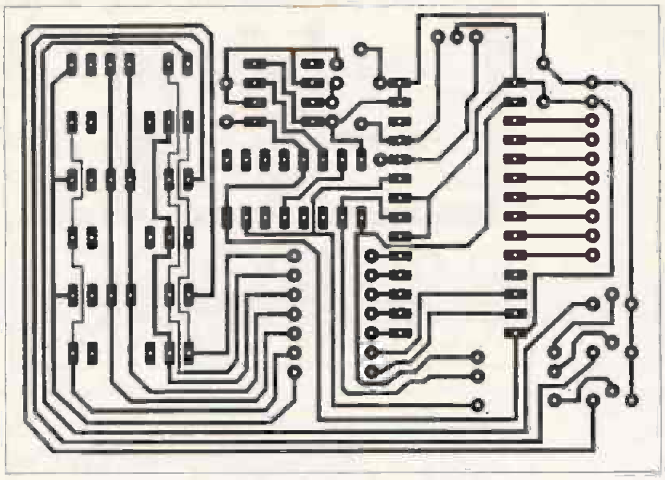


Mains Inverter



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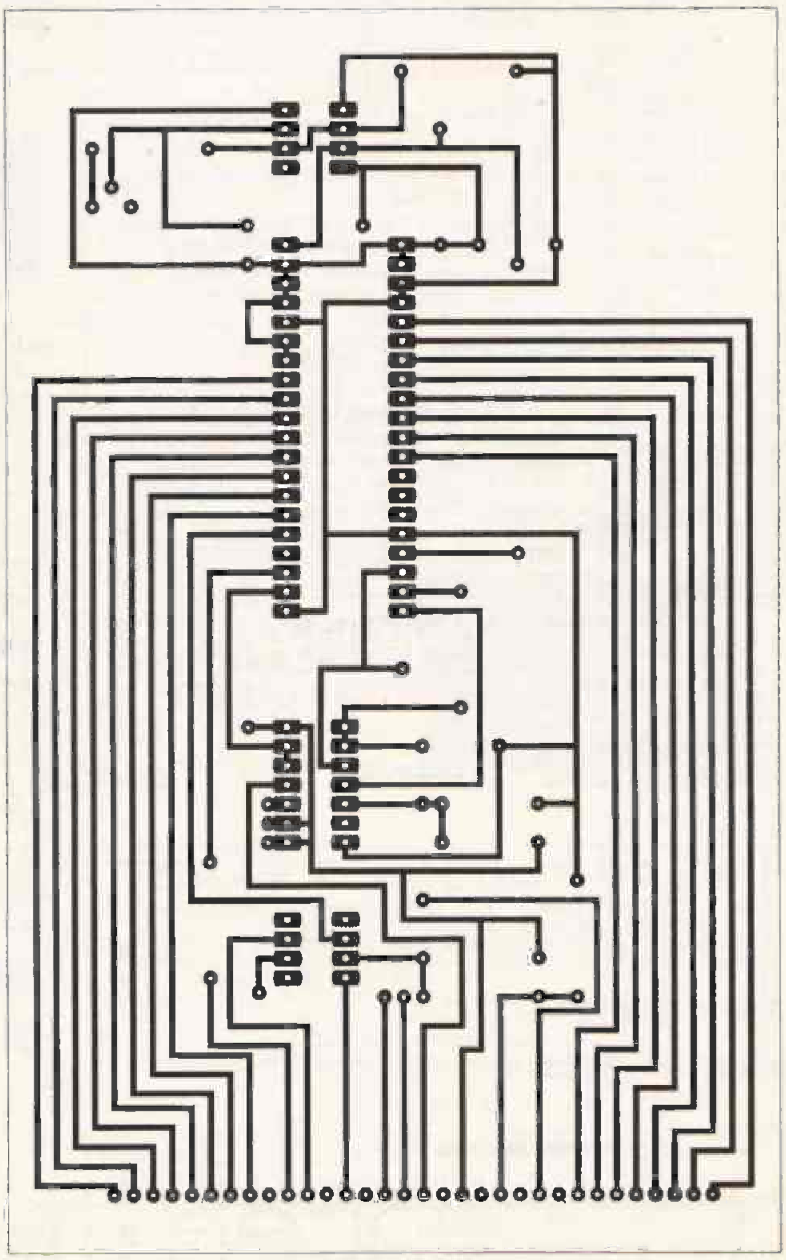
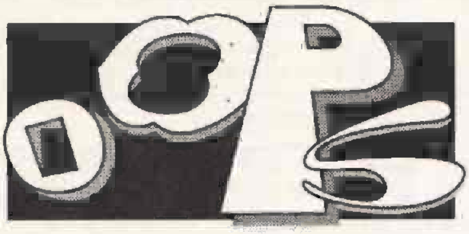


RS232 Interface



MIDI Keyboard August '92

The PCB overlay is correct but in Figures 1a,1c 3 and 4 all references to NC (normally closed) should read as referring to NO (normally open), and vice versa. On circuit diagram, R3 should go to +5V, and R4 to 0V.

Pin	PL2 Connection	PL3 Connection
10	Highest NO busbar	Highest NC busbar
9	Next NO busbar	Next NC busbar
8	"	"
7	"	"
6	"	"
5	"	"
4	"	"
3	"	"
2	Lowest NO busbar	Lowest NC busbar
1	+5V to pull ups	+5V to pull ups

It is necessary to connect each common key contact to the common line through adiode (1N4148), anode to the key contact, cathode to the common line to provide extra isolation.

Aerial Tuner Unit Oct '90

The circuit diagram in figure 1 should not show a connection between inductor L1 and the screened case. Follow the wiring diagram in Figure 3 as this is correct.

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E9108-2	Model Speed Controller-Main Board	F
E9108-3	Model Speed Controller-Power Supply	F
E9109-1	Geiger Counter	E
E9109-2	Hemisync Waveform Generator Board	G
E9109-3	Hemisync Pulse Generator Board	F
E9109-4	Hemisync Power Supply Board	C
E9109-5	Nighfighter Main Processor Board	O
E9110-1	Freeze Alarm	E
E9110-2	Document Saver	E
E9110-3	Prototype Designer	J
E9110-4	Nightfighter - Sound to Light (2 sided)	L
E9110-5	Nightfighter - Ramp Generator Board	F
E9110-6	Nightfighter - Cyclic Crossfade (2 sided)	M
E9110-7	Nightfighter - Strobe Board (2 sided)	J
E9110-8	Nightfighter - 8 Channel Triac Board	N
E9111-1	Digital Code Lock	L
E9111-2	Switched Mode Power Supply	E
E9111-3	Nightfighter Mode Selection (2 sided)	J
E9111-4	Nightfighter- Display Board (2 sided)	M
E9111-5	Nightfighter - Bass Beat Trigger (2 sided)	L
E9111-6	Nightfighter- Sequence Select (2 sided)	H
E9111-7	Nightfighter - Master Controller PSU	K
E9111-8	Nightfighter- Output Switch (2 sided)	M
E9112-1	Nightfighter Sensor Switch Master Control (2 sided)	L
E9112-2	Nightfighter Sensor Switch Channel Control (2 sided)	L
E9112-3	Nightfighter Sensor Switch Sound Trigger	H
E9112-4	Nightfighter Connector Board	F
E9112-5	Nightfighter Sensor Switch PSU	K
E9112-6	Nightfighter 8-Channel Input Interface (2 sided)	P
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E9201-2	Test Card Generator Board	M
E9201-3	LED Star (2 sided)	L
E9201-4	Enlarger Timer Main PCB (2 sided)	N
E9201-5	Enlarger Timer Selector Board (2 sided)	K
E9201-6	Enlarger Timer Switch PCB	E
E9203-1	MIDI Switcher- Main Board	L
E9203-2	MIDI Switcher- Power Suply	E
E9203-3	Sine Wave Generator (surface mount)	F
E9204-1	Auto Car Lights	F
E9205-1	Bat Detector	E
E9205-2	Pond Controller	F
E9206-FC	Stereo amplifier	G
E9206-2	Xenon flash trigger Main Board	J
E9206-3	Xenon flash trigger Flash Board	F
E9206-4	Scanner for audio generator	D
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E9207-5	AutoMate 5V/48V Mixer power supply	J
E9207-6	AutoMate Precision 17V power supply	J
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E9208-2	Touch Controlled Intercom (2 boards)	H
E9208-3	MIDI Keyboard	K
E9208-FC	Battery charger	F
E9209-1	Intercom for light aircraft	H
E9209-2	Alarm protector	C
E9209-3	Temperature controller	M
E9209-FC	45W Hybrid power amp	F
E9210-1	Universal I/O Interface for PC (2 Sided)	N
E2910-2	Rapid Fuse Checker	E
E9210-3	Heartbeat/Audio Listener	E
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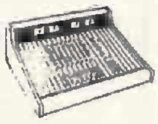

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Next Month

In our Christmas issue we have an interesting selection of projects for you. The next two cover PCBs will form the basis of a four channel infra-red remote controlled switching system. The receiver, presented next month is built to fit into a 'lightswitch-sized' box and is designed to work with commercially available touch dimmers. The transmitter will follow on in the February issue.

Something completely different on the project front for next month is a Macro-Heliograph receiver. A what? - you say! It's a device to detect very low frequency/very low power sound waves emanating from your garden using sunlight. There's nothing quite like it!

We also have an EPROM Programmer project for you to construct. Then there will be no fear of tackling projects containing EPROMs. Also as it is Christmas, the seasonal fading fairy lights could adorn your tree. See the January issue for details. **Out on Friday December 4th.**

The above articles are in preparation but circumstances may prevent publication

Last Month

Our November issue featured:

Nanotechnology
The Ten Year Capacitor
Auto Protection
AutoMate Pt7b
Audio Response Measuring System
Basic Multimeter Circuits
Universal I/O Interface for the PC Pt2
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10m TWIN SCREENED FLEX white pvc cover. Order Ref. 122.
2 x **WHITE PLASTIC BOXES** with lids, approx. 3" cube. Lid has square hole through the centre so these are ideal for light operated switch. Order Ref. 132.
2 x **REED RELAY KITS** you get 8 reed switches and 2 coil sets with notes on making relays and other gadgets. Order Ref. 148.
1 x **BIG PULL SOLENOID** mains operated. Has ½" pull, Order Ref. 871.
1 x **BIG PUSH SOLENOID** mains operated. Has ⅛" push. Order Ref. 872.
1 x **MINI MONO AMP 3W** into 4 ohm speaker or 1W into 8ohm. Order Ref. 268.
1 x **MINI STEREO 1W AMP**. Order ref. 870.
1 x **IN-FLIGHT STEREO UNIT** is a stereo amp. Has two most useful mini moving coil speakers. Made for BOAC passengers. Order Ref. 29.
1 x **MAGNETIC SECRET SWTICH** does not look like a switch and is supplied with a separate magnet to to operate it. Order Ref. 873.
1 x **0-1mA PANEL METER** full vision face 70mm square. Scaled 0-100. Order Ref. 756.
2 x **LITHIUM BATTERIES** 2.5V penlight size. Order Ref. 874.
2 x **3M TELEPHONE LEADS** with BT flat plug. Ideal for phone extensions, fax, etc. Order Ref. 552.
1 x **12V SOLENOID** has good ½" pull or could push it modified. Order Ref. 232.
4 x **IN-FLEX SWITCHES** with neon on/off lights saves leaving things switched ohm. Order Ref. 7.
2 X **6 1A MAINS TRANSFORMERS** upright mounting with fixing clamps. Order Ref 9.
12 x **30 WATT REED SWITCHES**. It's surprising what you can make with these – burglar alarms, secret switches, relay, etc. Order Ref. 13.
2 x **HUMIDITY SWITCHES**, as the air becomes damper the membrane stretches and operates a micro switches. Order Ref.32.
5 x **13A ROCKER SWITCH** three tags so on/off, or changeover with centre off. Order Ref. 42.
2 x **FLAT SOLENOIDS** you could make your multi tester read AC amps with this. Order Ref. 79.
1 x **SUCK OR BLOW OPERATED PRESSURE SWITCH** or it can be operated by any low pressure variation such as water level in water tanks, Order Ref. 67.
1 x **6V 750mA POWER SUPPLY**, nicely cased with mains input and 6v output leads. Order Ref. 103A.
2 x **STRIPPER BOARDS**, each contains a 400V 2A bridge rectifier as well as dozens of condensers, etc. Order Ref. 120.
12 x **VERY FINE DRILLS** for pcb boards etc. Normal cost about 80p each. Order Ref. 128.
5 x **MOTORS FOR MODEL AEROPLANES**, spin to start so needs no switch. Order Ref. 134.
6 x **MICROPHONES INSERTS** magnetic 400 ohm also act as speakers. Order Ref. 139.
6 x **NEON INDICATORS** in panel mounting holders with lens. Order Ref. 180.
1 x **MAINS SOLENOID** very powerful as ½" pull or could push it modified. Order Ref. 199.
1 x **ELECTRIC CLOCK** mains operated, put this in a box and you need never be late. Order Ref. 211.
4 x **12V ALARMS** makes a noise about as loud as a car horn. All brand new. Order Ref. 221.
2 x **(8" x 4") SPEAKERS** 16 ohm 5 watts so can be joined in parallel to make a high wattage column. Order Ref. 243.
1 x **PANOSTSAT** controls output of boiling ring from simmer up to boil. Order Ref. 252.
2 x **OBLONG PUSH SWITCHES** for bell or chimes, these can switch mains up to 5A so could be foot switch if fitted in pattress. Order Ref. 263.
50 x **MIXED SILICON DIODES**. Order Ref. 293.
1 x **6 DIGIT MAINS OPERATED COUNTER** standard size but counts in even numbers. Order Ref. 28.
2 x **6V OPERATED REED RELAYS** one normally on, other normally closed. Order Ref. 48.
1 x **CABINET LOCK** with 2 keys. Order Ref. 55.
1 x **MAGNETIC BRAKE** for stopping motor or rotating tool. Order Ref. 66.
1 x **SHADED POLE MAINS MOTOR** ¾" stack so quite powerful. Order Ref. 85.
2 x **5" ALUMINIUM FAN BLADES** could be fitted to the above motor. Order Ref. 86.
1 x **CASE** 3¾ x 2¼ x 1¾ with 13A socket pins. Order Ref. 845.
2 x **CASES** 2½ x 2¼ x 1¾ with 13A pins. Order Ref. 565.
4 x **LUMINOUS ROCKER SWITCHES** 10A mains. Order Ref. 793.
4 x **DIFFERENT STANDARD V3 MICRO SWITCHES**. Order Ref. 340.
4 x **DIFFERENT SUB MIN MICRO SWITCHES**. Order Ref. 313.
LIGHTWEIGHT STEREO HEADPHONES moving coil so superior sound. Order Ref. 896.
LOUDSPEAKER 6½" 4 OHM 12 Watt max. Order Ref. 900.

BARGAINS – GALORE

DRY BATTERIES CAN BE RECHARGED but not with a normal d.c. charger, it must be a periodic current reversal type. We can supply the kit, with data. **£9.** Order Ref. 9P10.
SOLAR ENERGY EDUCATIONAL KIT – an ideal present for electronics students, it shows how to make solar circuits and electrical circuits, how to increase the voltage or current, how to use solar power to work a radio, calculator, cassette player and to charge nicad batteries. The kit comprises 8 solar cells, one solar motor, fan blades to fit motor and metal frame to hold it to complete a free-standing electric fan. A really well written instruction manual makes this a lovely little present. Price **£8.00.** Order Ref. 8P42B.
HEAVY DUTY FLEX 3 core 15A, grey outer, 10m for **£2.50,** Order Ref. 2.5P3. 3 core 20A, white outer, 10m for **£3,** Order Ref. 3P109. 2 core 20A, 15m for **£3,** Order Ref. 3P110.
HIGH POWER SWITCH MODE PSU normal mains input. 3 outputs:- +12V at 4A, +5V at 16A and -12V at ½A. Completely enclosed in plated steel case. Brand new. Our special offer price of **£9.50** extended until 31st August. Order Ref. 9.5P1.
MULTI-CORE CABLES all with 8A 230V cores so suitable for disco and other special lighting effects. With earthcable woven screen and thick pvc outer. 3 core, **30p** per metre, 16 core **50p** per metre, 18 core, **80p** per metre, 25 core, **£1** per metre and 36 core, **£1.50** per metre.
ULTRA THIN DRILLS Actually 0.3mm. To buy these regular cost a fortune. However, these are packed in half dozens and the price to you is **£1** per pack, Order Ref. 797B.
YOU CAN STAND ON IT! Made to house GPO telephone equipment, this box is extremely tough and would be ideal for keeping your small tools. Internal size approx. 10½" x 4½" x 6" high. These are complete with snap closure lip and shoulder-length carrying strap. Taken from used equipment but in good condition, price **£2**. Order Ref. 2P283B.
POWER SUPPLY WITH EXTRAS mains input is fused and filtered and the 12V dc output is voltage regualted intended for high class equipment, this is mounted on a PCB and also mounted on the board but easily removed, are 2 12V relays and a Piezo sounder. **£3.** Order Ref. 3P80B.
ULTRA SONIC TRANSDUCERS 2 metal cased units, one transmits, one receives. Built to operate around 40kHz. Price **£1.50** the pair, Order Ref. 1.5P/4.
100W MAINS TRANSFORMER normal primary 20-0-20 at 2.5A. **£4**. Order Ref. 4P24. 40V at 2.5A, **£4,** Order Ref. 4P59. 50V at 2A, **£4,** Order Ref. 4P60.
PHILIPS 9" HIGH RESOLUTION MONITOR black & white in metal frame for easy mounting, brand new still in maker's packaging, offered at less than price of tube alone, only **£15,** Order Ref. 15P1.
16 CHARACTER 2-LINE DISPLAY screen size 85mm x 36mm, Alphanumericc LCD dot matrix module with integral; micro processor made by Epson, their Ref. 16027Ar, **£8,** Order Ref. 8P48.
INSULATION TESTER WITH MULTI METER internally generates voltages which enables you to read insulation directly on megohms. The multimeter has four ranges, AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are ex British Telecom but in very good condition. tested and guaranteed OK, probably cost at least £50 each yours for only **£7.50,** with leads, carry case **£2** extra, Order Ref. 7.5P/4.
MAINS 230V FAN best make "PAPST" 4⅝ square, metal blades, **£8**. Order Ref. 8P8.
2MW LASER Helium neon by Phillips, full spec. **£30,** Order Ref. 30P1. Power supply for this kit form with case is **£15,** Order Ref. 15P16. or in larger case to house tube as well **£18,** Order Ref. 18P2. The larger unit, made up, tested and ready to use, complete with laser tube **£69,** Order Ref. 69P1.
1/3 HP 12V MOTOR — THE FAMOUS SINCLAIR C5 brand new. **£15,** Order Ref. 15P8.
SOLAR CHARGER holds 4AA nicads and recharges these in 8 hours, in very neat plastic case, **£6,** Order Ref. 6P3.
FERRITE AERIAL ROD 8" long x 3/8 diameter, made by Mullard. Complete with 2 coil formers. 2 for **£1,** order Ref. 832B.
AIR SPACED TRIMMER CAPS 2-20 pf ideal for precision tuning UHF circuits, 4 for **£1,** Order ref. 818B.
MAINS ISOLATION TRANSFORMER stops you getting "to earth" shocks. 230V in and 230V out. 150 watt upright mounting, **£7.50,** Order Ref. 7.5P/5 and a 250W version is **£10,** Order Ref. 10P79.
5RPM MAINS DRIVEN This is a shaded pole motor. **£5,** Order Ref. 5P54.
POWER SUPPLY UNIT mains in, dc out, cased 4.5V 100mA **£1,** Order Ref. 104. 6V 200mA **£1,** Order Ref. 103. 6V 700mA **£1,** Order Ref. 103A. 24V 200mA **£2,** Order Ref. 2P4. 12V 2A **£6,** Order Ref. 6P23.
AMSTRAD POWER UNIT 13.5V at 1.9A encased and with leads and output plug, normal mains input, **£6,** Order Ref. 6P23.
ATARI 65XE at 65K this is quite powerful, so suitable for home or business, unused and in perfect order but less PSU, only **£19.95,** Order Ref. 19.5P/5B.
80W MAINS TRANSFORMERS two available, good quality, both with normal primaries and upright mounting, one is 20V 4A, Order Ref. 3P106 the other 40V 2A, Order Ref. 3P107, only **£3** each.
PROJECT BOX is approx 8" x 4" x 4½" metal sprayed grey, louvred ends for ventilation otherwise undrilled. Made for GPO so best quality, only **£3** each, Order Ref. 3P74.
WATER VALVE 230V operated with hose connctions, ideal for auto plant spray or would control air or gas into tanks etc. **£1** each, Order Ref. 370.
BT POWER SUPPLY UNIT output 9.5V AC at 600mA, in black plastic case with 13A plugs to go straight into socketand approximately 3 metres of twin output lead. Price **£1.50**. Order Ref. 1.5P7.
BUILDING YOUR OWN PSU, battery charger, night light, or any other gadget that you want to enclose in a plastic case and be able to plug into a 13A socket? We have two cases, one 3½" x 2¼" x 1¾" deep, **£1** each, Order Ref. 845. The other one is 2½" x 2¼" x 1¾" deep, 2 for **£1,** Order Ref. 565.

500V BRIDGE MEGGER developed for GPO technicians the Ohmeter18B is the modern equivalent of the bridge megger. 9V battery operated, it incorporates a 500V generator for insulation testing and a null balance bridge for very accurate resistance measurement. Ex B.T. in quite good condition with data & tested. Yours for a fraction of the original cost, **£45,** Order Ref. 5P167.
EXPERIMENTING WITH VALVES don't spend a fortune on a mains transformer, we can supply one with standard mains input and secs. of 250-0-250V at 75mA and 6,3V at 3A. **£5,** Order Ref. 5P167.
15W 8 OHM 8" SPEAKER & 3" TWEETER made for discontinued high quality music centre, gives real hi-fi, and only **£4** per pair, Order Ref. 4P57.
3V SOLAR PANEL price **£3,** Order Ref. 5P189.
WATER PUMP very powerful with twin outlets, an ideal shower controller, mains operated, **£10,** Order Ref. 10P74. Ditto but with a single outlet, same price & order ref. Please specify which one you require.
0-1MA FULL VISION PANEL METER 2¾" square, scales 0-100 but scale easily removed for re-writing, £1 each, Order Ref. 756.
VU METER illuminate this from behind becomes on/off indicator as well, 1½" square, **75p** each, Order Ref. 366.
EDGE-WISE PANEL METER ideal when short of panel space only 40 x 14mm, also have built-in led, 500µA f.sdd, scaled 0-5, **£1** each, Order Ref. 131.
THIS MONTH'S SNIP is a Japanese-made 12v DC or battery operated, brushless axial fan. 93mm square, its optium is 12 bit it performs equally well at only 6v and its current then is only 100mA so it could be made into a hand-held dry battery-operated cooler. Or, on your desk operated by a p.s.u. or in the car using the lighter socket. Snip price only **£4,** Order Ref. 4P65. Mains power unit to operate this at variable speeds, **£2,** Order Ref. 2P3.
MOVEMENT ALARM goes off, with the slightest touch. Ideal to protect car, cycle, doorway, window, stairway, etc. etc. Complete with Piezo shrieker, ready to use. Only **£2** (PP3 battery not supplied). Order Ref. 2P282.
PROJECT BOX a first-class, Japanese two-part moulding size 95 x 66 x 23mm. held together by 2 screws, take a battery and a PCB and is ideal for many projects. To name just a few, the washer bottle monitor, the Quicktest and the model railway auto signal,described in September's issue of E.E. This is nicely finished and very substantial. You get 2 for **£1,** Order Ref. 876.
HOLD IT MAGNETIC BASE embedded is a circular metal shallow disc, diameter approx. 65mm (2½"), is the most powerful magnet. We have yet to find anyone who can remove this with his fingers. Ideal for adding extra shelves inside a metal case or to glass without drilling. Its uses, in fact, are innumerable. Price **£2** each, Order Ref. 2P296.
AM/FM MAINS RADIO CHASSIS with separate LCD module to display date and time. This is complete with loudspeaker and is main powered but it is not cased. Price **£3.50,** Order Ref. 3.5P5.
2, 3 AND 4 WAY TERMINAL BLOCKS the usual grub screw types. Parcel containing a mixture of the 3 types, giving you 100 ways for **£1,** Order Ref. 875.
12/24V DC SOLENOID constructed so that it will push or pull, plunger is a combined rod and piston. With 24v is terrifically powerful but is still very good at 12v and, of course, with any intermediate voltage with increasing or decreasing power. It has all the normal uses of a solenoid and an extra one, if wired in series with a make and break, this could be a scribing tool for marking plastics and soft metals. We welcome other ideas and will give a £25 credit voucher for any used. Price **£1,** Order ref. 877.
2M 3-CORE LEAD terminating with flat pin instrument socket, **£1,** Order Ref. 879. Ditto but with plug on the other end so that you could use this to extend an instrument lead. **£1.50,** Order Ref. 1.5P10.
20W 5" 4 OHM SPEAKER mounted on baffle with front grille, **£3,** Order Ref. 3P145. Matching 4 ohm 20W tweeter on separate baffle, **£1.50,** Order Ref. 1.5P9.

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