ETI ELECTRONICS TODAY INTERNATIONAL

THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

JULY 1990 £1.60

FOOTSTEP INTRUDER ALARM

COMPACT DFM

HARNESSING THE WIND

Alternative Technology becomes a commercial reality

GUITAR PRACTICE AMP

TRANSISTOR TESTER

SORTING SIGNALS FROM NOISE

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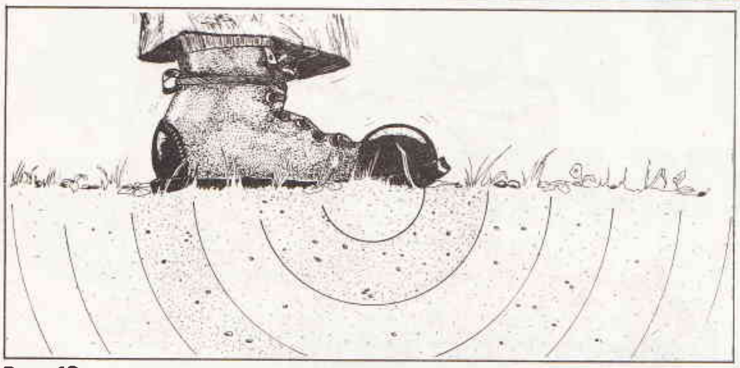
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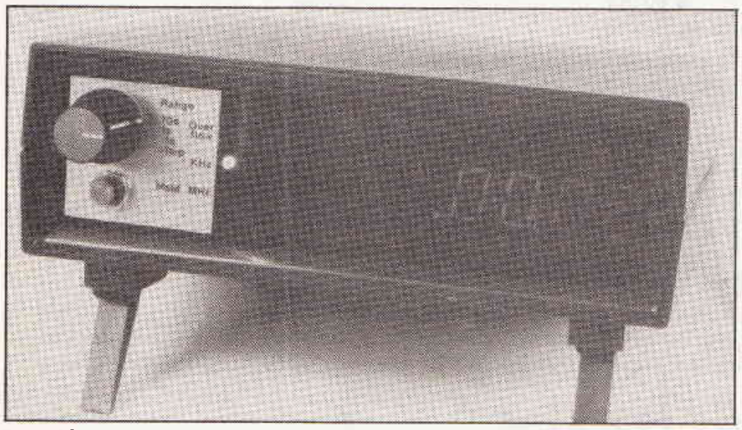
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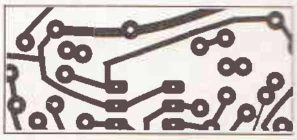
REGULARS



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ETI
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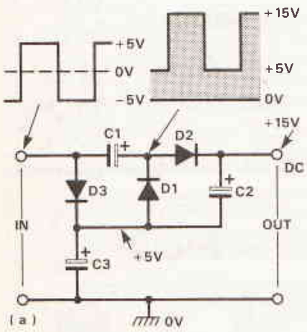
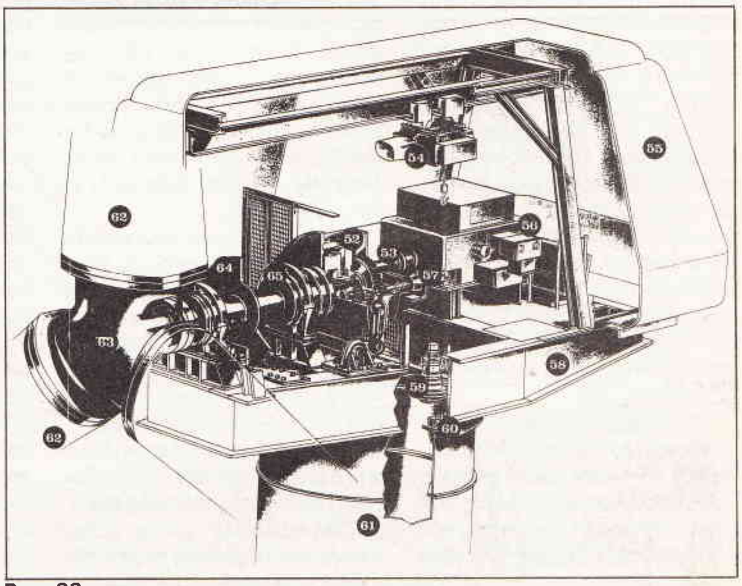
FEATURES/PROJECTS



ETI Audio



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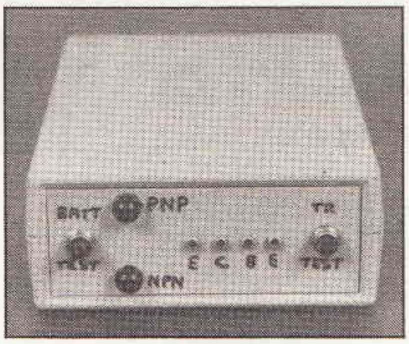

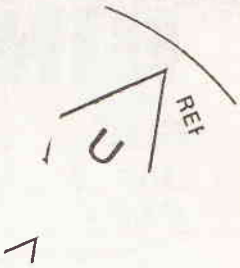

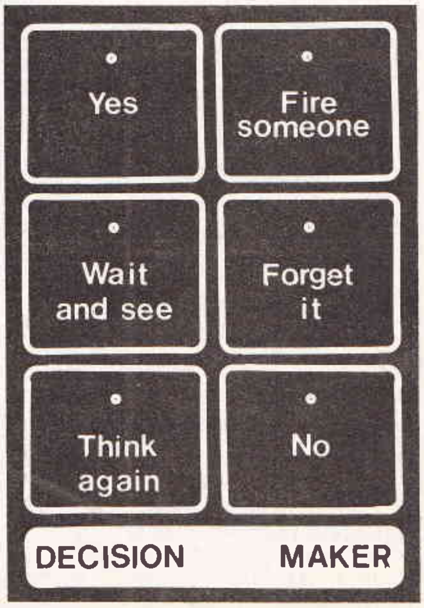

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OPEN CHANNEL

The word *telecommuting* is almost self-explanatory — instead of commuting to a central office, telecommuters work at home, in touch with their employers (or at least those who pay them for work done) using common communications means. Telecommuters, also known as networkers or homeworkers, are desk bound — not office bound — people, who do things with a computer for money. Thus, the costs of actual commuting (borne by the employee) are eliminated. Also the cost of office space (borne by the employer) are dispensed with. There are non-financial advantages, too.

Journalism is a career ideally situated to telecommuting. Nearly six years ago, I gave up full-time employment in journalism in London to become self-employed, freelance and to work at home. Nobody had even heard the word *telecommuter* in those days.

Prior to this I commuted by British Rail from the midlands, with a total journey time of five hours. Couple this with the normal eight hours work in the office and I had a total thirteen hours working day. Not good for family life. And train fares currently run into thousands of pounds a year.

So, freelance journalism seems a good option to me. Now I rarely leave the house in the course of my work. There are no interruptions — by the 'phone, by colleagues wanting to waste time with a chat, by business meetings and so on. Time is now precise — I know it will take me, say, an hour and a half to write this column, so I can plan much more effectively.

Nevertheless some companies are beginning to see the advantages of allowing their full-time employees to telecommute. Rank Xerox and ICL are main examples.

But I don't think all employees could telecommute. One of the problems with telecommuting is only a certain type and number of personnel will be able to do it. First, it's only when you reach a certain level of competence and reliability will you find companies willing to allow you to do it. Self-starters, people who will work conscientiously even when the boss isn't looking over their shoulders are probably suitable. Second, it's not the sort of thing which suits everyone. It can be odd, stuck at home with no-one to talk to except the cat. So, it you need the stimulation of others around you, telecommuting is probably not for you.

But supposing it is, what do you need to telecommute? In the simplest form, not much more than many people already have. A computer to do your things with (whatever those things may be); a telephone so you can verbally communicate with your employer or customer; and arguably a fax machine and/or modem to transmit and receive work done and work to do. However, such urgent communications means are rarely needed. Royal Mail is normally fast enough.

Finally, you need either an aware employer, or you have to go it alone, on a freelance basis. If you commute, are reliable, and have a job which need not be done in an office, the rewards in terms of standard of living are immeasurable.

Keith Brindley

BLUEPRINT

Blueprint is a column intended to provide suggested answers to readers' electronics design problems. Designs are only carried out for items to be published, and will not be prototyped by the columnist. Circuits published in Blueprint are believed to work, but may need minor alteration by the reader after prototyping. Individual correspondence will not be entered into, save as necessary to prepare items for publication.

Here is an audio query with a difference:

> Dear Sir/Madam,
>
> I am interested to know whether a circuit can be designed to effectively jam any sound in an adjustable radius around it. For example, if I have my hifi on loud, could I cancel the sound outside the listening area to avoid disturbing other people?
>
> Yours sincerely
>
> **A Q Ahmad**
> **Bolton.**

The short answer is "No". There is no practical means to produce the effect you want. I only wish there were, as I have had neighbours, too. However, the topic has exercised the minds of designers for some time, and it may be worth reviewing what can been achieved.

As featured in ETI last month, at least one car manufacturer (Lotus) has devised a microprocessor controlled noise reduction system for cars. Transducers measure the noise waveform and the microprocessor system calculates the signal required to cancel as much of the noise as possible. An array of amplifiers and loudspeakers is used to achieve this, and it is said to be very effective.

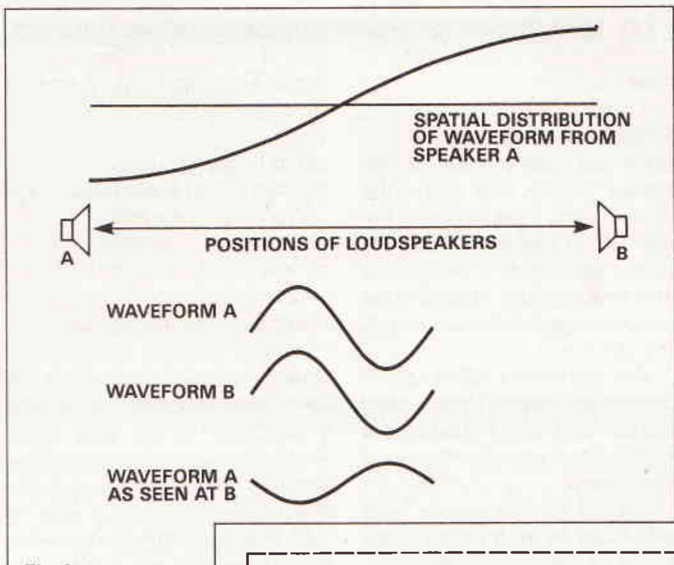


Fig 1

Reflection

Note, however, that the aim is limited to partial noise cancellation in the upper half of an enclosed space whose acoustic characteristics are well known. This last point is important. In an enclosed space, the sound field from any one sound source will be affected by reflections from surfaces, resonances and so on. The positioning of objects in the area can change the characteristics substantially. If sound is generated or reflected from several different directions, either each must be cancelled individually, or the total effect at some point must be calculated and a cancelling signal introduced to cancel the effect at that point only.

To illustrate this, consider the simple case of two loudspeakers each fed with the same sinewave signal, and situated half a wavelength apart. If the volume of one speaker is reduced to match the sound from the other speaker at this point, then cancellation will take place (assuming that only the direct signal path exists, and there are no reflections). This is illustrated in Figure 1. Note that the cancellation only occurs at the loudspeaker with the reduced volume. Adjustment of sound level in this channel can cancel the waveform at any other point at which the signals from the two loudspeakers are 180° out of phase, but cancellation occurs nowhere else.

This is the bad news. The corresponding good news is that if the loudspeakers are less than ¼ wavelength apart, then a degree of sound reduction over the whole area can be achieved. This is fine for a sinewave, but not for a normal music waveform. However, simple soundproofing techniques can cut middle and treble sounds from adjacent rooms, leaving the bass as the main problem. From the reasoning above, low frequencies are easier to cancel over a given range then high frequencies.

To reduce the annoying effect of bass feedthrough to adjacent rooms, a bass or sub bass loudspeaker in the adjacent room, fed with a suitably phased low frequency signal, can cut the sound. Such a scheme, illustrated in Figure 2, may be sufficient to reduce noise below the point at which it is irritating. Considerable experiment may be needed to achieve the best results in any given situation.

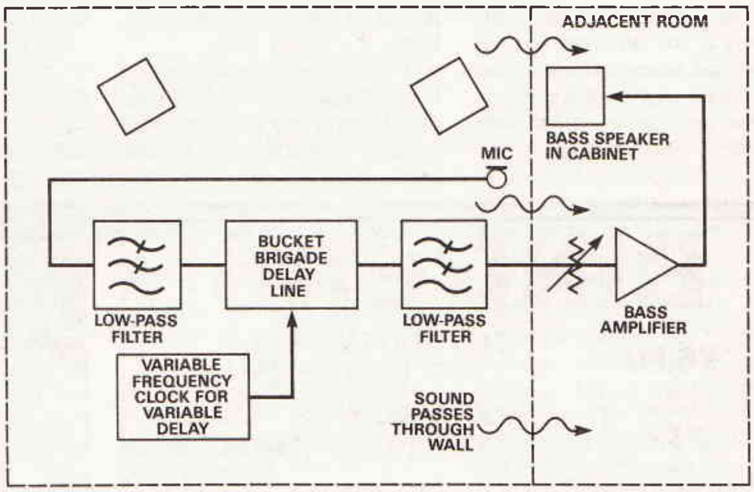


Fig 2

Andrew Armstrong

READ\WRITE

ETI LETTERS

Superscope Hints

Before I make too many comments on the Superscope project, I would like to thank you for a splendid effort both theoretically and practically. I've had many parts lying around for several years waiting for this to come up.

I had great difficulty in getting the sync/trigger working and was surprised to find hitherto unmentioned 'Oops'. The PCB tracks for Q302 and Q303 must be wrong if you are using BC169C. However, the circuit works OK by substituting BC109C, which has the more usual E,B,C configuration.

Also Q304 needs to be cross-legged to line up. The drawing shows a different transistor may have been used in this position but the 'free-run' works OK with BC107.

I've had difficulty obtaining an LM710 comparitor, ending up at Guildford. Radiospares and Maplin no longer stock this. I cannot locate a supplier for 15μ 450V electrolytics. I would have thought 15μ a non-standard value. At present I'm running on temporary power supplies using HF EHT on a Brimar D77-220-GH small rectangular CRT with about 1000V EHT. I've still got plenty of scan power in hand.

I had a lot of trouble with parasitic oscillation on the Y-amp but by using just 4 inches of wide spaced feeder and two small encapsulated chokes right adjacent to the collectors of the Y output transistors, it completely cured the problem. (It's still at the hook-up stage but I'm very happy with it.)

I've used an LM592 differential amplifier which seems OK, and also FET 2N3819 instead of BF256 which I couldn't find listed anywhere.

SW501 should strictly be 3 pole 4 way on the Y2 amp, not 4 pole 3 way as stated in the Parts List.

I've had trouble with Maplin's Make Before Break Wafers. One out of a set of four was assembled wrongly where the wiper didn't line up with the other three. I'm waiting for a replacement.

I have just to get over the Beam Blanking now. I've hooked a pulse amplifier up as you suggest but it doesn't seem to have much effect. I'll have to borrow a 'scope and sort it out.

Anyway, thanks again for the design.

Aubrey Holman
Burgess Hill,
West Sussex

Glad to hear that you're getting on well with the Superscope project. I'm sure other readers who are working on the project will find your suggestions and hints useful.

Dennis Stanfield replies:

I was pleased to read Mr Holman's letter containing both praise and constructive criticism. I was glad to see that he is experimenting with yet another type of C.R.T. As I mentioned in the original articles I was keen to see constructors experimenting with changes to the circuit.

On to his problems.

Re Q307, the BC109C specificed is OK but the base lead needs to be bent through between the emitter and collector leads. The BC107C used by Mr Holman should work just as well. In fact most of the small signal transistors used throughout the design are non-critical and normal substitutes may be used.

The LM710 was purchased from Radiospares. I did not know that they had deleted this item from their lists. An alternative supplier is Grandata Ltd., who may be contacted on 081-900-2329.

The 15μ capacitors are not critical and were simply to hand at the time. Maplin's 10μ 450V axial types will serve just as well and are of similar physical size.

Parasitic oscillations are always difficult to sort and can sometimes arise from the most unlikely sources. Careful layout and maximum separation of the Y1 and Y2 leads whilst keeping these as short as possible goes a long way to preventing parasitics. Varying the inductance in the leads using a choke could have an adverse effect on frequency response and this would be a matter for experimentation but obviously in this case it works.

The LM592 is a pin-for-pin replacement for the 733 and appears to be more widely available. BF256s are available from Greenweld, Watford Electronics, P.M. Components and several other suppliers. However the 2N3819s should be OK.

Yes, the switch on the Y2 amp should be a 4-way type.

On the question of beam blanking, without specification for this tube type I can't really give an authorative reply and experimentation is the only solution, primarily in the values of the resistor and high voltage capacitor in the collector lead of the BD115.

New Amps For Old

The following should be of interest to those who, like myself, have built the original Linsley Hood 80W Amplifier (ETI June '84) and do not wish to go to the expense of buying the new power amp board to upgrade the amplifier.

First remove the angle bracket holding all the power transistors, saw it into three sections, one holding two power transistors, and one each holding the MOSFET power transistors. Cut away all wiring between MOSFETs and power amp boards. Make 4 small brackets and bolt these straight onto the power amp board then glue the angle bracket using epoxy resin to board.

This allows a much shorter length of wiring to the MOSFETs, new gate resistors and the series resistors R16 and R17 deleted. Upgrade as in ETI May 89, fitting Q9, C21 etc. C1 should be upgraded to 470n polypropylene (supplied by Maplin) as this is the direct signal path. RV1 should be changed for an APLS version, concentric type (note no balance control, R9-390R as in July ETI 1984).

The power supply can be upgraded as in May ETI 89. The power supply MOSFET heat sink can now be moved neare to the power supply board. A new smaller heat sink works OK. The input sockets can be changed from phono to BNC ensuring a high grade connection. All internal wiring should be solid core signal wire.

I have built the amp into a large rack mounting industrial cabinet to allow at a future stage, the installation of the pre-amp section. The output from the pre-amp can then be directly connected to the power amp volume control.

The problem with the MJ2501, I solved by fitting a MJ11015 in the original design. All earth returns, except the small signal leads are made with solid core heavy duty wire.

My equipment consists of a modified Dias turntable, Rega RB 300 arm with a Glanz cartridge and Stax-Lamba electrostatic loudspeakers.

The JLH modifications seem to give the amp an even greater separation of instruments, better HF and LF response with a greater clarity. It gives a certain air which makes you feel that you really are at the performance. Tape hiss is more obvious but this only shows the clarity of the amplifier.

Full marks to JLH who gave me a faith in transistors after years of building valve units.

We also await the pre-amp section to this much admired amplifier.

D. Lucas
Glasgow

Remote Control Cable

Thank you very much for the most illuminating article on Cable TV, in ETI April 90.

I am a subscriber to the Maxwell Cable TV in Eastbourne which relays Sky programmes and is distributed via pairs of wires and an 'inverter'. I use a Sony Multistandard TV which has both UHF and VHF facilities. I wonder if I could bypass the inverter and connect the VHF signals to the TV directly, thereby putting to use the remote channel changing facility of the TV.

I would be most grateful for your advice on this matter, and if possible on how to go about doing it.

A S Joseph
Eastbourne

Jim Slater replies:

I was pleased to hear that you found the ETI Cable TV article helpful, and interested to hear that you are a subscriber to the Eastbourne cable system; some years ago I had the job of talking to the residents of East Dean to make excuses as to why the broadcasters did not provide a satisfactory service in some parts of the area!

Your idea of trying to get at the cable signals directly, so that you can make use of the remote control unit, is an interesting one, which would work if you were connected to a system which sends signals around at VHF, although I dread to think what the cable company might say! From what you tell me, however, it seems clear that you are connected to an HF multipair system. These use frequencies of anywhere between 3 and 30 MHz on the different wires, and your receiver must be switched to the appropriate wires to display the pictures from any particular channel. The signals coming along the wires are not suitable for direct connection to any 'standard' television receiver, and so I am afraid that there is no alternative but to use the 'inverter'.

It seems hard, however, in these days when everything is remote-controlled, for you to have to get up and turn a switch every time you want to change channel, and I think it might be worth talking to the cable company to see if a suitable remote control receiver is suitable.

Down To Earth

An interesting and down to earth series of articles on Earth Current Signalling from George Pickworth. However, regarding Part 3, I cannot agree with George Pickworth on the information available for values suitable for C Type amplifiers.

I have operated a pair of PX4 triodes in a similar circuit to Figure 1 in the article, replacing the 2N3055 pair and modifying the power control circuitry to allow for the extra current drain. Of course, the superb linearity of the PX4 makes is ideal for positive earth current experiments — especially in marshland where single copper rods are easily inserted and give superior results over the spade or fork idea. The ammeter in the centre tap of the power transformer shown in the figure will of course have to be replaced by a 3 amp fuse.

R Harry
Bristol

RIAA Please!

Over the past few years your magazine has published several hi-fi amplifier designs. In these designs a huge variety of approaches has been seen, most of which have been clearly explained in the articles. The exception which springs to mind is RIAA phono equalisation. In each amplifier a series of active filters are shown, but little explanation of RIAA characteristics is offered.

I'm writing to ask whether someone could produce an article on RIAA compensation circuits including details on what they must achieve (i.e. the reference curve), how to go about designing them, and a couple of examples of hi-fi quality circuits with a breakdown as to which components are performing which part of the compensation.

I think an article of this kind would be very popular and I certainly would appreciate the lifting of the veil from this branch of audio electronic design.

S A Baker
Gloucester

If anyone out there is an expert in this field, and would like to try writing an article, we will gladly consider it for publication.

BT Disapproval

An article published in the May edition of ETI concerning a "Phone Lock" has been brought to my attention. You will recall that the article outlines how to build an electronic circuit which will act as a password-protected call barrer to limit the calls made on a particular telephone outlet. It further details connection of the device to BT lines and how it may be fitted within a telecom socket.

I would like to point out a number of concerns that we have with this article and to place it within the current regulatory regime. As you may be aware, it is a legal requirement that any device connected to a public telecommunications network in this country requires approval. The body normally responsible for evaluating apparatus against British Standards is BABT. The prime reason for approvals is to ensure that network safety is maintained. You do make mention of the subject but the requirement to pass compliance testing by BABT before being connected to the network is interpreted as meaning "the unit must be capable of getting BABT approval". This phrase combined with the use of BABT Opto-isolators would lead the reader to believe that it was perfectly acceptable to connect to the network without BABT approval. This also extends to any devices connected to the parallel or serial ports of the phone lock.

There are two further issues of serious concern. The first involves unauthorised persons disassembling the master socket and making connection within. The master socket forms part of the network and remains the property of British Telecom. Accordingly, any alteration to the socket would require the prior approval of BT. We take a serious view of anyone tampering with it or any wiring on the line side since this may result in serious harm to the network or persons working on it. The second item concerns emergency access. If my reading of the article is correct an attempt to contact the emergency services by dialling 999 would fail, as a first digit of 9 excludes all calls under the password scheme. The standard for call barring devices specifically excludes this. I am sure that you would agree that this could have most serious and unfortunate consequences.

In view of the above I believe that it important to clarify the approval requirements and the restriction on opening the master socket to your readers.

Finbarr Ring
Government Relations Department
British Telecom

Kevin Kirk will reply next month

NEWS

VISION ON

Sony Corporation has announced the "Sony Design Vision 1990", which challenges students worldwide to create innovative designs for the theme "Person-to Person Communication: The Telephone".

Sony hope that the design competition will promote global communication through design. This year's theme highlights the importance of the telephone as a means of communication. Sony hopes that through this theme, students of design will closely examine the process of interaction between people and propose new possibilities for communication.

Sony are offering 36 prizes, of between $1,000 and $10,000 plus lots of Sony goodies.

The closing date for the design competition is July 31 1990, and it is open to anyone who is a student on that date and to 1990 graduates. For details contact: Sony Design Vision 1990, c/o Gabrielle Sommer, Corporate Communications, Sony Europa GmbH, Hugo-Eckener-Str 20, 5000 Koln 30, West Germany.

WHO YOU GONNA CALL?

Paperless communication has been technologically possible for many years, yet many businesses are slow to take up its advantages.

Paperbusters is run by a consortium of European market leaders in Electronic Data Interchange (EDI), including Hapag-Lloyd UK International, International Network Services Ltd, Marinade Ltd, National Westminster Bank plc, Scicon Industry and SITPRO (the Simpler Trade Procedures Board). The aim of the consortium is to demonstrate the ease and benefits of using paperless business communications for both national and international trade for small to medium sized companies.

The members of the consortium are each bringing to the project their expertise in their respective areas, to document the implementation, hurdles and success of a complete electronic trading environment. A full analysis will be published when the project is finished in mid 1991.

SITPRO's vice chairman Jim Fetherston says:

"Too many people perceive EDI as only applicable to major corporations. This project will prove that the benefits of electronic trading are critical for the continued success of small to medium sized companies."

ELECTRICAL ENGINEERING SALARIES UP 10%

Salaries of Chartered Electrical and Electronic Engineers have risen 10% over the past year to a median of £25,000, according to the 1990 Salary Survey of its members by the Institute of Electrical Engineers (IEE). The members surveyed will have a good engineering degree, and will have held a responsible position in an electrical or electronic field for at least two year. For associate members, who must have a good engineering degree, the median figure is £18,500.

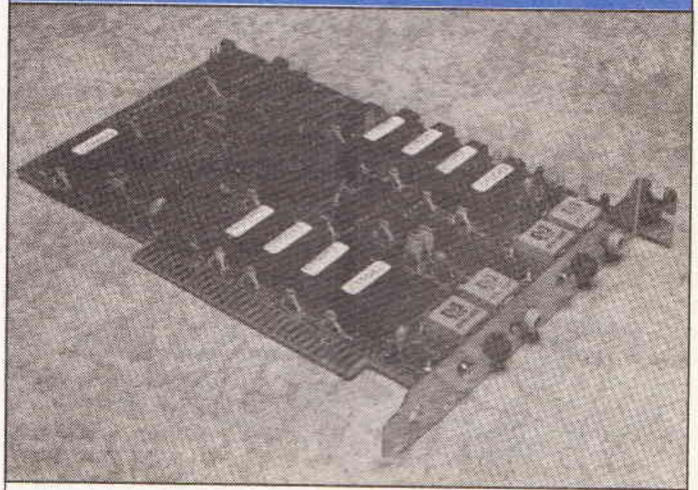
The survey was based on a random sample of 40% of IEE Fellows, Members and Associate Members in the UK and Eire, of whom 50% responded.

The highest salaries were in insurance, banking, finance, broadcasting, telecommunications and the armed forces. Public sector salaries continue to be higher than those in the private sector, but the gap has narrowed considerably over the past few years.

In geographical terms, the highest salary increases were in Northern Ireland (15.7%) and the lowest in Scotland (5.6%). Unemployment in the profession remains low, and stands at just under 1%.

The number of women respondents to the survey was very small, but showed that their salaries are lower than their male counterparts with a median of £16,500.

HIGH FIBRE, HIGH SECURITY



The increased use of PCs to control industrial automation requires secure data links, but these can be difficult in harsh or hazardous environments. Ordinary RS232 cables, often used to transfer data between a computer and peripheral devices, are prone to electrical interference in difficult environments such as manufacturing plants and allow electronic eavesdropping.

Fibre-optic data links are immune to electrical interference and eavesdropping and are safe in hazardous environments. The CPCFS fibre optic communication card from Concise Technology provides IBM-PC, -XT or -AT computers, or systems based around the PCbus, with two FOSIL (Fibre Optic Standard Interface Link) data communication channels. The card operates with RS232C protocol at standard baud rates, so it can be installed without making any changes to existing communications software.

The CPCFS's two FOSIL channels are fully compatible with the PC's COM1 and COM2 serial ports, but can be allocated to any other I/O channel address if required. Unlike many fibre optic modems, they provide full flow control via the RTS/CTS and DTR/DSR signals which are multiplexed along with the transmit and receive data on to a single pair of optical fibres.

The CPCFS occupies a single short slot in the computer's I/O channel expansion bus (PCbus), and is priced under £250.

For more information contact John Halford, telephone: 0603 789432.

COMPACT DVM

Autona Limited have introduced a low cost DVM module which has an overall depth of only 11mm, so it can be incorporated into very compact equipment.

The unit is called the DVM 456, and features 14mm high efficiency displays which, together with the red filter fitted in the moulded bezel, are readable under high ambient light conditions.

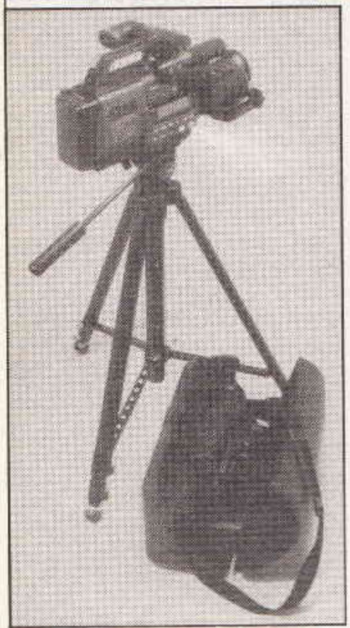
A built-in supply stabiliser simplifies installation into a wide range of equipment, since the module operates from an unregulated supply of between 7 and 12V. The unit is protected against input over-load and reverse polarity supplies to ensure safe operation in hostile environments.

Available in standard form with a basic sensitivity of ±1.999V, the unit may be supplied with alternative FSDs where quantity requirements exist.

Supplied with a comprehensive Data Sheet, the unit costs £19.95 + VAT for a single unit.

For more information contact Mr J Leith. Tel: 08444 5740.

INTEREST RATES HIT ELECTRONICS MARKET



High interest rates mean that many electronics consumers are unlikely to make non-essential purchases in 1990, according to a survey published by Ferguson.

The third Annual Consumer Electronics Market Report reveals that two thirds of consumers are affected by interest rates. Those paying mortgages are hardest hit, with three out of four claiming to be affected. The report claims that sales are likely to remain depressed, the exceptions being new product areas such as satellite, with 14% of consumers expressing interest, and camcorders, where the market is expected to exceed that of small screen television.

Half of those questioned in February 1990 expect to have less money available to spend on leisure compared with under a third last year. Fewer consumers plan to make purchases compared to the same time last year.

The small screen market, driven by a requirement for more sets in the home, declined for the first time and is predicted to decline further in 1990. However, flat screen television almost doubled its share.

In video, sales held up better than in television, probably due to the high proportion of first time purchases, particularly from the younger 18-24 age group and the 55+ age group, who are also least affected by increases in mortgage payments. One in four VCRs went to homes with a functioning player, most as early replacement purchases, the old models either being retained or joining the 350,000 unit second hand market.

The main feature trends were the continued growth of long play and the diversity of remote programming techniques. However, 28% of consumers never set their video to record, or find it difficult to do so.

In contrast to other categories in the market, sales of camcorders more than doubled to 280,000 units, a trend which is expected to continue in 1990.

Satellite sales were respectable rather than a triumph or disaster, at 450,000. While this figure exceeded those of colour TV or video in their launch years, neither had benefitted from the equivalent level of hype and promotion and both were considerably more expensive than satellite. Consumer interest, at 14%, whilst growing is also beginning to polarise heavily towards the young, with 30% of 18-24 year olds interested in buying a system, compared with 7% of those aged 45 or above.

50% of consumers do not favour either BSB or Astra and are waiting to see what both broadcasters have to offer. For that reason, only a quarter of those interested believe they will definitely or probably buy this year.

The audio sector is generally fairly static. Consumer interest in CD remains high, with 29% of those not owning a player interested in buying one in the future. Again interest is polarised, varying from 59% of 18-24 year olds to 8% of the over 65s. Only 28% of those interested cited falling software prices as a relevant factor in their decision.

REWRITE WITH LIGHT

The world's first commercially available rewritable optical disc recorder has been introduced by Panasonic Communications & Systems Company. Previously, optical discs could record images only permanently. The LQ-4000 provides producers and other video professionals with large scale storage of still images and full-motion video.

The discs have a minimum 10-year life and are capable of one million erase-and-write cycles.

The recorder could have enormous potential in the video industry. Its rewritable capabilities and long playing time make it suitable for videodisc mastering, interactive video training, point-of-sale information, image storage and retrieval and security environments.

Using an FM recording system for colour signal, the optical disc recorder significantly reduces chroma noise, and achieves a chroma signal-to-noise ration of 45dB. As a result, colour smearing is suppressed and colour rendition is improved.

An analogue unit, the LQ-4000 can provide access to any individual frame on the disc in less than a second, avoiding a time-consuming linear search. Sports producers could retrieve and broadcast highlights of the start of the game before it finishes, without waiting for a tape to rewind.

The rewritable optical disc recorder will be available in the US and Japan in the last quarter of the year.

GETTING ORGANISED

Just as we were getting bored with ordinary personal organisers, electronic organisers began to hit the market. The range available is now rapidly expanding, with manufacturers competing to fit the widest range of functions into the smallest devices.

The Sharp IQ 7000 Personal Organiser is the size of a pocket diary and offers a range of functions ranging from a schedule manager to a calculator.

The IQ7000 has 27kBytes of memory, allowing a range of facilities including a 199-year calendar (for when you want to plan 199 years ahead!), a schedule manager for appointments and timetables with capacity for over 500 entries, a calculator, a telephone directory, a memo facility and an alarm function for any entry.

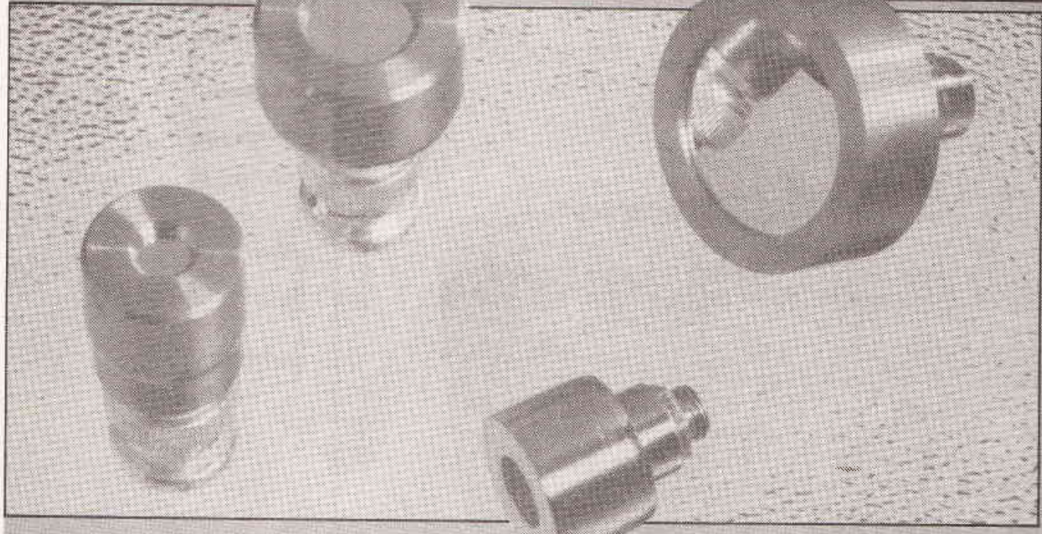
Plug-in options include an eight language translator, a time/expense manager, a thesaurus/dictionary and a link to transfer data to and from a PC.

NEW CRICKLEWOOD CATALOGUE

The Cricklewood 1990 Catalogue is now available. The catalogue contains around 2400 more items than last year. The range of products has been increased to cover such items as hobby kits, microphones, speakers, headphones, video heads and aerials. Here in the ETI office we find it very comprehensive, with a very good selection of transistors and other semiconductors. The catalogue now also covers a range of books.

The catalogue costs £1.50 (this includes postage) and can be ordered from: Cricklewood Electronics Ltd, 40 Cricklewood Broadway, London, NW2 3ET. Telephone 081 452 0161.

HARWELL CHIPS IN WITH RADIATION DETECTOR



Novel radiation detectors, designed and manufactured at Harwell Laboratory, are to be sold throughout Europe by EG&G (Instruments).

Ion-implanted Radiation Detectors (IRDs) are silicon chip devices capable of measuring a variety of radiations, and are sensitive to very small amounts radiation. They are very rugged and can be manufactured in a variety of shapes up to 100mm across.

Ion-implanation is a process in which dopant ions are accelerated towards a silicon wafer. The process allows a very high degree of uniformity and control, so enabling the very shallow p-n junctions required for detectors to be formed. Semiconductor radiation detectors can be made to detect Alpha particles, Beta particles and X-rays. They are low-noise, thin window devices, combining high performance with ruggedness. They are particularly suitable for use in high resolution spectrometers for analysis work and in environmental monitoring systems.

Much of the early work on silicon doping by ion-implantation was pioneered at Harwell in the 1960s, but recent advances have produced highly efficient electronic devices capable of measuring many different radioactive isotopes simultaneously. Customers are expected to include public analysts, MAFF, food research associations, BNFL, universities and MOD.

FIRE PROOF TRANSFORMERS

A range of high performance transformers now use an advanced fire safe material to make one of the safest types of distribution transformer available.

The Securamid range from Goodyear has been developed for use inside buildings where the reduction of an incoming voltage of 11kV down to 3 phase 433V may present a fire hazard. The fire retardant characteristic of meta-aramid materials to give the transformers a high performance in fire.

The transformers use meta-aramid to insulate both the high and low voltage coils, and can withstand operating temperatures of up to 220°C without combustion or degredation of the insulating material.

In addition, the transformers open-wound design minimises the amount of organic material used in their construction, which significantly reduces the potential of burning, fire propagation and toxic gas emission.

For more information contact Neil Botting, telephone: 021 707 8557.

INTRODUCING ISDN

British Telecom has announced further plans for its ISDN service, including key dates for its introduction.

Lines have been offered to terminal manufacturers and are currently being tested by them, allowing the benefits of ISDN to be demonstrated to customers.

From the end of July, a larger number of lines will be provided to customers in several business areas throughout the country, enabling customers to work together with their terminal suppliers and British Telecom to establish pilot configurations to assess how best to use ISDN.

International interworking to a number of countries will also be offered during this phase.

From the beginning of next year, the service will progressively become available throughout the country, and deployment to all digital local exchanges serving business communities or high streets will be achieved by the end of 1991.

The National Computing Centre is undertaking a project, sponsored by British Telecom and the DTI, to increase public awareness of how the capabilities of ISDN might benefit today's business needs.

MAY I PRESENT . . .

The latest sales device is the portable video presenter, consisting of a very compact video player and screen, allowing promotional or informative video recordings to be easily displayed at meetings in any location.

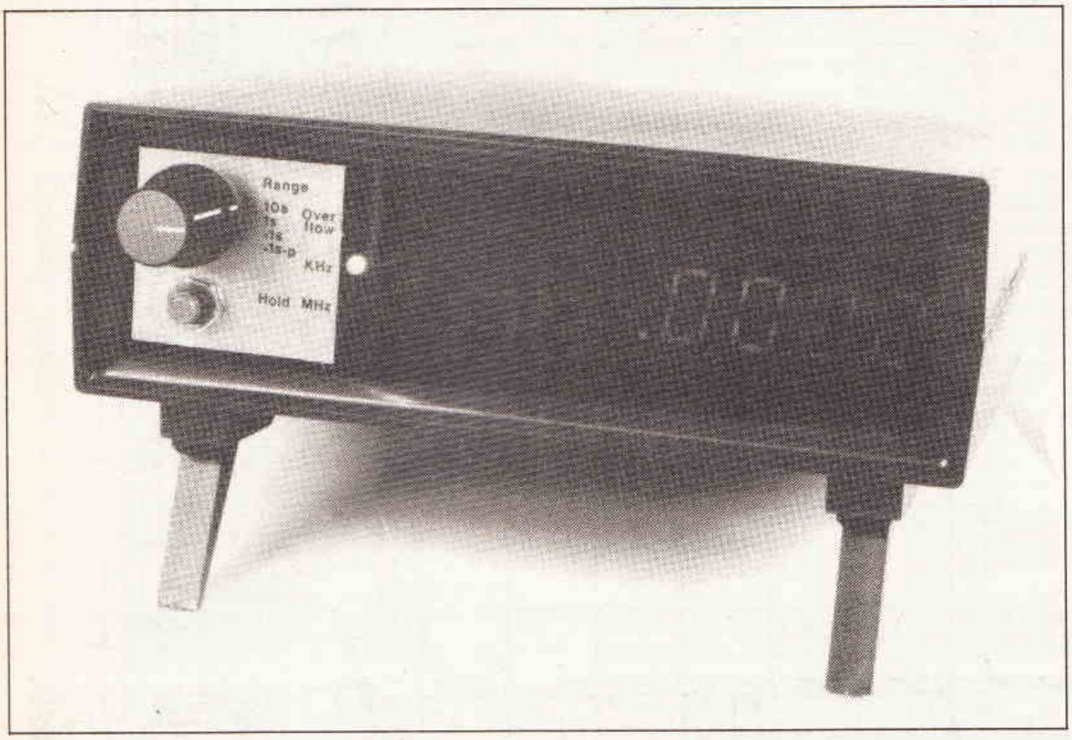
Hanimex have introduced the VCP34, which combines a full-featured video player and a 14 inch screen. It is suitable for groups of up to about six people, or for continuous point of sale presentations.

The VCP34 presenter is lightweight, and is easy to transport using a handle on top. Infrared remote control allows the VCP34 to be controlled 'hands free' during the course of a meeting.

The manufacturers hope that it will also have a major impact for training and safety films, and for corporate company videos. They also see potential applications in airport or station queues, travel agents and estate agents.

DIGITAL FREQUENCY METER

PROJECT



Mike Bedford builds a low cost, compact frequency meter.

We published another project for a digital frequency meter in ETI in November 1989 and this one does indeed offer a similar specification. However, we are presenting this design, as both articles give some insight into the design process and it is interesting to see how two quite different design philosophies emerged from the same basic requirements. Also this design uses fewer chips and so may appeal to less experienced constructors and the end result is quite a compact unit.

The Requirements

I recently found myself in need of a frequency counter for the first time, and discovered that commercial equipment has a price tag of approaching £100 for the simplest of models. I therefore turned my attention to designing and constructing my own.

In my opinion the ideal design for a general purpose digital frequency meter has a maximum frequency in the region of 30MHz (covering all the HF amateur radio bands), an 8-digit display and is inexpensive to build. A single chip, the ICL7216D from Intersil, comes close to providing these functions, but has a top frequency of 10MHz. However, by adding an LS TTL divide-by-10 chip a maximum frequency figure of 50MHz (the maximum switching frequency of LS TTL) can be achieved.

Design Considerations

Figure 1 shows the basic manufacturer's application circuit for the ICL7216D. To keep the price down without compromising performance I tried to keep as close as possible to this minimum configuration. The 8 seven-segment LEDs are driven directly from the chip in a multiplexed arrangement and the inputs for mode, gate time and external decimal point are also multiplexed. Taking these inputs in turn, I decided that the only modes needed are normal frequency counting operation, hold display and test display. Also, as we shall see later, external decimal point mode is always active.

Now coming to the gate times, the possible options are 10s, 1s, 0.1s or 0.01s which give resolutions of 0.1Hz, 1Hz, 10Hz and 100Hz respectively. As 0.1s doesn't seem too long wait for a reading and the 0.01s option loses a digit of accuracy, I decided to use only the longer three gate times. The divide-by-10 pre-scaler, (not shown in Figure 1), could in theory be used in conjunction with

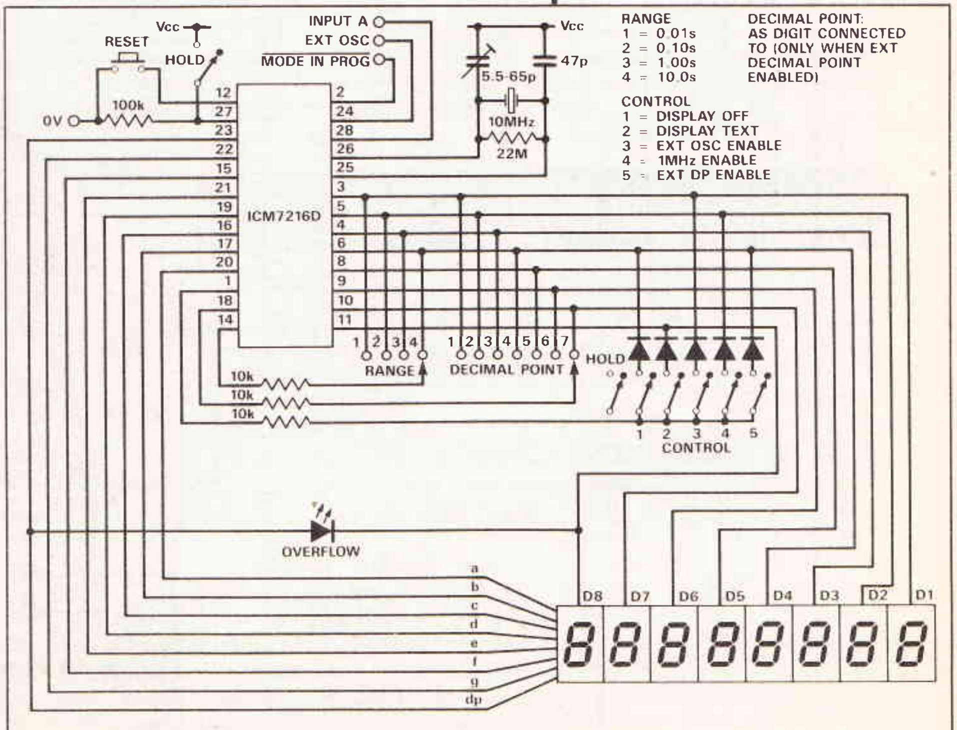


Fig. 1 7216D Application Circuit

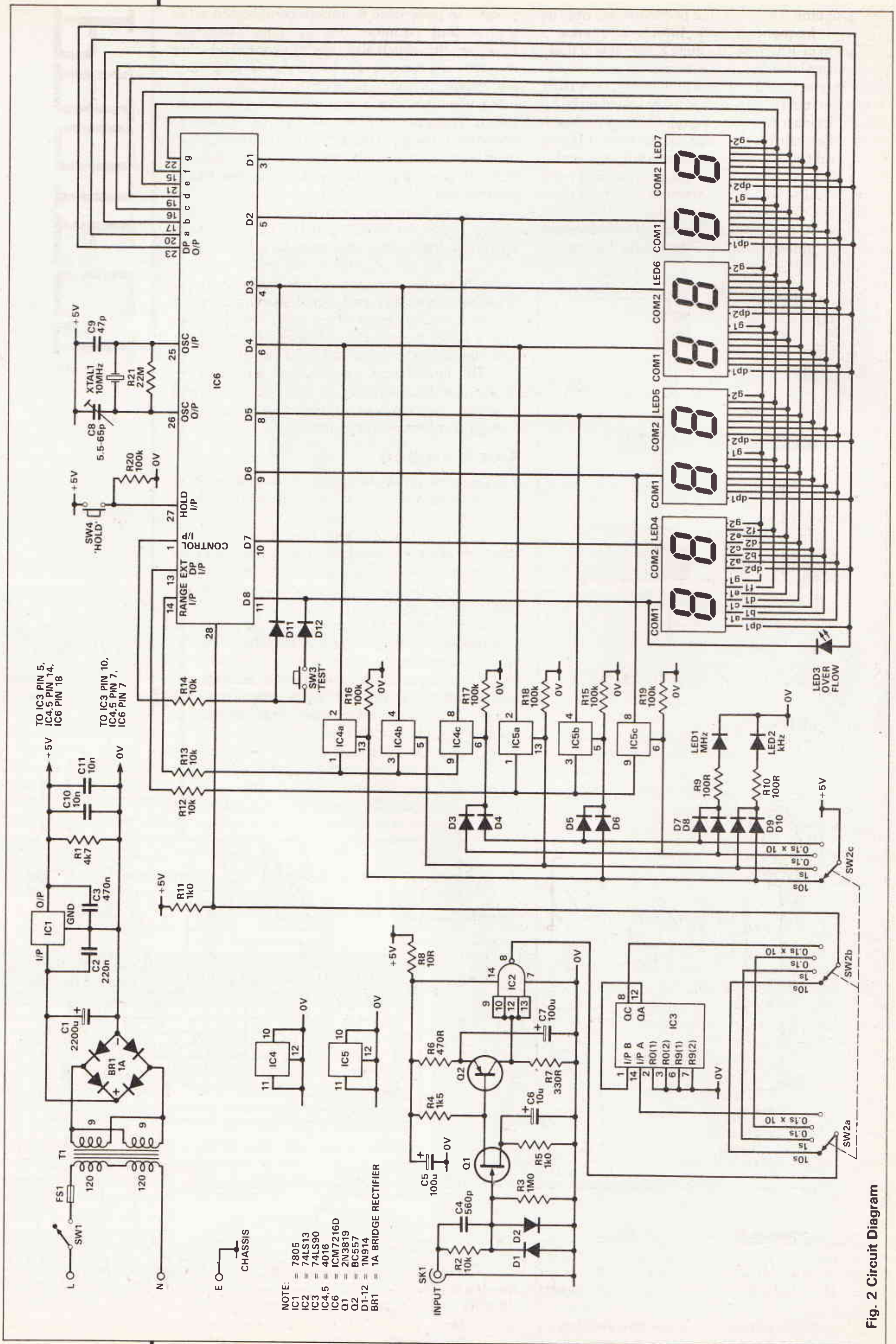


Fig. 2 Circuit Diagram

any gate time. However, the pre-scaler will only be used for frequencies over 10MHz and since a resolution of 100Hz seems quite acceptable at these frequencies I decided to use the pre-scaler only with the 0.1s gate time. (This gate time does give a 10Hz resolution, but remember that we are dividing by 10 thereby losing a digit of accuracy). So, we are left with four ranges with 10s gate time, 1s gate time, 0.1s gate time straight and 0.1s gate time through the pre-scaler.

Finally we come to the external decimal point input. Because we are using the pre-scaler, we need to shift the decimal point one position to the right whenever the pre-scaler is in circuit. We can also move it a further three positions to the left on the top two

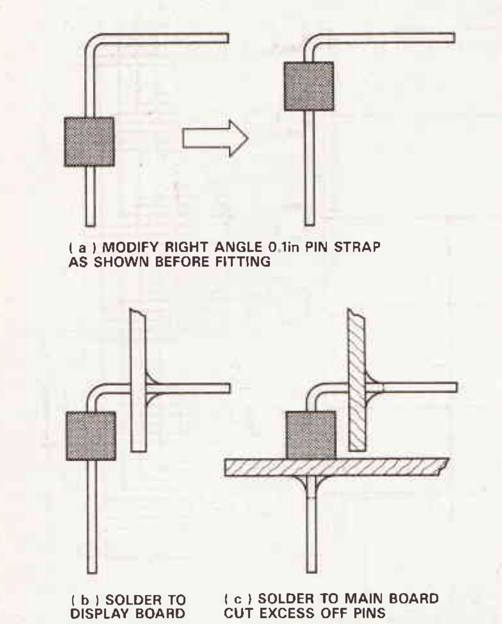


Fig. 3 PCB Interconnection

directly, in preference to a more complicated set of latches and counters driving digital switches. However, this switch also needs to control whether the pre-scaler is in circuit (which uses two gangs) and also to switch the kHz/MHz LEDs. The total requirement was therefore a four-way, five-gang rotary switch. However four-way switches get expensive above the three-gang variant, so inexpensive CMOS digital switches are used to switch the gate times and decimal point inputs hence keeping the switch requirement to four-way, three-gang.

It is perhaps not immediately obvious from Figure 1 that the main input is TTL compatible, whereas a frequency meter must be able to handle sine waves as well as square waves and amplitudes of much less than 5V peak-to-peak. An input limiter, broadband amplifier and signal shaping circuit is required, the output of which is fed into the input Figure 1. The input circuitry is based on that used in a frequency meter published in ETI in 1985.

The final design consideration relates to the powering of the unit. There are no surprises here, and a simple mains power supply utilising the 7805 voltage regulator has been included.

Construction

The electronic construction is straightforward but there is some work involved in the physical side of making a neat unit in a compact case.

Firstly a few miscellaneous points on the assembly of the two boards and the connection of the main board to the display board. Both boards should be fully assembled before they are interconnected as shown in Figure 3.

It would be wise to adhere to normal practice of using sockets for the ICs (but don't plug them in at this stage) but not for the seven-segment LEDs as this would push them further forward and affect the board position within the case. The cathode (-ve) of the other LEDs is indicated by either a flat on the body or an extra long lead.

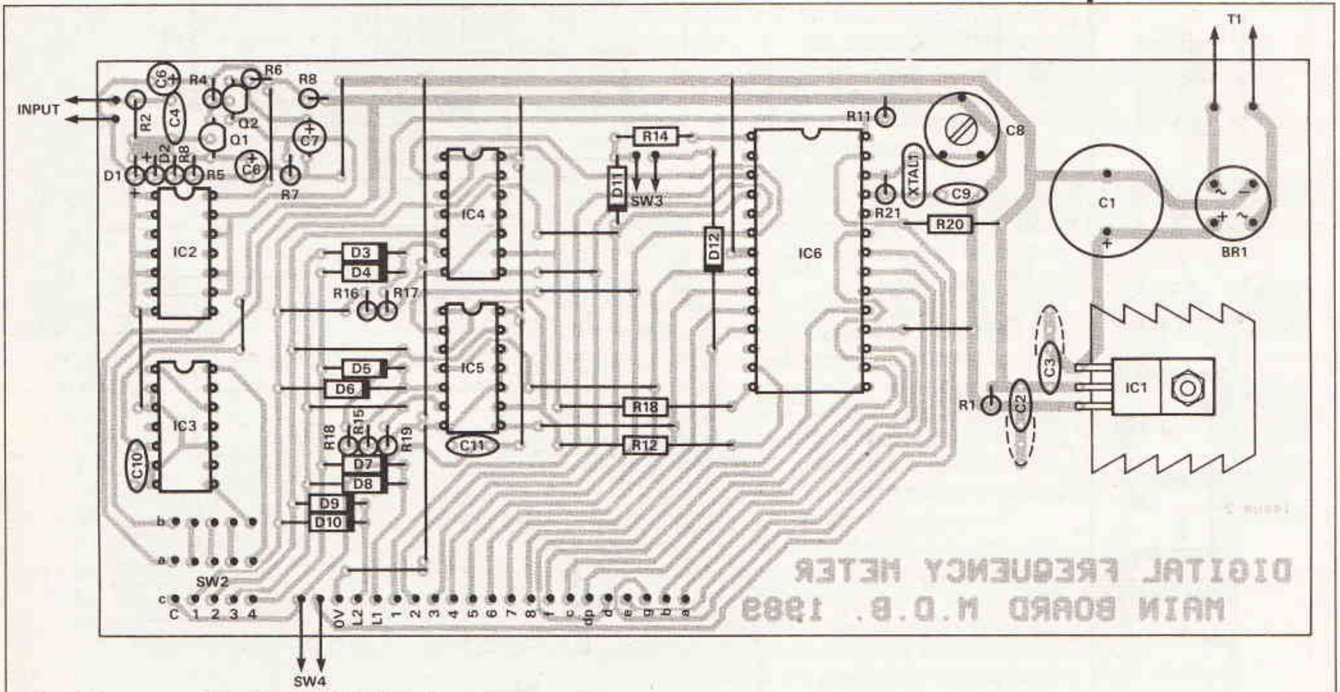


Fig. 4 Component Overlay for Main Board

ranges to give a MHz reading here — all this costs is two LEDs to indicate whether the reading is in kHz or MHz.

I originally intended to use rotary switches to switch the gate time and external decimal point inputs

The mains transformer is mounted off-board but needs a little bit of wiring. The type specified has two 120V primaries which need connecting in series for 240V mains and two 9V secondaries which need connecting in parallel (make sure they are paralleled

0 to 0 and 9 to 9). Mains earth should also be connected to the transformer case using a solder tag and to the one remaining metal part, the back panel. To avoid the risk of damage to the relatively expensive IC6, apply mains power to the transformer at this stage and use a multi-meter to check that the power supply voltage is correct and of the right polarity. If all is OK it is now safe to plug in the ICs. Take care not to touch the pins of IC4, IC5 or IC6 as these are CMOS parts and liable to damage by static.

Turning now to the physical construction, these comments refer to the case specified in the Parts List. If you use a different enclosure you will have to work this out for yourself. The case used results in a very compact unit but the boards only just fit in and even then only after a bit of modification. This type of construction method can be successfully used by the amateur enthusiast but certainly wouldn't lend itself to manufacturing.

The first such modification is to remove a some stand off pillars from the bottom of the case. These are five towards the front of the case (underneath the main board) and two in the middle at the back (which would otherwise prevent the positioning of the transformer). Now remove the notch from the front left side of the main board (as viewed from the front). You must also remove the right front of the four pillars (through which the top of the case screws to the bottom) in both the top and bottom half of the case. In doing this, note that the lid only fits to the bottom one way round. The board can now be positioned sufficiently far forward and low down in the case and is secured by a number of bolts through the bottom of the case.

Most frequency counters have a filter covering the display and this is surrounded by a bezel. In this compact design there isn't really room for such a bezel and instead the entire front panel supplied is replaced by a piece of filter material. Clearly this filter needs a couple of holes cutting for the rotary switch and 'hold' push button. This solution, does in fact give a very professional appearance to the unit.

The only difficulty is that the filter material suggested is 1.5mm thick compared to 1mm for the original front panel. In order to accommodate this a few spacers in the appropriate slots in the top and bottom of the case need cutting out with a sharp knife. To cut the filter, score it well with a scapel, after which it will readily snap along the scored line.

The case specified comes complete with four feet, the front two of which allow the unit to be tilted up. These feet are supposed to be screwed on, but since you have removed the pillars into which they screw, you will have to glue them on. The front two feet are in the same positions as two of the bolts fixing the main board, so the bolts in question should be glued firm before the feet are fixed. The PCB is then secured by tightening the nuts on these captive bolts. The two side brackets supplied with the case were not used.

The photo shows suggested front panel labelling. The lettering used is 2mm. Because the front panel is filter material, Letraset and laquer cannot be used as the laquer would damage the optical properties of the filter. The ideal solution is screen printing in white ink but most people won't have the necessary facilities. Instead, make a small label to be positioned between the switches and the three LEDs.

The unit is calibrated simply by applying a good stability signal of a known frequency to the unit and adjusting CB until the correct frequency is displayed. This should be carried out at the longest possible gate time though the display will only update every 10 seconds on this range.

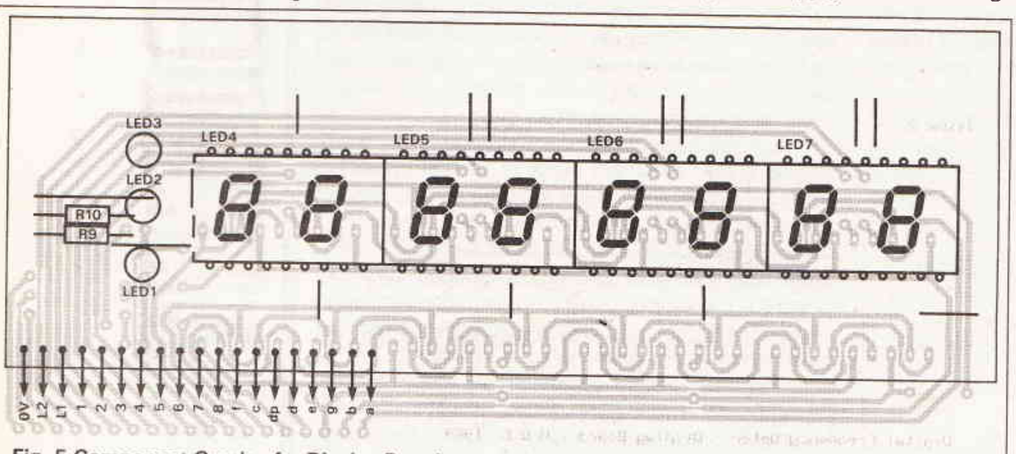


Fig. 5 Component Overlay for Display Board.

HOW IT WORKS

This will be a brief account since all the counting happens in the depths of IC6. We are only concerned with the peripheral circuitry which is all fairly simple stuff. The circuit diagram is shown in Figure 3.

First to the input circuitry. R2, D1 and D2 form an input limiter to the FET input amplifier (Q1) which was used to give a high impedance input. Q2 provides level shifting to give a suitable signal for driving IC2. This is a Schmitt trigger TTL device and serves to 'sharpen up' the edges of the waveform, a criterion required by IC6.

IC3 is arranged in its normal divide-by-ten configuration (by connecting pin QA to the input B pin) and the signal is routed through this chip by SW2 gangs a and b when the switch is in its 0.1s × 10 position. In all other positions, the switch routes the signal from the input circuitry directly to Input A of IC6, the counter. SW2 gang C is used to control the gate time and decimal point functions of IC6.

As we showed in Figure 1, this is all controlled by connecting one of the digit outputs to the range input and one to the external decimal point input. The digital switches IC4 and IC5, in effect 'fan out' this one switch gang to provide both these functions. These digital switches conduct when their control inputs are high. Since the high comes as +5V directly from SW2 gang c, when a particular control input does not have this supply switched to it, it would be open circuit. To prevent this, each of the control inputs of IC4 and IC5 are held low through 100k resistors. When a particular range or a particular decimal point position is selected by more than one position of SW2, these are isolated by diodes. In accordance with CMOS practice, the unused inputs of IC4 and IC5 are held low to prevent excessive power dissipation.

With the exception of the power supply, which is a standard design, all the remainder of the circuitry is from the ICM7216D manufacturer's application circuit.

BUYLINES

sources. However, Farnell (0532 636311) or Trilogic (0274 691115) can supply the part for £21.58. The part number is ICM7216DIPI.

Farnell or Trilogic can also supply display filter in sufficiently large sheets. (The sheet supplied will be no more than twice the size needed so it may be a good idea to go halves with another prospective builder as it is quite expensive). The part number is 178-183.

The transformer is 88-0255 from Rapid Electronics (0206 751166) but similar ones could be obtained elsewhere. The only suitable rotary switch found by the author comes from Martelec (0252 515666) where it is simply referred to as Miniature Rotary Switch, Break-before-make, 3P/4W. The source and part number of the case is specified in the parts list.

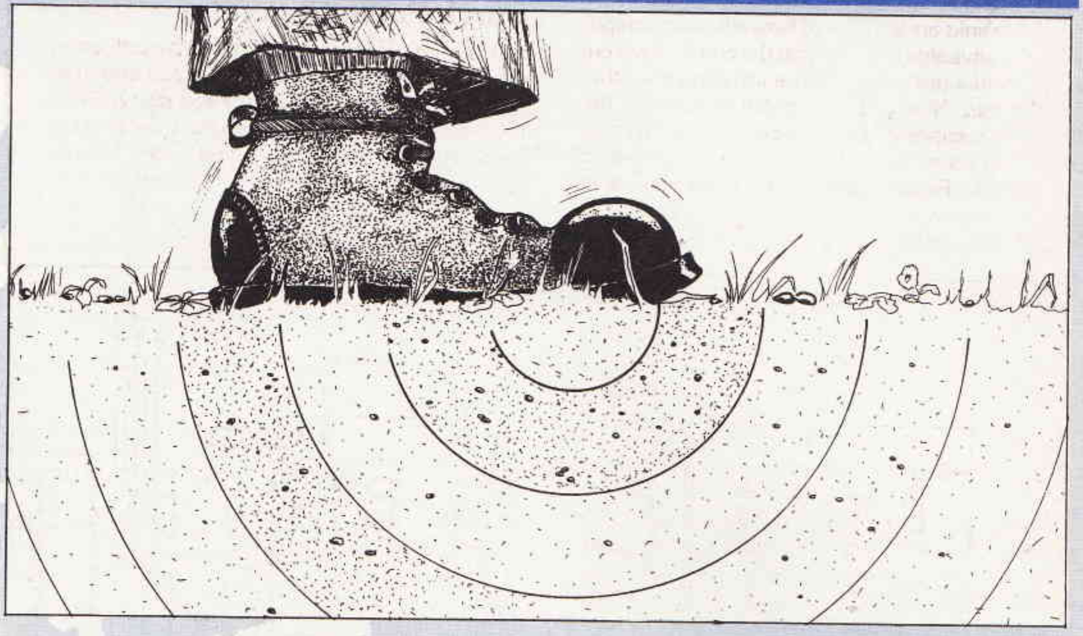
Other components can be obtained from most suppliers.

PARTS LIST

RESISTORS (All 5%, ¼W unless otherwise stated)	
R1	4k7
R2	10k,1W
R3	1M
R4	1k5
R5,11	1k
R6	470R
R7	330R
R8	10R
R9,10	100R
R12,13,14	10k
R15,16,17,18,19,20	100k
R21	22M (Probably have to use 2 x 10M)
CAPACITORS	
C1	2,200µ, 16V, Radial Electrolytic
C2	220n
C3	470n
C4	560p, Plate Ceramic
C5,6	10µ, 16V, Radial Electrolytic
C7	100µ, 16V, Radial Electrolytic
C8	5.5-65p Trimmer
C9	47p, Plate Ceramic
C10,11	10n, Disc Ceramic
SEMI-CONDUCTORS	
D1-12	1N914
Q1	2N3819
Q2	BC557
B1	1A Bridge Rectifier
LED1-3	3mm Red LED
LED4-7	0.56" High, Double Digit, Common Cathode 7 – Segment LED Display, RH decimal point
INTEGRATED CIRCUITS	
IC1	7805
IC2	74LS13
IC3	74LS90
IC4,5	4016
IC6	ICM7216D (NOT suffix A,B or c)
TRANSFORMER	
T1	0-9, 0-9V @ 0.33A, 6VA Miniature
MISCELLANEOUS	
SW2	Miniature Rotary 3-Gang, 4-Way, Break before Make and Knob
PB1,2	Momentary Action, Miniature Normally Open
SK1	BNC Socket
Test Lead	BNC to 2 × Crocodiles or as preferred
Heatsink	T0220, 21° C/W
IC Sockets	4 x 14-pin, 1 x 28-pin
PCBs	Main, Display
0.1" Pin Strip	Single Row, 90° PCB Header, 19-way (use 2 × 10-way)
Case	Rapid Electronics 30-0905
Display Filter	Red, 50mm × 165mm
SW1	Mains Rocker Switch
F1	1A Fuse in 20mm, Panel Mounting Holder
3-Core, 3A Mains Cable	
13A Mains Plug	
Strain Relief Bush (for Cable)	

ETI

FOOTSTEP INTRUDER ALARM



Robert and David Crone have found a way to catch the intruder before they reach the house using this mini project.

PROJECT

The ground's ability to carry vibration has many practical applications. An example that immediately springs to mind is the exploration work carried out by oil or mining companies. In order to build up a picture of the underground rock strata, a small explosive charge is detonated in the ground and then measured for the time it takes echoes to return from rock faults or discontinuities deep down. The echoes are measured by a simple electromechanical sensor called a geophone.

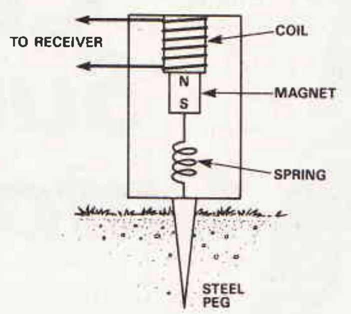


Fig. 1 Outline of geophone

Figure 1 shows the arrangement. Ground vibrations are picked up by the 100mm long steel peg which rattles the magnet/spring combination so inducing small voltages in the coil. The coil output is then passed via a length of cable to a receiver where it is analysed. The geophone is about the size of a cricket ball and is very expensive mainly because the frequency response from about 10Hz to 500Hz has to be manufactured to a very tight specification for exploration work.

Now a villain sneaking in through the garden creates a lot of ground vibration. So a very cheap sensor would be sufficient to detect him. A sensor can be made in the following way. Obtain an inexpensive medium impedance (approximately 70R) miniature loudspeaker and glue a cork to the centre of the loudspeaker cone. Then with a small self tap screw attach the other end of the cork to the bottom of a plastic or metal box. Figure 2 shows the construction. The loudspeaker is effectively resting on top of the cork and vibration will be passed to the cone from the ground via the 70mm long metric 5 screw.

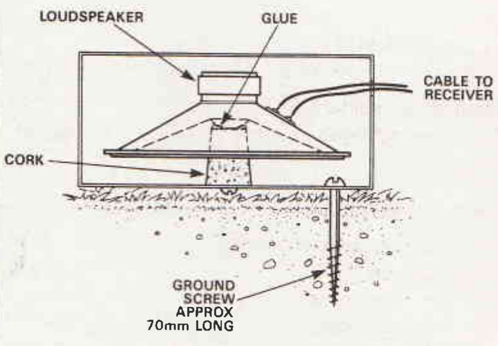


Fig. 2 Construction of footstep sensor

We have now completed the hardest part of the job. The electronics is plain sailing as will be seen.

Figure 3 shows the block diagram of the system. The sensor is located somewhere in the back garden and its output is routed via the length of cable C to the amplifier A1. A1 has a fixed gain of 100 and drives the simple diode detector, the output of which goes to amplifier A2 whose gain may be varied from 10 to 100 so as to provide a sensitivity control. When the output of A2 momentarily exceeds a certain level, hopefully caused by a villain dropping over the garden wall, the latch flips over and lights the lamp.

Construction

The sensor has already been described in detail. The interconnecting cable should be screened. A length of 75R TV cable would do. The prototype used ordinary screened audio cable. The circuit, being quite small, is built on veroboard and the layout is not critical as the frequencies involved are very low.

Stabilised power supplies are *not* required as the circuit is AC coupled with only modest gains being used. The circuit draws 4mA from each rail and provided it is switched off when not required, the two batteries should last for a reasonable time.

Setting Up

It is advisable to place a brick or small bag of sand on top of the sensor box to prevent a strong wind setting it off. If a multimeter is connected to the monitor point and the sensitivity control is set to maximum, you should find that if a foot is stamped on the ground about 7 metres from the sensor then the monitor point will go negative to the supply rail voltage.

However, in most cases the LED will come on with only a very small meter deflection. This is because the vibrations are coming in at around 10Hz and although the IC2 output will be momentarily dipping to the negative rail, a meter will not respond in only a small fraction of a second. The sensitivity control should be set so that the alarm does not go off on local ambient noise. Unfortunately, there are areas where the vibration type of alarm cannot be used at all, for example proximity to a main road with high traffic density or a mining or quarrying area where there are frequent explosions.

HOW IT WORKS

Figure 4 shows the detailed circuit diagram. The sensor output is fed to IC1 which has a nominal gain of 100. Note that C3 is included to make the frequency response begin to fall off after 160Hz. The output of IC1 is clamped and detected by C4 and D1. The negative going detected voltage is amplified by IC2 whose gain may be varied from 10 to a nominal 100 to provide a sensitivity control. Should the IC2 output momentarily go negative to 60% of the rail voltage (−5.4V) it will cause pin 2 of IC3 to trigger and cause pin 3 to go permanently high thus lighting the LED alarm. T1 is switched fully on and so could be used to operate a small buzzer or provide a logic 0 for external equipment.

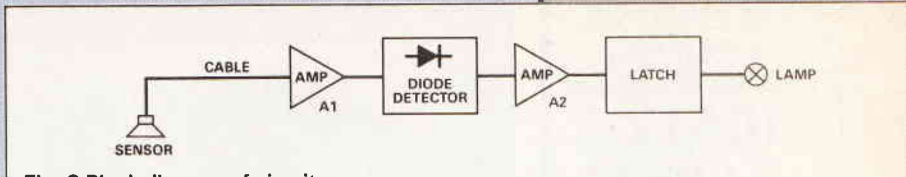


Fig. 3 Block diagram of circuit

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,2	1k
R3	100k
R4,8	2M2
R5	47R
R6	470R
R7,9,11	4k7
R10	680R
RV1	5k
CAPACITORS	
C1,2	22µ/16V
C3	10n
C4,5	470n
SEMICONDUCTORS	
IC1,2	TL081
IC3	7555
Q1	BC108
D1	0A90
LED 1	High Intensity LED
MISCELLANEOUS	
SW1	Single pole on/off
SW2	Single pole push to make
LS1	70R miniature loudspeaker

Cork, glue, plastic instrument case, 2 9V batteries, 70mm screw thread.

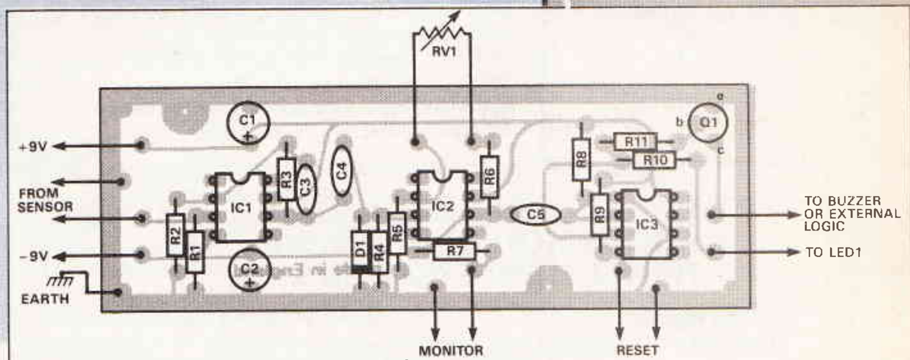


Fig. 5 Component overlay of intruder alarm

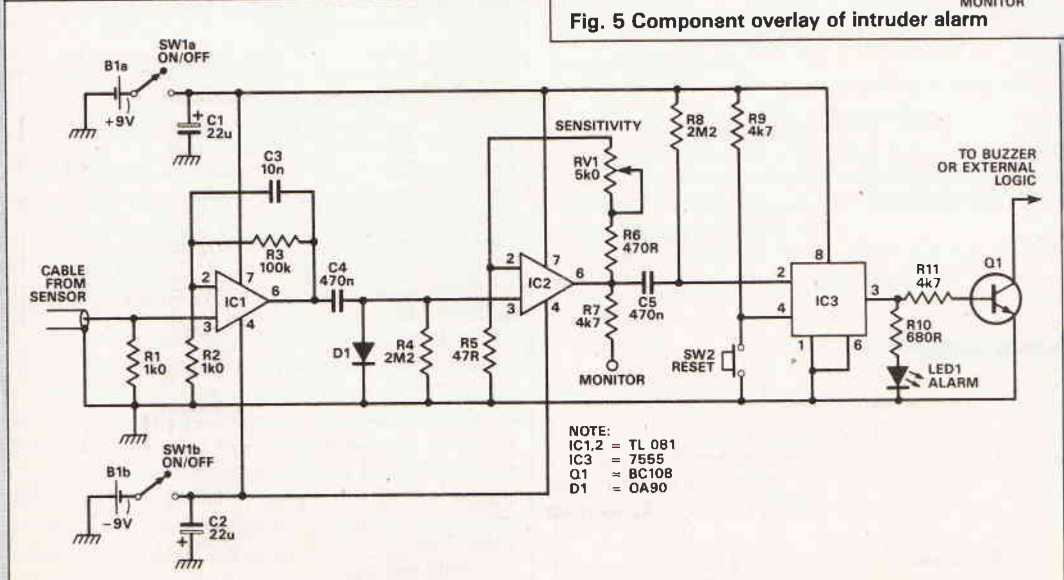


Fig. 4 Circuit of intruder alarm

TELEPHONE ORDERS
may be made on
(0442) 66551
ACCESS or VISA

Price code	Price (inc. VAT)
C	£1.80
D	£2.50
E	£3.25
F	£4.00
G	£4.75
H	£5.50
J	£6.62
K	£7.20
L	£8.80
M	£10.60
N	£13.10
O	£15.80
P	£17.90
Q	£21.80
R	£23.90
S	£25.90
T	£29.00
U	£32.20
V	£35.80
W	£37.90
X	£40.70

ETI
ELECTRONICS TODAY INTERNATIONAL

PCB SERVICE

July

E9007-1	Guitar Practice Amp	G
E9007-2	Digital Frequency Meter (two boards)	M
E9007-3	Footstep Alarm	E
E9007-4	Transistor Tester	C
E9007-5	Decision Maker (two boards)	J

PCBs for the remaining projects are available from the companies listed in Buylines.

Use the form or a photocopy for your order. Please fill out all parts of the form. Make sure you use the board reference numbers. This not only identifies the board but also tells you when the project was published. The first two numbers are the year, the next two are the month.

Terms are strictly payment with order. We cannot accept official orders but we can supply a proforma invoice if required. Such orders will not be processed until payment is received.

E8907-1	MIDI Patch Bay	G
E8907-2	Priority Quiz Switch	E
E8907-3	Camera Trigger Infra-reds (2 boards)	G
E8907-4	Aerial Amplifier main board	E
E8907-5	Aerial Amplifier power supply	E
E8908-1	Intercom master station	L
E8908-2	Intercom slave station	F
E8908-3	Intercom power mixer	E
E8908-4	Digital joystick-to-mouse conversion	H
E8909-1	Twin Loop Metal Locator	H
E8909-2	Trembler movement detector	D
E8909-3	Field power supply (spec 3)	C
E8909-4	Micro monitors active filter	F
E8909-5	Chronoscope auto-reset	C
E8910-1	Multimeter	H
E8910-2	MIDI Mapper	M
E8911-1	Smoke Alarm main board	F
E8911-2	Smoke Alarm power supply	F
E8911-3	Frequency Meter (3 boards)	O
E8911-4	Serial Logic Scope	L
E8912-1	Mains Failure Alarm	D
E8912-2	Surveilance PCB	D
E8912-3	Slide/Tape Synch	E
E8912-4	Pedal Power	L
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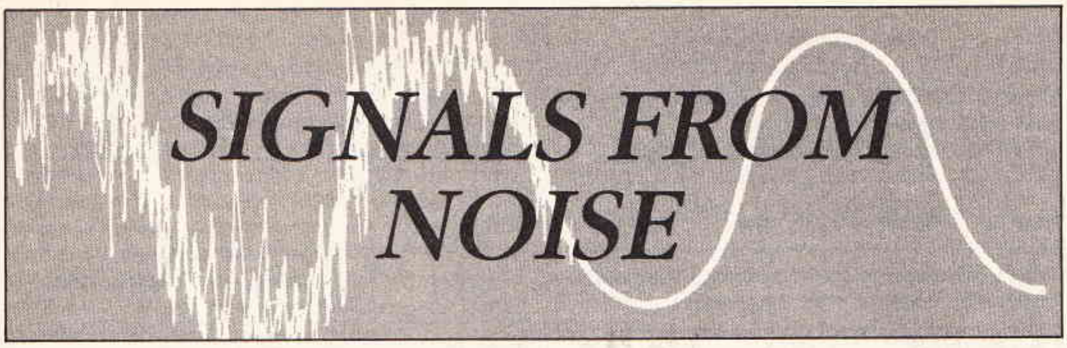
SIGNALS FROM NOISE



NOISE

Mark Robinson takes a fascinating look at some of the elegant techniques used to extract signals from noise.

In a perfect world a transducer would provide us with a signal proportional to the physical parameter which we want to measure. In practice however, an additional signal which is completely independent of the parameter (referred to as *noise*) is superimposed on the wanted signal. This can be caused by imperfections in the sensor (for example, at low light levels, a significant part of a photodiode's output is due to leakage current) or by the sensor receiving signals from sources other than the one of interest (such as when trying to measure the light from a star against ambient background light). Since noise is caused by random fluctuations, it has a very wide bandwidth and is often called 'white' noise by analogy with white light, which contains all visible frequencies.

A measure of how much noise a signal contains is given by its signal-to-noise ratio, defined as:

$$\text{SN ratio} = 10\log_{10}\left(\frac{\text{signal power}}{\text{noise power}}\right)\text{dB}$$

Often it is necessary to improve the SN ratio of a measurement to obtain a better accuracy, or, in really bad cases, just to get a sensible reading. So, how is it done?

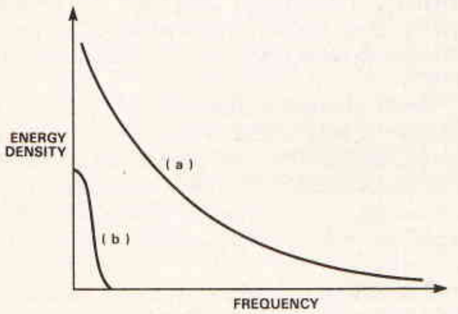


Fig. 1 Noise has a 1/f characteristic (a) so most of its energy falls in the same band as the signal (b)

Filtering

Since noise has a wide frequency spectrum, the first idea which comes to mind when thinking of SN ratio improvement is to remove high frequencies with a lowpass filter. Unfortunately, this does little good for two reasons. First, the filter makes the response of the instrument 'sluggish' by removing high frequency parts of the signal, and second, the noise power density usually has a 1/f characteristic, so most of the noise energy is contained below the cutoff frequency anyway. See Figure 1.

What is needed is a method of centering the signal on some frequency above the bulk of the 1/f noise. This can be achieved by arranging the experiment to give a periodic (or *chopped*) output, which moves the output spectrum to the chopping frequency (just like AM radio modulation). A bandpass filter can then be used to remove the noise, as in Figure 2.

Although this is a great improvement over lowpass filtering it still has one major drawback. If the chopping frequency or the passband of the filter drift slightly, the wanted signal will be attenuated severely, producing a false reading.

The Lock-In Amplifier

The lock-in amplifier is a bandpass filter which can be made to track a reference frequency. A block diagram is shown in Figure 3.

The operation of the circuit is not obvious from observation, so a mathematical analysis is needed to understand it fully.

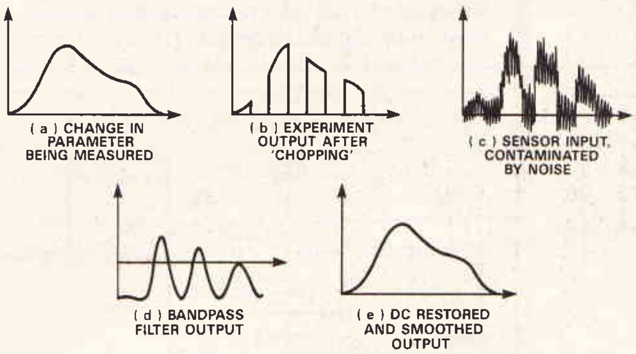


Fig. 2 Typical voltage time graphs at various points in a chopped and bandpass filtered system
a) Change in parameter being measured
b) Experiment output after chopping
c) Sensor input, contaminated by noise
d) Bandpass filter output
e) DC restored and smoothed output

To simplify matters, consider the case when the signal and reference are both sinusoidal and of constant amplitude.

$$\text{So: } V_{sig} = e_{sig}\sin\omega t + N(t)$$

where e_{sig} is the amplitude we are trying to measure, ω is the chopping frequency and $N(t)$ is an unknown term to account for the noise.

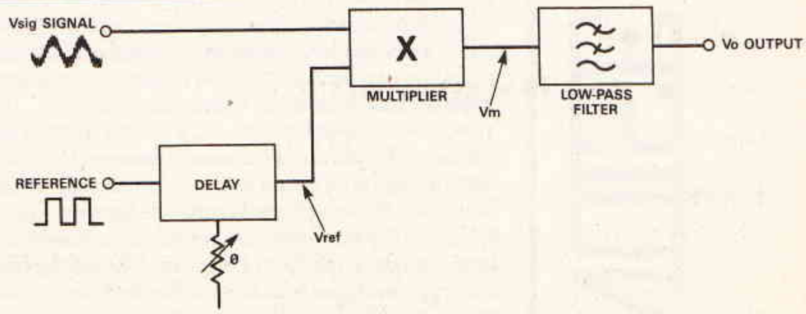


Fig. 3 Block diagram of a lock-in amplifier

Also: $V_{ref} = e_{ref} \sin(\omega t + \phi)$

where ϕ is the phase difference between the reference and signal inputs.

The output of the multiplier, V_m, will be:

$$V_m = Ae_{sig}e_{ref}\sin(\omega t)\sin(\omega t + \phi) + e_{ref}N(t)\sin(\omega t + \phi)$$

which, by applying the trig identity $2\sin A\sin B = \cos(A-B) - \cos(A+B)$, becomes:

$$V_m = \frac{Ae_{sig}\,e_{ref}}{2}\left\{\cos\phi - \cos(2\omega + \phi)\right\} + Ae_{ref}N(t)\sin(\omega t + \phi)$$

where A is the multiplier gain.

Assuming the lowpass filter removes all frequencies above DC completely, the oscillating terms will vanish, leaving:

$$V_o = \frac{Ae_{sig}\,e_{ref}\cos\phi,}{2}$$

which is proportional to the amplitude e_{sig}, which we are trying to measure.

In use the delay control is set to maximise the output voltage, which occurs when $\cos\phi = 1$, ie $\phi = 0$. Provided A and e_{ref} are stable and known, the amplitude e_{sig} can be found.

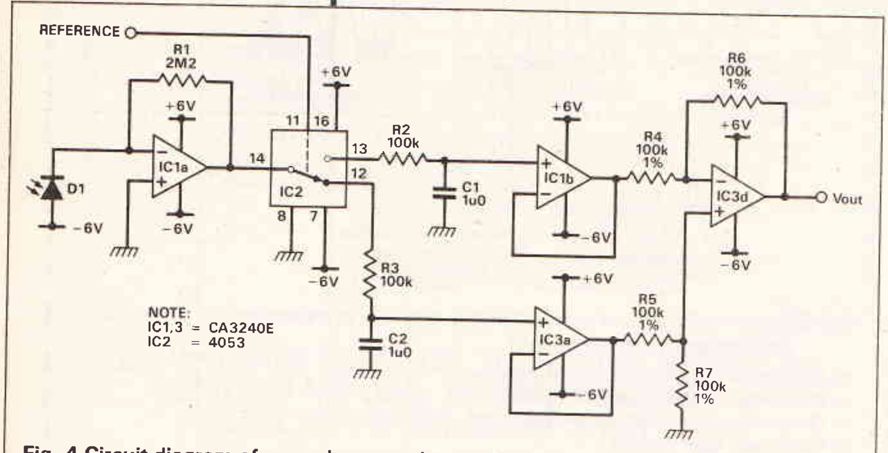


Fig. 4 Circuit diagram of a synchronous detector

No mention has been given so far about how the signals are made periodic, since this depends on the physical system being monitored. To give an example, lock-in detection is common in infra-red astronomy where the telescope secondary mirrors are wobbled so that the detector alternately sees the object of interest or an empty patch of sky. The chopping frequency is typically in the 10-100Hz range. A similar system is used in radioastronomy, where it is called a Dicke switch.

Commercial lock-in amplifiers contain refinements like a vernier delay control, a variable frequency chopping oscillator and a meter to display the output. Typically they cost a few thousand pounds.

Synchronous detection is a similar method for use when the reference is a square wave and in phase with the signal. A circuit diagram for a synchronous detector with a photodiode input is shown in Figure 4. To use the device, set up a squarewave oscillator with a frequency of about 1kHz (a 555 astable will do) and connect its output to an LED and the circuit's reference input. Since the switch, IC2, is synchronised with the LED, the voltage across one of the capacitors

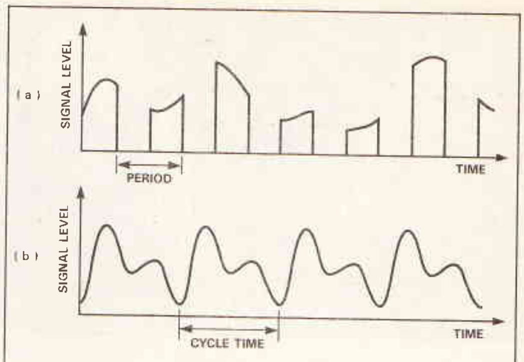


Fig. 5 Examples of (a) a periodic function (b) a repetitive function

will be the average signal when the LED is on, and the other will be the average signal when the LED is off. A subtractor circuit is used to find the difference between these voltages, which is the signal due to light from the LED.

Any signals which are not at the same frequency or phase as the reference will eventually contribute equally to both paths and (provided the time constants R_2C_1 and R_3C_2 are long enough) will generate the same voltage on both capacitors resulting in no output.

This can be demonstrated by turning the room lights on and off, which should make only a small difference to the output voltage whereas blocking light from the LED should cause it to fall to almost zero.

Repetitive Signal Methods

The snag with lock-in and synchronous detection is the need to make the input signal periodic, which is not always possible. Often, however, the phenomenon being measured can be made to repeat at some stable interval, and in these cases devices called repetitive signal averagers can be used.

It is important to understand the difference between a periodic (or chopped) signal and a repetitive one. Figure 5 shows an example of each, and includes some of the definitions associated with them.

Some phenomena are naturally periodic, for example the light output of a pulsar, but these are often the hardest to deal with since the cycle time must be accurately known. Signal averagers build up a clean waveform of the input by adding each cycle to the previous ones, creating a running average of the input voltage.

The advent of cheap semiconductor memory has meant that digital averagers are now almost universal, except at high frequencies, but in the interest of completeness, a brief overview of the 'olde worlde' analogue techniques will be given.

Analogue Averagers

A skeleton circuit diagram of an analogue signal averager is shown in Figure 6. The incoming signal is buffered and fed to the drains of a chain of FETs. Each FET has its source connected to a capacitor, C_1 to C_n. The gates are controlled by a shift register such that they are off when the corresponding output is at logic 0 and on when it is at logic 1.

At the start of each cycle a trigger pulse causes the clock to ripple a logic 1 through the shift register. Each FET comes on in turn, connecting its capacitor to the input for one clock cycle. When the logic 1 reaches the end of the shift register, the circuit waits for the next trigger pulse, and starts again. Provided the time between each trigger pulse is the same as the cycle time, a particular FET will be on at the same

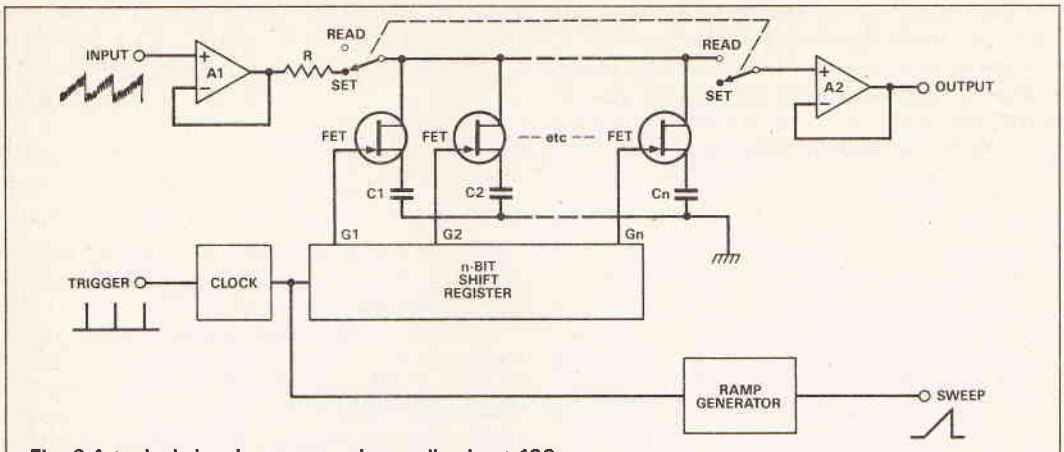


Fig. 6 A typical signal averager. *n* is usually about 100

point in each cycle, and so its capacitor will accumulate a charge proportional to the average signal level at that point.

To read the signal, the switch is put into the 'read' position and a logic 1 is repeatedly clocked through the register. The output of A_2 connects to the Y input of an oscilloscope, and the ramp generator provides an X deflection signal.

For optimum use of an averager with n channels, the clock should be n times as fast as the cycle time, although it can be made even faster than this to examine parts of a waveform in more detail.

Boxcar Integrator

This is a greatly simplified version of the signal averager which uses only one FET channel. A block diagram is shown in Figure 7.

In the boxcar integrator the signal is averaged and read out at one point at a time. The operation is as follows:

The hold-off circuit delays the trigger for a time proportional to the voltage on its control input. Initially the staircase output is at minimum so no delay is introduced. Therefore, an average of the signal level at the trigger point is developed on the capacitor. When sufficient sweeps have been taken the value is read out and the control voltage increased such that the trigger is delayed by one monostable period. The second section of the signal is then averaged and read, and so on for the whole cycle.

Although boxcar integrators are cheap and simple they suffer from two drawbacks which severely limit their practical use. Firstly, the output from one point must be cleared before starting the next, which means the waveform must be displayed on an expensive storage oscilloscope, or read and plotted manually. Secondly, most of the information available in each cycle is thrown away, so a very large number of sweeps is required to give results comparable to other averaging methods. For example, a boxcar integrator will take n times as long as an averager with n channels to accumulate the same amount of data. Since n is typically 100, it can be seen just how inefficient a boxcar is! For this reason they are only used with high frequency signals where the number of cycles required is not so important, and the cost of high speed components makes conventional averagers prohibitively expensive.

Doing it Digitally

There are two types of digital signal averager, one dealing with analogue inputs and the other with pulse inputs. They are usually combined in one unit since the electronics are very similar for both types.

The heart of both types is a memory, typically 1k by 20 bit, and an address counter. Consider first the pulse input type, called a multichannel analyser (MCA). These are designed for use with sensors whose output is in the form of a pulse train, the rate of which depends on the parameter being measured. Examples of this type of sensor are nuclear particle detectors and photomultiplier tubes used at low light levels (where individual photons can be resolved).

MCAs accept three inputs: the pulses from the sensor, a *channel advance* pulse and a reset pulse. They operate as follows:

When a pulse arrives at the signal input, the memory location (or channel) currently being addressed is incremented by one. A pulse on the channel advance input increments the address counter by one, while a pulse on the reset input sets it to zero.

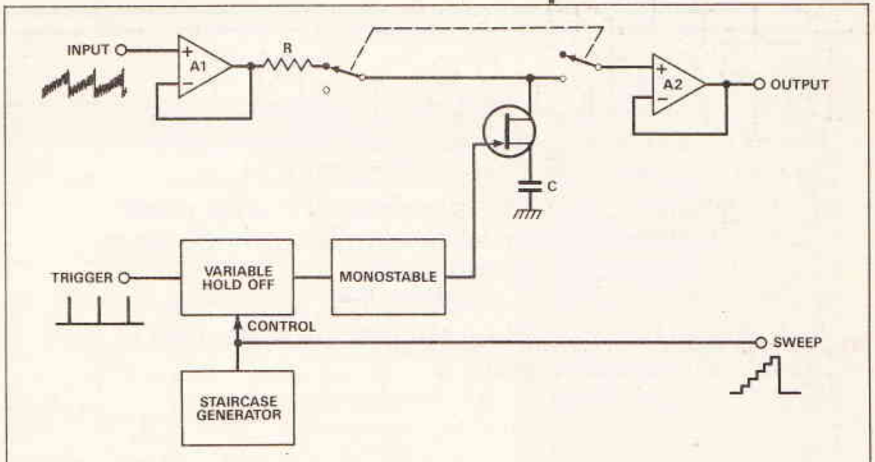


Fig. 7 The boxcar integrator

Suppose our input consists of a signal, which repeats after period T, and random background noise pulses. We arrange that at the start of each cycle a pulse is issued to the reset input (equivalent to the trigger on an analogue averager) and that 1024 equally spaced pulses arrive at the channel advance input each cycle (equivalent to the clock in an analogue averager).

The MCA will sweep through all its channels, adding to each one the number of pulses which arrive while it is selected. Since the counts due to the signal will always add into the previous ones while the noise will, on average, contribute equally to all channels, the signal will eventually begin to emerge from the background. Figure 6 shows a typical MCA output after 10 and 100 sweeps for the case when the noise is 10 times greater than the signal, which contributes 10 counts in the channels where it peaks, per sweep.

Consider the general case of an incoming signal with a cycle time T, n_B counts per channel per sweep from background and an extra n_s counts per sweep in those channels where the signal peaks. After N sweeps the background count will be Nn_B and the extra counts in the signal peaks will be Nn_s.

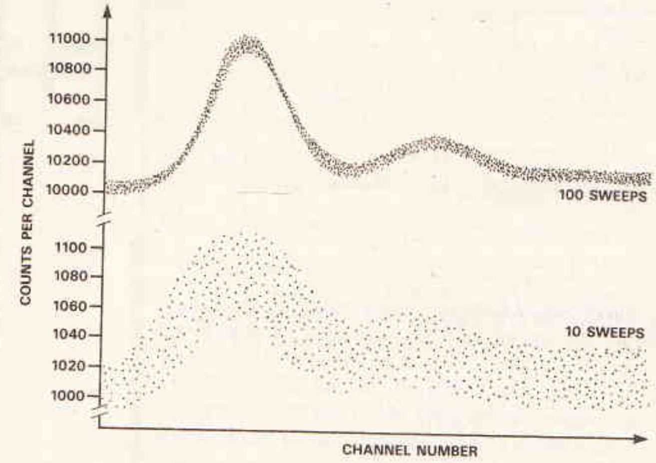


Fig. 8 Typical MCA output. Note the increase in SN ratio and the number of counts per channel as the number of sweeps increases.

It can be shown using the statistics of random numbers that the fluctuation in the background count (ie the difference between the maximum and minimum background counts) is equal to the square root of the average number of background counts per channel. Hence, the background fluctuation after N sweeps will be $\sqrt{Nn_B}$ counts. So:

$$\frac{\text{signal fluctuations}}{\text{background fluctuations}} = \frac{Nn_s}{\sqrt{Nn_B}}$$

$$\text{And: SN ratio} = 10\log_{10}\left(\frac{Nn_s}{\sqrt{n_B}}\right) = 10\log_{10}\sqrt{\left(\frac{Nn_s^2}{n_B}\right)}$$

$$= 5\log_{10}\left(\frac{Nn^2}{n_B}\right)$$

Since $N = \frac{t}{T}$ this equation can be used to find how long an experiment must be run to achieve a desired SN ratio.

To use an MCA with analogue signals, it is necessary to convert them into pulse form using a VCO and a differentiator. Commercial analysers usually have this facility built in along with an oscilloscope type display of the memory contents.

A similar device called a pulse height analyser (or *kick* analyser) exists, in which the channel incremented on receipt of a pulse depends upon the height of that pulse. This can be used to extract a non-repetitive signal from noise of a different energy, for example strong nuclear disintegrations from weaker background radiation using a proportional counter as a sensor, but it is usually used to plot energy spectra of already noise free pulse signals.

Conclusions

It is quite easy to get carried away with the beauty of these techniques, but it must be remembered that there is no magic involved. The old physics adage "You can't get owt for nowt" applies here. A better SN ratio can only be achieved by sacrificing response speed (ie bandwidth) or by running the experiment for a longer time. Still, when faced with a seemingly impossible noise problem and all else fails, one of these methods can be employed to great advantage.

ETI

MODERN DIODE CIRCUITS

2

Ray Marston looks at a wide range of diode circuits and applications in the second part of his series.

Last month we covered the basic characteristics of the modern junction diode and associated devices such as zener and varicap diodes, photodiodes and LEDs. We went on to look at a variety of practical half-wave and full-wave rectifier circuits. This month we will be looking at practical circuits and applications based on the ordinary junction diode and rectifier.

Clamping Diode Circuits

A *clamping* diode circuit takes an input waveform and provides an output that is a faithful replica of its shape but has one edge clamped to the zero-voltage reference point. Figure 1a shows a version which clamps the waveform's negative edge to zero and gives a purely positive output, and Figure 1b shows a version which clamps the positive edge to zero and gives a purely negative output.

You should note two important points about these apparently simple circuits. First, their peak output is (ideally) equal to the peak-to-peak value of the input waveform, so if the input swings symmetrically about the zero voltage point, the peak output value is double that of the input. Secondly, the circuits fall short of the ideal because the output is in fact clamped to a point that is offset from zero by an amount equal to the diode's V_f value (about 600 mV in silicon types), as illustrated in Figure 1 and in many other diagrams in this article.

Figure 2 shows what happens to these circuits when a 10k resistor is wired across D_1, and the inputs are fed with a good 1 kHz square wave from a low impedance source. In this case C_1 and R_1 form a differentiator network, with a time constant equal to the C-R product. If this product is very long (100 mS) relative to the waveform period (1 mS), the circuits act like simple clamping diode types, as shown in Figures 2a and 2c. If the C-R product is very short (10µS) relative to the 1 mS waveform period, however, the C-R network converts the square-wave's rising and falling edges into positive and negative 'spikes' each with a peak amplitude equal to the peak-to-peak input value. D_1 then effectively eliminates (discriminates against) one or other of these spikes, as shown in Figures 2b and 2d. These last two are thus useful in detecting the leading or trailing edges of square or pulse waveforms, and are generally known as differentiator/discriminator diode circuits.

In an ordinary clamping circuit the diode clamps one edge of the waveform close to the zero-voltage reference point. The basic circuit can also be used to clamp the waveform edge to a reference voltage other than zero by simply tying the 'low' side of the diode to a suitable bias voltage. Such circuits are known as

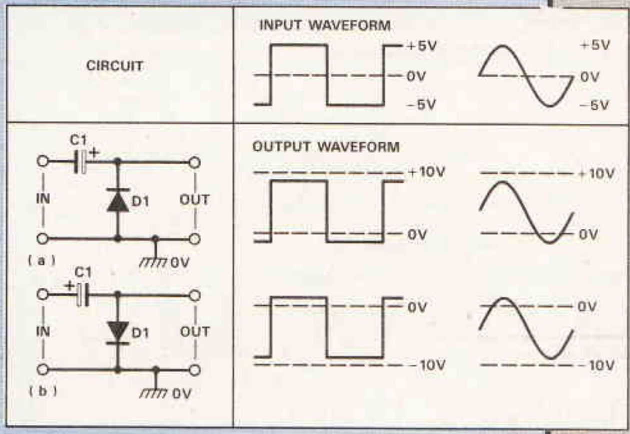


Fig. 1 Clamping diode circuits

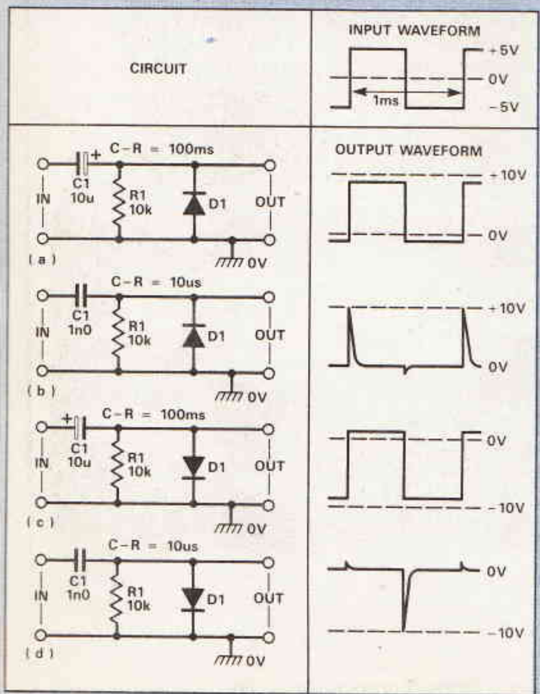


Fig. 2 Differentiator/discriminator-diode circuits

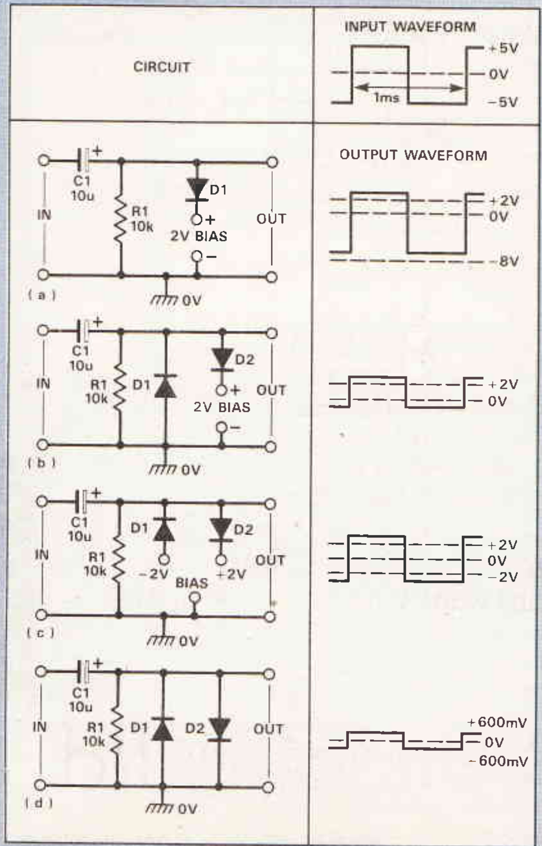


Fig. 3 Biased clamping diode circuits

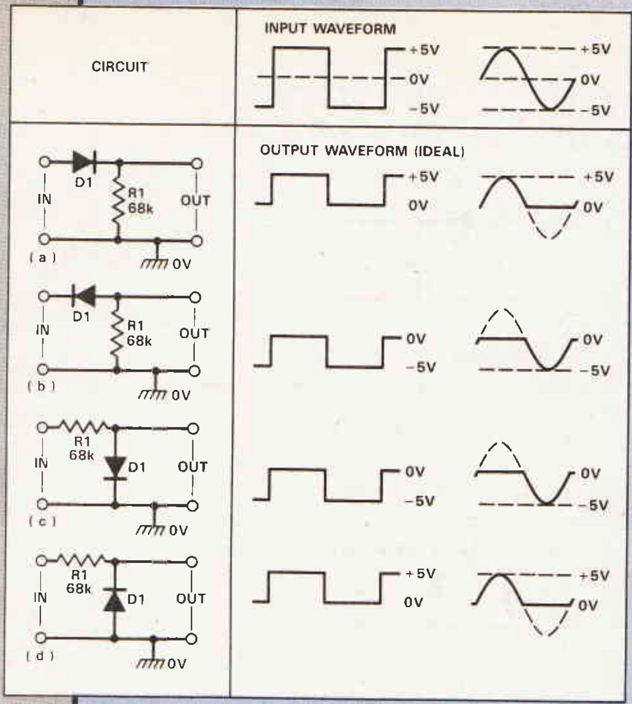


Fig. 4 Single-diode rectifier circuits

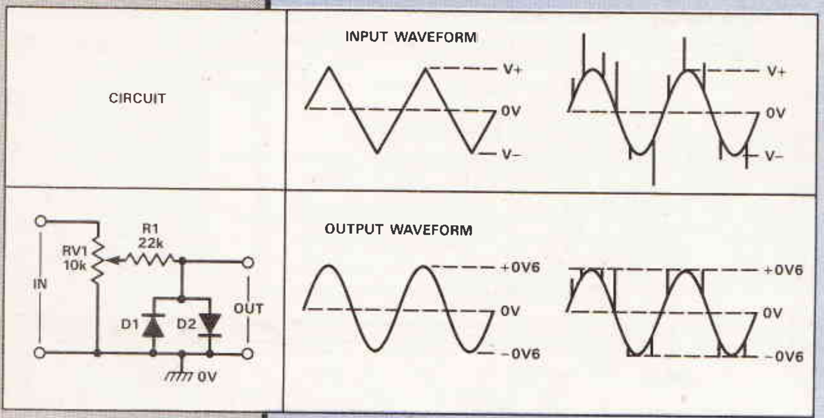


Fig. 5 Two-diode limiter circuits

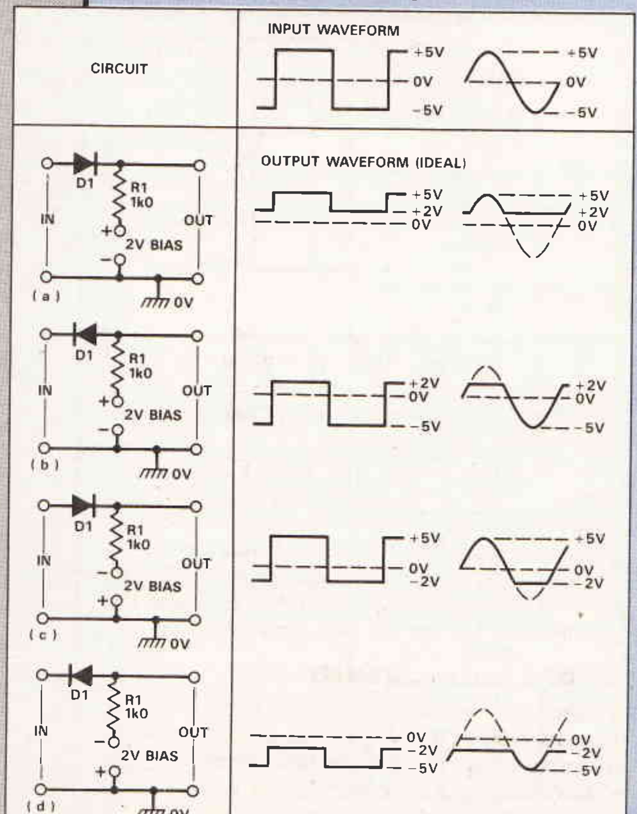


Fig. 6 Biased single-diode rectifier circuits

biased clamping diode types, and a variety of these (with very long C-R products) are shown in Figure 3.

Figure 3a shows a biased clamping diode circuit using a +2V clamping point and a 'negative output' diode, so that (ideally) the output swings from +2V to −8V when fed from a 10V peak-to-peak input. If the diode is reversed and a +5V bias point is used, the output will swing between +5V and +15V.

Figures 3b and 3d show circuits using pairs of clamping diodes. Obviously, a waveform can not be clamped to two different voltages at the same time, so in these circuits one diode acts effectively as a clamp and the other as a waveform clipper. The matter of precise diode task designation is purely academic; in Figure 3b, it does not matter if D_1 is regarded as a zero-volts clamp and D_2 as a +2V clipper, or if D_2 is regarded as a +2V clamp and D_1 as a zero-volts clipper. The net effect is the same; the output is clipped at zero and +2V. Similarly, the Figure 3c circuit (which uses −2V and +2V reference points) is clips the output at −2V and +2V. Finally, Figure 3d uses a pair of zero-voltage reference points and would ideally give zero output. Because of the offsetting effects of the D_1 and D_2 V_f voltages (about 600mV each) in fact it gives output clipping at +600mV and −600mV.

Diode Rectifier Circuits

Figure 4 shows four different ways of using a single diode as a half-wave rectifier. In all cases assume that the input comes from a low inpedance source, the output feeds a high impedance, and the output waveform is 'idealised' (it ignores the effects of diode offset). The Figure 4a and 4d circuits give positive outputs only, and Figures 4b and 4c give negative outputs only. However, the 4a and 4b circuits have low output impedances (roughly equal to the input signal source impedance), but the 4c and 4d designs have high output impedances (roughly equal to the R_1 value).

Figure 5 shows how the Figure 4c and 4d circuits can be combined to make a very useful signal 'limiter' which can accept a variety of inputs and gives an output that is amplitude-limited at ±600mV via D_1 and D_2. It can be used as a triangle-to-sine waveform converter by adjusting RV_1 to give gentle clipping of the triangle peaks (generated sine wave distortion is typically about 2%), or can be used as an audio signal noise limiter by adjusting RV_1 to clip the worst of the noise bursts.

Figure 6 shows how the Figure 4a and 4b circuits can be modified to give outputs that are above or below a selected 'bias' or reference level. Thus, Figure 6a produces outputs of only +2V or greater, Figure 6b gives outputs of +2V or less, 6c of −2V or greater, and 6d of −2V or less. In each case, the output load impedance is assumed to be small relative to the R_1 value.

Voltage Multiplier Circuits

Figures 7 to 9 show various ways of connecting diodes and capacitors to make AC *voltage multiplier* circuits that give a DC output equal to some multiple of the peak voltage value of an AC input signal. Although these circuits look rather complicated, their operation is in fact remarkably simple. The *voltage doubler* circuit of Figure 7 in fact consists of a simple $C_1 - D_1$ clamping diode network which gives an AC output with a peak value equal to the peak-to-peak value of the input, followed by a peak voltage detector $(D_2 - C_2)$ that gives a DC output equal to the peak values of D_2's input voltage. Figure 7a shows the conventional diagram of this circuit, and Figure 7b shows it redrawn as a 'standard' voltage-doubler section.

Figure 8 shows a *voltage tripler* circuit, which gives a DC output equal to three times the peak voltage value of a symmetrical AC input signal. In this case (as can be seen from Figure 8a) $D_3 - C_3$ act as a peak voltage detector that generates +5V on the $D_3 - C_3$ junction, and $C_1 - D_1 - D_2 - C_2$ acts as a voltage doubler section (identical to Figure 7) that generates a voltage doubled output on top of the +5V potential, giving a final tripled output of +15V. This circuit in fact consists of a $D_3 - C_3$ *half section* plus a full $C_1 - D_1 - D_2 - C_2$ *doubler* section, as shown in Figure 8b.

Figure 9 shows a voltage quadrupler circuit, which gives a DC output equal to four times the peak voltage value of a symmetrical AC input signal. In this case $C_1 - D_1 - D_2 - C_2$ act as a voltage doubler section that generates +10V on the $D_2 - C_2$ junction, and $C_3 - D_3 - D_4 - C_4$ act as another voltage doubler section that generates another +10V between the $D_2 - C_2$ junction and the $D_4 - C_4$ junction, to give a final +20V of output between the $D_4 - C_4$ junction and ground.

Figures 8b and 9b show that any desired amount of voltage multiplication can be obtained by wiring appropriate numbers of full and half multiplier sections in series. Seven-times multiplication could be obtained by wiring three full sections in series with a single half input section. In all cases, all multiplier diodes and capacitors need minimum ratings of twice the peak input voltage value.

The Figure 7 to Figure 9 circuits are all designed to give positive output voltages; they can be made to give negative output voltages by simple reversing the polarities of all multiplier diodes and capacitors, as in the negative voltage doubler in Figure 10.

The Diode Pump Circuit

In the basic voltage doubler circuit of Figure 7, C_1 and C_2 have equal values, and C_2 charges to the full doubled voltage value within a few cycles of initial input signal connection. However, if C_1 is made small relative to C_2, each new input cycle makes the C_2 charge increase by a small *step* voltage value that diminishes with each successive cycle, so that a non-linear *staircase* waveform is generated across C_2 as it moves towards its full charge value. Such a circuit is known as a *diode-pump*, and takes $2 \times C_1/(C_1+C_2)$ input cycles to charge C_2 to approximately 75% of its final voltage value.

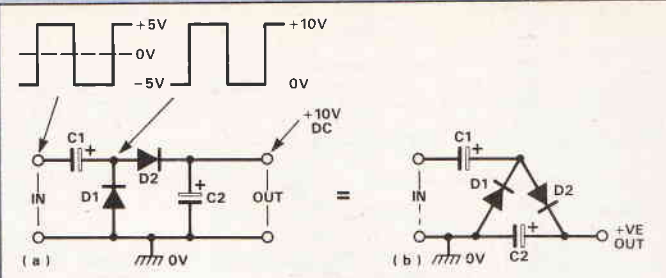


Fig. 7 Voltage doubler circuit

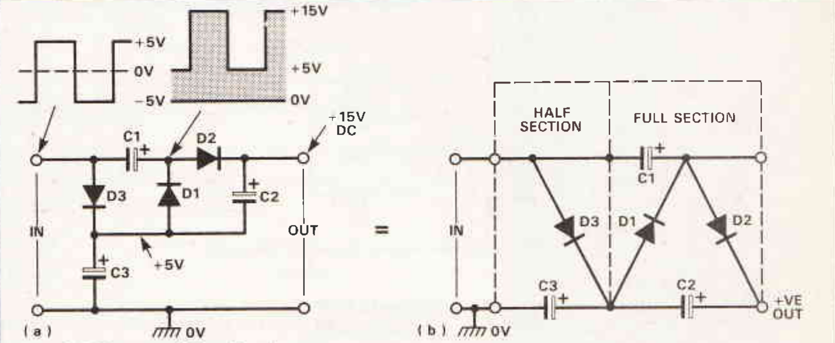


Fig. 8 Voltage tripler circuit

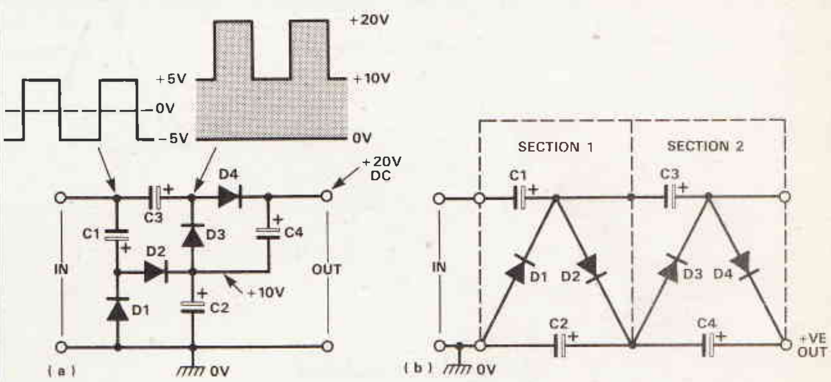


Fig. 9 Voltage quadrupler circuit

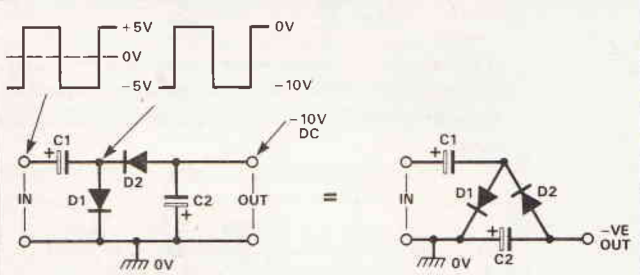


Fig. 10 Negative voltage doubler circuit

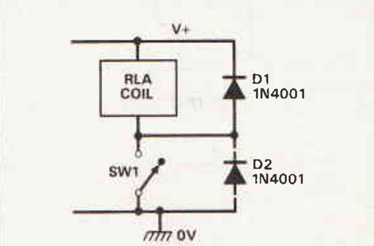


Fig. 11 Damping diode circuit limits relay coil back-emfs to safe values.

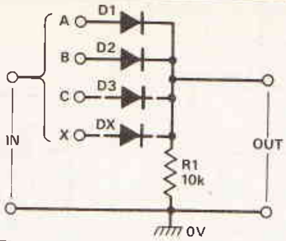
Damping Diode Circuits

When the operating current of an inductive device such as a transformer, coil or electric motor is suddenly interrupted, the inductor intrinsically generates a substantial switch-off back-emf, which may damage associated electronic or electro-mechanical devices. This danger can be eliminated by wiring a *damping* diode across the inductor, as in the relay circuit of Figure 11. D_1 stops the RLA-SW_1 junction from swinging more than 600mV above the positive supply. Alternatively, D_2 (shown dotted) can be used to prevent the junction from swinging more than 600mV below the negative supply rail.

Single-diode damping protection is adequate for most practical applications. In critical applications in which SW_1 is replaced by a transistor or other solid state switch, you can obtain perfect protection by using both diodes to made a two-diode damper that stops back-emfs from going more than 600mV above the positive or below the negative supply rail lines.

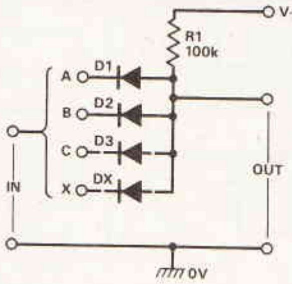
Diode Gate Circuits

Figure 12 shows how a few diodes and a resistor can be used to make an OR gate that gives a high (logic 1) output when any one of its inputs is high, and also shows the truth table of the circuit when it is wired in the two-input mode. The circuit can be given any number of inputs required simply by adding extra diodes, as shown dotted by D_3 and D_x.



A	B	OUT
0	0	0
0	1	1
1	0	1
1	1	1

Fig. 12 Diode OR gate circuit, with 2-input truth table



A	B	OUT
0	0	0
0	1	0
1	0	0
1	1	1

Fig. 13 Diode AND gate circuit, with 2-input truth table

Figure 13 shows an AND version of the diode gate, which gives a high output only when all inputs are high, and also shows its truth table when used in the two-input mode. The circuit can be given any desired number of diode inputs.

Miscellaneous Diode Circuits

Figures 14 to 19 show a variety of useful diode circuits. The Figure 14 design protects a polarity-sensitive load (for example, an electronic circuit) against damage from an incorrectly applied battery voltage. If the battery is correctly connected it feeds the load via D_1 but is blocked from the alarm buzzer by D_2. If it is wrongly connected, D_1 blocks the load's current and D_2 enables the alarm buzzer.

The Figure 15 circuit gives polarity protection to the load via the bridge-connected D_1-to-D_4 set of rectifiers, which ensure correct load polarity irrespective of the polarity of the supply battery.

Figure 16 shows how to make a high-value non-polarised capacitor from a pair of electrolytic types and two diodes. Each diode effectively shorts out its capacitor if connected to the wrong polarity. The circuit has an effective capacitance equal to the C_1 or C_2 value.

Figure 17 shows how a pair of silicon diodes can be used to protect a moving-coil current meter against overload damage. Such meters can withstand 2–3 times full scale deflection without damage, and in this circuit R_x must be chosen so that about 300mV is developed across the diodes at full scale deflection. Under this condition the diodes pass zero current, but at readings greater than twice full scale deflection they start to conduct and shunt the meter current.

Figure 18 shows how two 6V relays can be independently controlled via a 12V AC two-wire link. Note that the two relay coils are wired in series, but are each shunted by a diode so that RLA is turned on only by positive half-cycles and RLB only by negative half-cycles. When SW_1 is set to position 1, zero power is fed to the relays, and they are both off. In position 2, only positive half-waves are fed to the relays, so RLA turns on. In position 3 only negative half-waves are fed to the relays, so RLB turns on. Finally, in position 4 full-wave AC is fed to the relays, and RLA and RLB both turn on.

Figure 19 shows a modified version of the above circuit, in which each relay can be independently controlled via its own on/off switch. The circuit operates in the same basic way as described above.

A 'Scope Trace Doubler

Figure 20 shows how a pair of diodes can be used as the basis of a simple but effective oscilloscope trace doubler, allowing two individual signals to be simultaneously displayed on the screen of a single-beam 'scope. The two diodes are connected as simple gates that are driven via a 10V square wave input. C_1 causes the gate signal at the C_1-R_1 junction to switch between +5V and −5V.

When the C_1-R_1 junction is at +5V, D_2 is reverse biased and R_2-C_2 are effectively disconnected from the circuit, but D_1 is forward biased and R_1 and R_3 are effectively shorted together. This

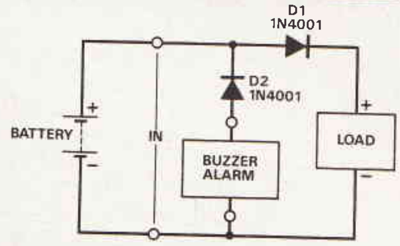


Fig. 14 Polarity protection circuit

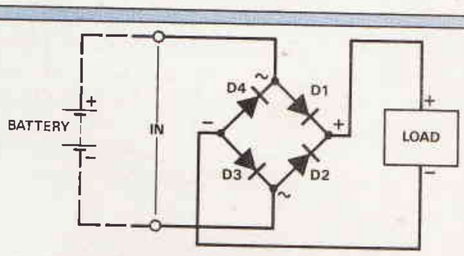


Fig. 15 Alternative polarity protection circuit

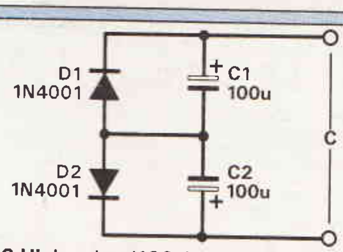


Fig. 16 High-value (100μ) non-polarised capacitor

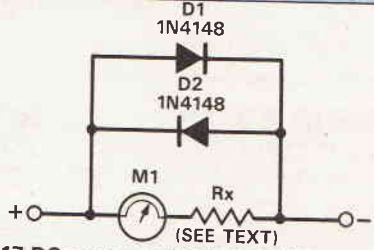


Fig. 17 DC-meter overload protection

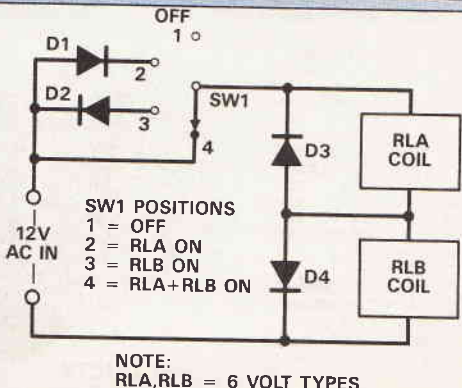


Fig. 18 Dual relay control

presents a mean potential of +2.5V, on which the input 1 signal is superimposed, at the output. When the C_1-R_1 junction is at −5V the reverse action is obtained. D_1 is effectively open circuit and D_2 is short circuit, thus presenting a mean potential of −2.5V, on which the input 2 signal is superimposed, at the output. When this complex output signal is fed to the input of a single beam 'scope, the vertical switching transitions disappear, and the tube displays input 1 vertically displaced above input 2. The trace separation can be varied by altering the amplitude of the square-wave gate drive signal.

In practice, the gate drive square wave frequency can either be made high relative to the 'scope's time base frequency, or can be made exactly half the time base frequency (via a simple binary counter). In the latter case, the 'scope displays the input 1 and input 2 signals on alternate sweeps.

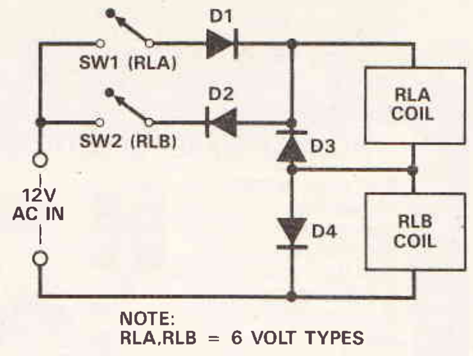


Fig. 19 Alternative dual relay control

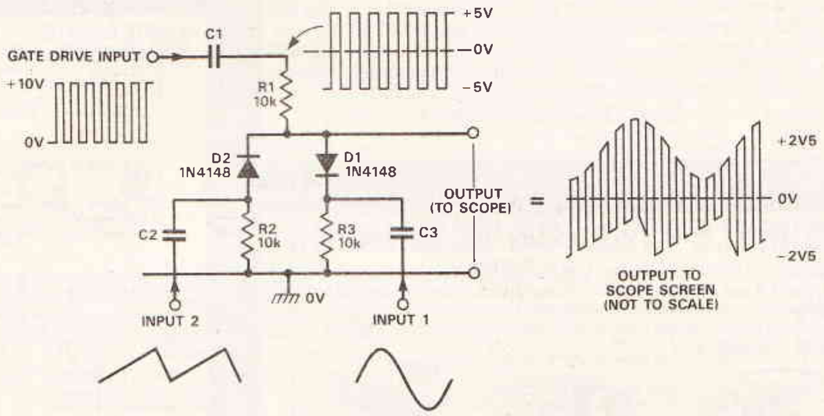


Fig. 20 Diode gate circuit used as a oscilloscope trace doubler

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BASS POLYMER CONE D: 22cm

DOME TWEETER: 14mm

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BP030	2	10k wire wound double precision potentiometers *UK made*
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BP036	6	Fuse holders, panel mounting 20mm type
BP037	6	In line fuse holders 20mm type *UK made by BULGIN*
BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
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BP051	6	14 watt output transistors. 3 complimentary pairs in T066 case *(Ideal replacement for AD161 and 162s)*
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BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diagram
BP056	4	7 segment 0.3 LED display (red)
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BP058	200	Assorted carbon resistors
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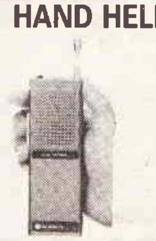

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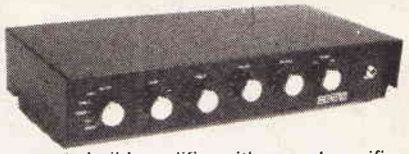

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HARNESSING

In the past, wind generation was taken seriously by nobody except Alternative Technologists. Now things are very different. Paul Freeman explains how the wind is changing . . .

ENERGY 1

It has long been the intention and practice of Alternative Technologists to introduce wind-generated electricity into their schemes for a greater contribution towards self sufficiency. The ATs, as they were known in the 1960s and 70s, were against centralisation, including that of power generation, and so they set up simple low-power wind generators for their own local supply of electricity.

The notion of setting up large scale windfarms during the 1970s for generating electric power was against the tide of an expanding nuclear power industry and was regarded by governments and the CEGB as an unworkable method of power generation. Current official thought in this direction was probably swayed by the lack of research into the subject and by the fact that high power commercial machines were not available.

Fig. 1 Horizontal Axis Wind Turbine

But today, in the changing climate of privatisation, the high cost involved by any company to maintain, run and dispose of waste from nuclear power plants does not seem to be an attractive proposition. Also with the new supply companies obliged to buy up to 600MW of renewable energy sources, it is therefore not surprising to see a renewed interest in wind generated power.

Wind, by its very nature, is a variable source of energy, changing in speed and direction. But the UK is probably in one of the best positions in Europe to utilise such a source of energy. Fluctuations in generated power might be considered as a nuisance, but strategic placing of wind farms around the countryside together with natural fluctuations from consumer demand throughout the day can iron out some of these problems. The wind speed and strength is never the same across the country and so by placing wind power stations carefully, the addition of these supplies will reduce fluctuations in power availability through the national grid system to a minimum. Change in consumer demand throughout the day would mean that other sources of electrical power can provide the balance at times of peak demand.

Wind systems are easier to integrate into a large grid system since the fluctuations in output would be less noticeable, but on a smaller scale this can become a problem.

Economical load management can tackle this problem in two ways. Firstly, by cutting demand on low priority equipment. This might be from a persuasive approach by encouraging the consumer to switch off something from a list of electrical gadgets like lights to more drastic measures of stopping the supply for non-essential items. A second way to iron out demand would be by the development of energy storage systems like batteries, flywheels and water elevation (Figure 2).

Studies suggest that land-based wind energy could provide up to 10% of the UK electrical energy demand by the year 2025, provided that the generating equipment will last 'all of its life, all of its time'. Wind generated electricity would save on fuel costs and at the same time would help reduce the greenhouse effect indirectly.

The UK wind industry has developed over the last ten years with two companies supplying medium sized wind turbines, but much higher output machines are operating and are becoming available as the technology grows.

Two major types of wind generator are currently in existance: Horizontal Axis Turbines (HAWT) where the blades rotate in a conventional manner perpendicular to the wind (Figure 1) and Vertical Axis Turbines (VAWT) (Figure 3) which are of newer design. Vertical Axis machines carry the advantage that they are not sensitive to wind direction.

HAWTs will, by virtue of the mass of their rotating parts, rotate with an approximately constant frequency. If more electrical energy is demanded, the increased torque is supplied by rotating the blades or the tips. Horizontal axis machines are moved into the wind by a geared electric motor. A wind vane acts as a direction sensor, feeding a control signal to the servo-motor.

In recent times, for whatever reason, gale-force winds seem to be more prevalent and the UK has become a damage conscious nation. So protective design, when building wind turbines, is an all-important factor.

The power of the wind is proportional to the cube of the wind speed, so doubling the wind speed will increase the power by 8 times. To avoid damage in high speed winds, each machine must have a fail safe mechanism. Just as a conventional windmill can adjust its vanes to allow strong winds to pass through, the modern day wind turbines must adopt similar designs. A brake can be applied but would lead to wasted energy and unnecessary wear to the machinery. Early vertical axis turbines had the option of turning their blades away from the wind to reduce input power. Blade flexing and constant adjustments can lead to fatigue and is a high design priority, but

THE WIND

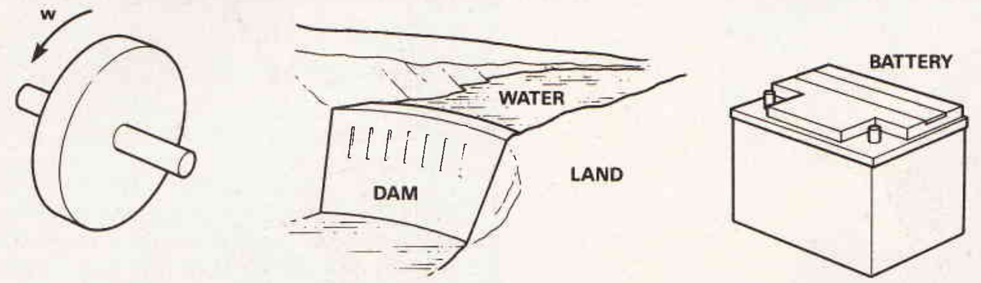
a manufacturer of VAWTs has overcome some of these problems.

Position and Number

With commercial generators now available, suitable sites have to be found. Winds are generally stronger around coastal regions, on exposed high sites and out to sea. Britain is fortunate in this respect and has many potential sites to offer. Wind parks or farms are popular and could contain many thousands of smaller turbines. They already exist in Belgium, Holland, Denmark and the United States. In California some 18,000 wind turbines produce around 1500MW of power. But the cost could be to the detriment of the environment. Noise and visual intrusion could be a problem.

Three experimental windfarms are to be set up in the UK. Possible sites are in Cornwall, Durham and Dyfed and the Department of the Energy along with Natpower or Powergen will monitor their technical and economic performance, together with the impact the installation has on the environment. The farms will contain 25 medium sized turbines giving an output of around 8MW. Spacing between machines will be around 300-400m to minimise inter-turbulent effects.

The alternative is to have single large high output generators of 1-3MW. Britain already has an operational 3MW horizontal axis turbine made by the Wind Energy Group, a joint company of Taylor Woodrow Construction and British Aerospace and installed in Orkney in 1987.



(a) FLYWHEEL

ENERGY STORED $= \frac{1}{2} I w^2$
I = MOMENT OF INERTIA
w = ANGULAR VELOCITY

(b) STORAGE OF WATER TO HIGHER LEVEL

ENERGY STORED
m = MASS OF WATER
g = ACCELERATION DUE TO GRAVITY
h = HEIGHT OF WATER

(c) BATTERIES

ENERGY STORED = QV
Q = CHARGE
V = POTENTIAL DIFFERENCE

Fig. 2 Wind Energy Storage in Flywheels, Water and Batteries

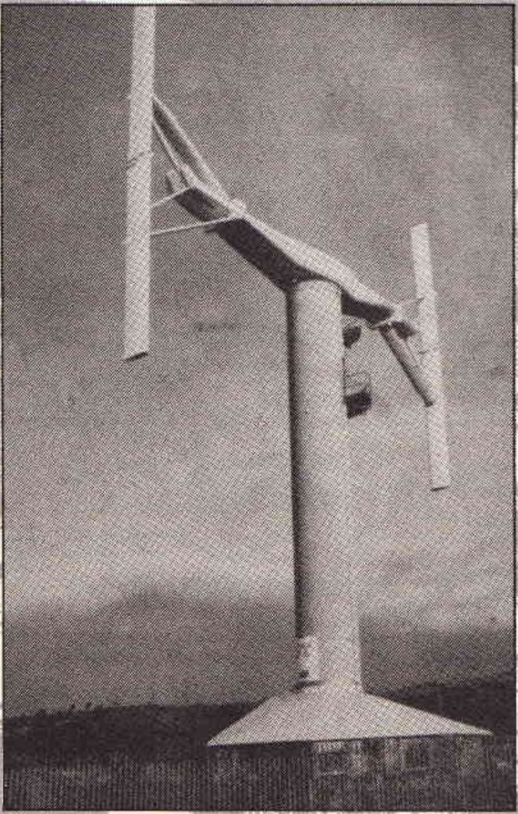


Fig. 3 Vertical Axis Wind Turbine

Offshore Electricity

Shallow waters around Britain would seem to be the ideal site for offshore operation of wind farms. Wind speeds are far greater and this solution would be more acceptable from an environmental point of view. However, offshore generation of electricity is considered by the Department of Energy to be a 'longshot technology which might be deployed effectively if there were to be dramatic improvements in costs of wind turbines or increase in fuel prices'. Having said that, there are plans afoot to install the UK's first offshore wind turbine off the coast of Norfolk in the early 1990s.

Much experience has been gained from Vertical Axis Wind Turbines, as a company of the same name built and commissioned a 25m 130kW machine at Carmathen Bay in Wales in 1986. The machine was fitted with a regulating mechanism so that the blades would be angled into an arrowhead shape in high winds, but it was discovered that this is not needed as the blades stall automatically in high winds. This led to the development of blades with fixed geometry and as a result reduced capital costs and maintenance. A new 500kW version of similar design is also to be built at Carmathen. The company has on the drawing board a design for a 1.7MW VAWT.

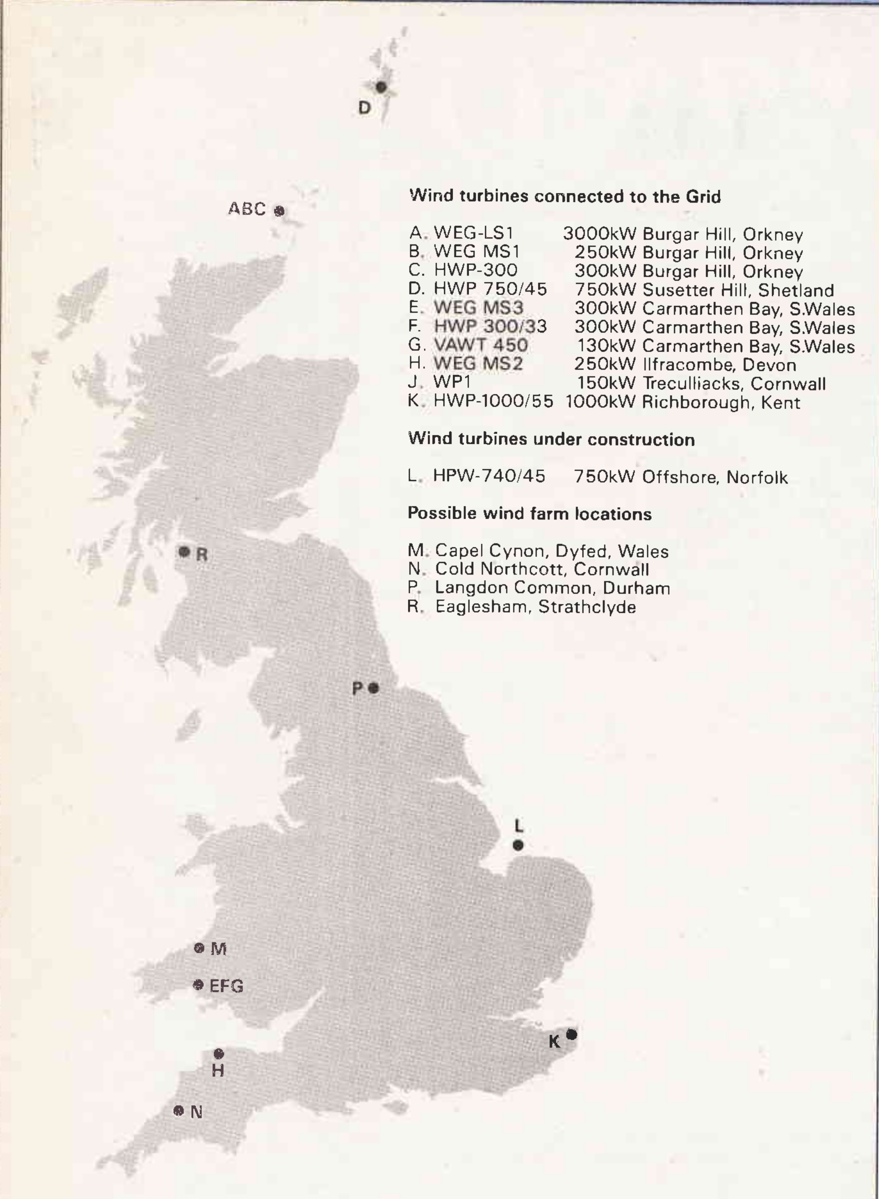


Fig. 4 Locations of Wind Driven Generators In The UK

Noise

Large rotors, rotating horizontally or vertically, would not at first thought seem to be a noisy machine. We relate our thoughts to a conventional windmill where rotation is slow. But the noise emitted from these new giants fall into two categories. Aerodynamic noise comes from the blade motion. It is more technically known as pink noise and is a range of random lower audible frequencies. From the side of the rotor, the sound is a swept range of frequencies due to the well known phenomenon known as the Doppler effect. This is brought about by any moving body emitting a vibration and changing direction relative to the observer. It's the sort of sound created when an object is whirled around on the end of a string. The intensity of the noise will depend upon the speed of the blades and the rotor tips will cause extra noise if they are out of smooth alignment. The other main area where the noise contribution is significant is mechanical in origin and comes from the gearbox.

The noise created from wind turbines is a 'far field' problem. This means the noise only becomes apparent at certain distances from the source (Figure 4). The reason for this comes as a result of the wind speed varying with height from the ground and the sound appears to be bent and directed in a refractive manner. Sound can be naturally amplified or absorbed and can travel over long distances for a variety of reasons. It can be reinforced by resonance if the source is in a hollow or using a hill as a reflector. Sound will also travel better at night, hugging the ground due to refraction. It is also common knowledge that any sound will be heard more easily directly downwind of the source.

Green light for Richborough

The latest wind generator to appear on the scene was opened in June at Richborough Power Station in Kent, and if successful could save the burning of 1 million tonnes of coal a year. The 1MW wind turbine is of a 55m diameter three-bladed design and has been developed from the knowledge gained from the smaller 300kW turbine at the Carmarthen Bay site in Wales.

The rotor blades are made of light-weight wood/epoxy laminate and mounted on a 45m tower. The blades have movable tips to control the generator output. This HAWT will start to operate in winds greater than 11mph and the generator is synchronised to the national grid automatically at 24.5rpm.

Rotation of the rotor blade tips in excessive winds will reduce the torque and maintain a constant output of 1MW. This latest aero-generator will be monitored over the next two years for its electrical performance, its mechanical operating efficiency and of course its effect on the environment.

With a current annual turnover of £4 million, the development of wind power in the next few years should give the privatised electricity companies the impetus to commission many new wind generator sites with increased output power, lower cost per unit and a knowledge that the environmental impact has been reduced to a minimum.

Our thanks go to the Energy Technology Support Unit, Harwell, and the National Wind Turbine Centre, Glasgow, for information provided in the preparation of this article.

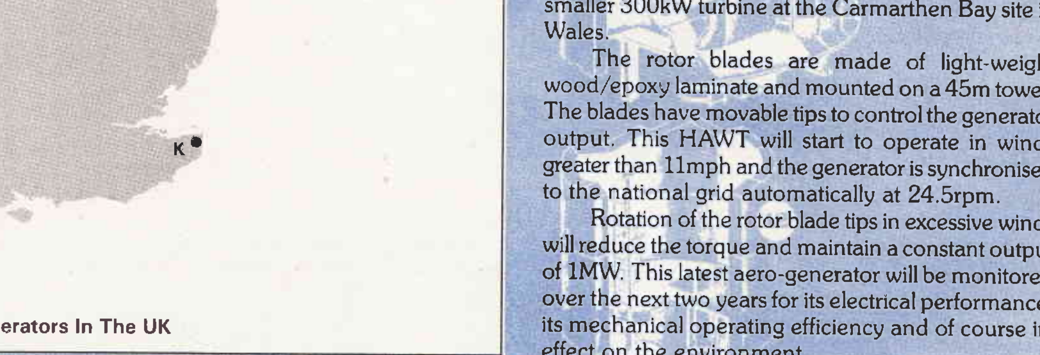
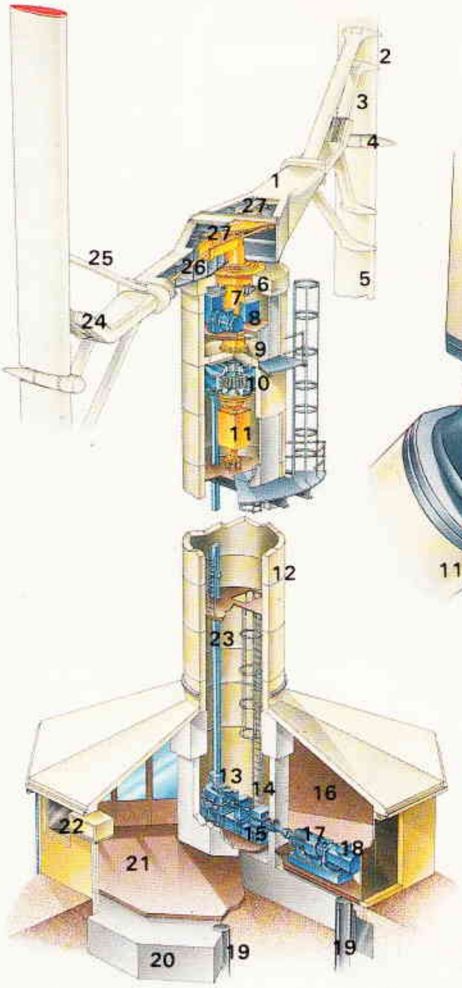
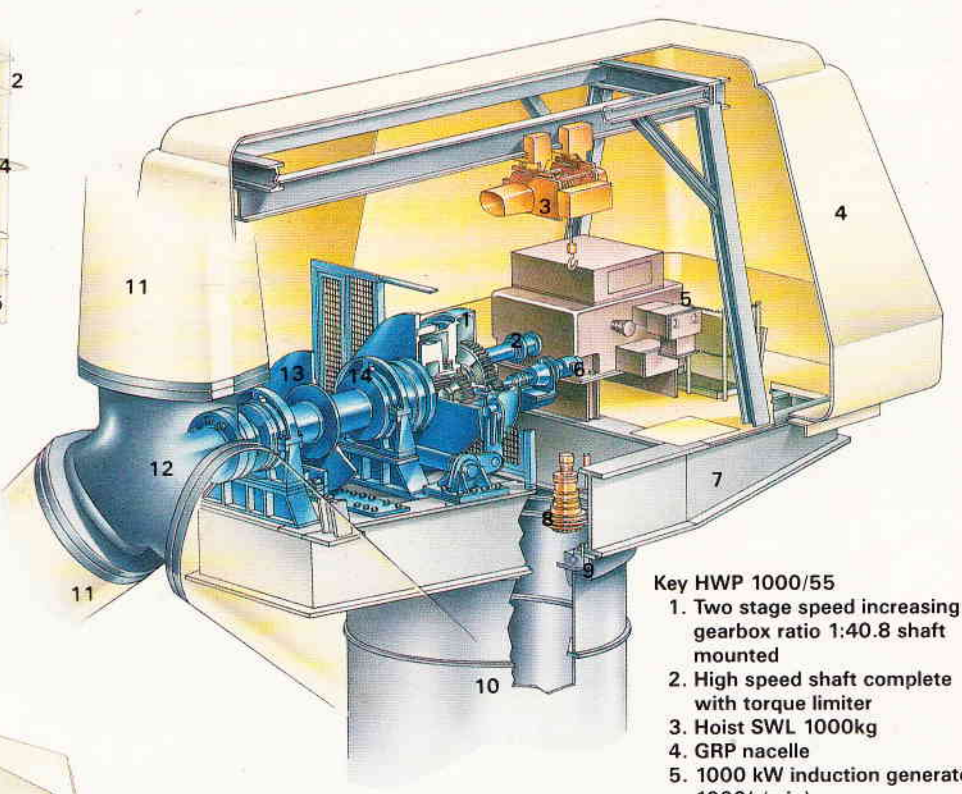


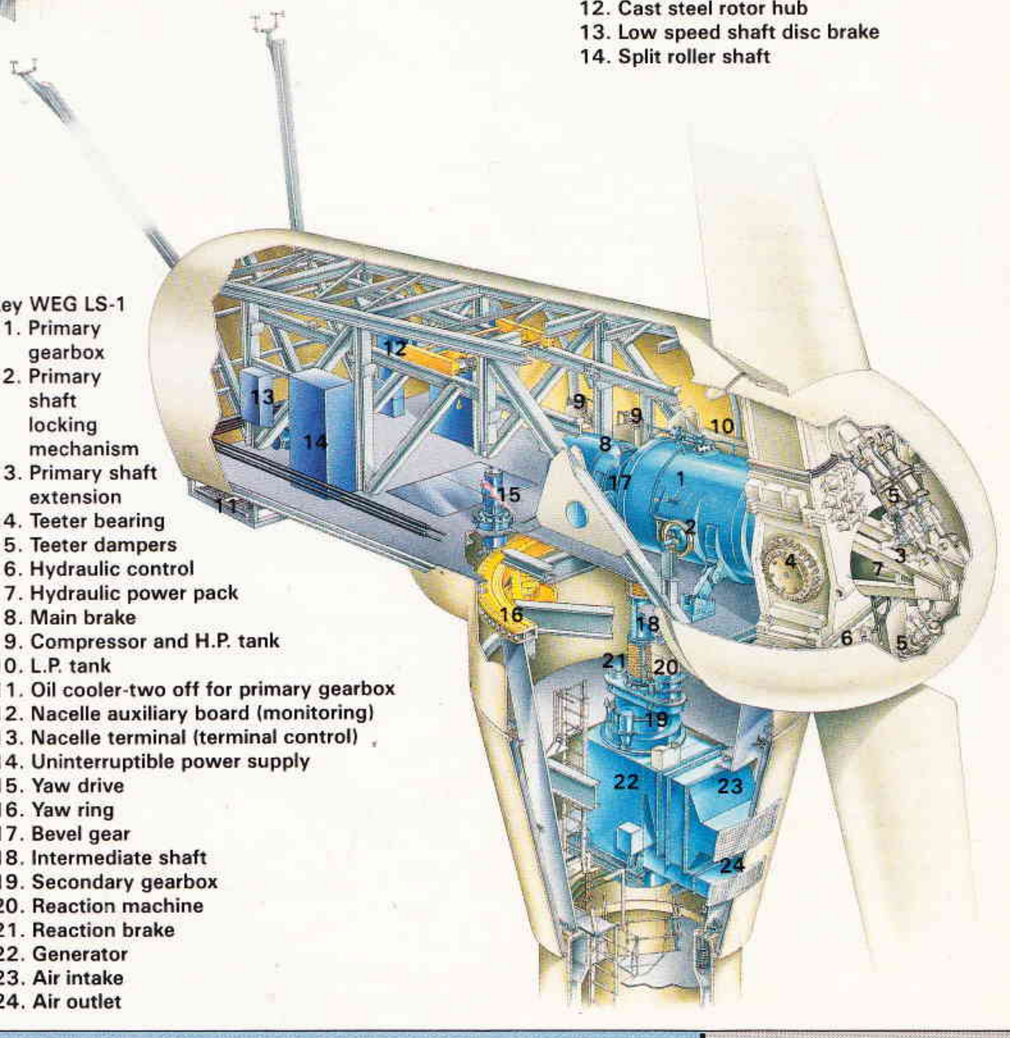
Fig. 5 Far Field Noise Effect





Key HWP 1000/55
1. Two stage speed increasing gearbox ratio 1:40.8 shaft mounted
2. High speed shaft complete with torque limiter
3. Hoist SWL 1000kg
4. GRP nacelle
5. 1000 kW induction generator 1000(r/min)
6. Rotor barring drive
7. Fabricated steel machine bedplate
8. Hydraulic geared yaw drive motor
9. Slew ring bearing with internal ring gear
10. Fabricated steel tower
11. Wood/epoxy composite rotor blades
12. Cast steel rotor hub
13. Low speed shaft disc brake
14. Split roller shaft

Key VAWT 450
1. Cross arm
2. Upper half-blade
3. Actuator strut
4. Centre hinge
5. Lower half-blade
6. Slip rings
7. Pintle shaft
8. Hydraulic power pack
9. Primary brake
10. Upper gearbox
11. Data acquisition unit
12. Concrete tower
13. Secondary gearbox
14. High speed brake
15. Tuning gearbox
16. Plant room
17. Induction generator
18. Synchronous generator
19. Piles
20. Concrete foundation
21. Control room
22. Air conditioning unit
23. Intermediate drive shaft
24. Swinging link
25. Main strut
26. Reefing mechanism
27. Reefing actuators



Key WEG LS-1
1. Primary gearbox
2. Primary shaft locking mechanism
3. Primary shaft extension
4. Teeter bearing
5. Teeter dampers
6. Hydraulic control
7. Hydraulic power pack
8. Main brake
9. Compressor and H.P. tank
10. L.P. tank
11. Oil cooler-two off for primary gearbox
12. Nacelle auxiliary board (monitoring)
13. Nacelle terminal (terminal control)
14. Uninterruptible power supply
15. Yaw drive
16. Yaw ring
17. Bevel gear
18. Intermediate shaft
19. Secondary gearbox
20. Reaction machine
21. Reaction brake
22. Generator
23. Air intake
24. Air outlet

ENERGY STORED = mgh

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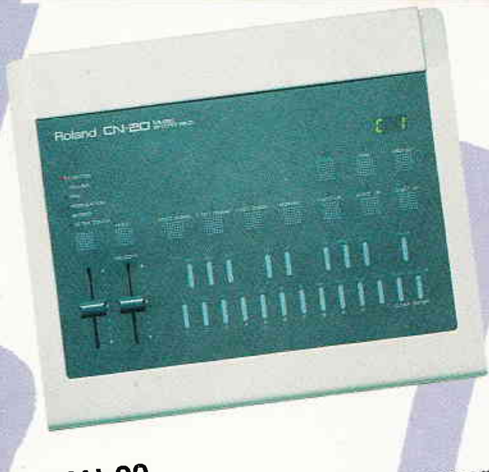
ROLAND'S DESK-TOP COMPUTER MUSIC RANGE

CM-64 LA/PCM

The CM-64 LA/PCM Sound Module gives a maximum 63-voice polyphony, is 15-part multi-timbral (including rhythm part) for full orchestral reproductions and provides 64 PCM preset tones and, from the wonderful world of LA synthesis, 128 synthesizer presets, 30 percussion sounds plus 33 sound effects for the rhythm part. The CM-64 also accepts U-110 sound sample library cards and incorporates an on-board digital reverb.

CM-32L CM-32P

The CM-32 LA Sound Module provides all the LA capabilities of the CM-64, is 32-voice polyphonic and 9-part multi-timbral and likewise has built-in digital reverb. The CM-32P PCM Sound Module contains the CM-64's PCM section with its 64 presets, is 31-voice polyphonic and 6-part multi-timbral, has the same digital reverb, and is U-110 sound-card compatible.



CF-10

Next in the range comes the CF-10 Digital Fader. This is an easy-to-use mixing controller with the feel of an analogue audio mixer and featuring 10 multiple MIDI channels, designed to mix song data for sequences created on a PC or MIDI sequencer, it also enables control change messages for volume and panning to be transmitted to external MIDI devices.

CN-20

The CN-20 Music Entry Pad facilitates the programming of basic song data on a PC. It offers, for instance, easy editing of data pre-recorded from an external keyboard in real time. Its multi-purpose fader can be assigned to control a variety of MIDI information such as Control Change Bender and Aftertouch over any of the 16 MIDI channels.

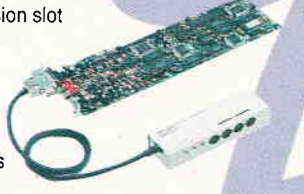
CA-30

Last of the modules is the CA-30 Intelligent Arranger. Designed to be linked with the CM-64 or CM-32L, the CA-30 is a sophisticated auto arranger with similar intelligent arranging functions as found on Roland's best-selling E-20 Intelligent Synthesizer. With the CA-30, even complete beginners can create interesting and convincing song data.

CM SUPPORT

Supporting the CM modules themselves are three peripheral components. The LAPC-1 LA Sound Card fits into the expansion slot of an IBM-PC for instant access to the great sounds of Roland's MT-32 Multi-Timbre module. The MCB-1 is an optional MIDI connector box for the LAPC-1, allowing the LAPC-1 to be used as an interface with external MIDI devices. And the MPU-IMC is a MIDI interface compatible with Micro Channel Architecture, the new IBM bus format used on the PS/2 PC.

LAPC-1



MPU-IMC

Roland

Roland (UK) Ltd. West Cross Centre, Brentford, Middx TW8 9EZ.
Telephone: 01-568 1247 • Fax: 01-847 1528

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Session Music · Belfast · 0232 238502

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Silica Shop · Sidcup · 01 302 8811

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LONDON
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Graphic Music Systems · SE16 · 01 231 6018
Inter Computer Consultants · W2 · 01 402 2683
London Rock Shop · NW1 · 01 267 7851
Silica Shop · W1 · 01 580 4000
Silica Shop · W1 · 01 629 1234 Ext. 3214
Software Circus · W1 · 01 436 2811
Software Circus · WC1 · 01 404 4492
Soho Sound House · W1 · 01 434 1365
The Synthesizer Company · NW8 · 01 258 3454

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A1 Music · Manchester · 061 236 0340

MERSEYSIDE
Hessys Music Centre · Liverpool · 051 236 1418

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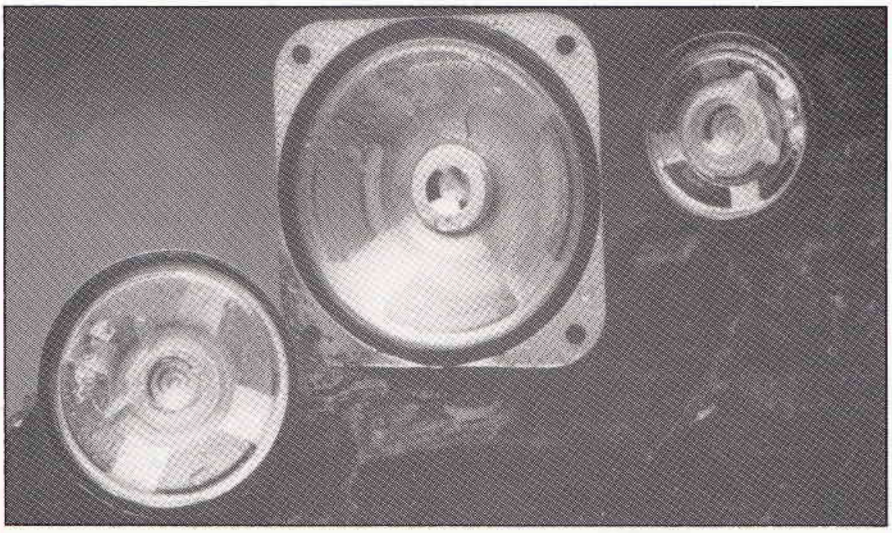
ETI Audio news

Nimbus Records, the recording and CD manufacturing company, has signed an agreement with the British Technology Group securing the rights to ambisonic technology.

Ambisonics, the British surround-sound system, was developed by a research team from Reading University in 1975. The system records and reproduces concert hall sounds in a more natural way by having a cluster of microphones pointed around a concert hall recording three channel spacial information. An ambisonic decoder will reproduce the sounds via strategically placed speakers in the home. A Universal Matrix H — Matrix J decoding mechanism will ensure compatibility between three and two channel systems.

Nimbus has been using the ambisonic technique in recording since the 1970s and it hopes that the technology will form the basis of home entertainment systems in the future.



Fieldtech Electrocomponents has recently introduced a specialised range of weather proof speakers. The cones are made from a transparent polyester film material and are completely unaffected by water. As a result are less prone to tearing and degradation.

The speakers are particularly suited to environments where water or excess humidity may be encountered. They are ideal for use as sounders and alarms where multiple tones are required particularly in portable or exterior mounted equipment.

There are 10 sizes available, ranging from 1 inch to 4 inch in diameter with the smallest weighing less than 14g! Maximum power input ranges from 0.1 to 12 watts with a nominal impedance of 8 ohms.

Roland's new S-770 professional digital sampler offers a sound quality specifically designed for any recording or live performance application.

With a 16-bit linear data sampling format, the S-770 uses 48kHz, 44.1kHz, 24kHz, and 22.05kHz sampling rates to provide high quality sound. Sample data is modified with 24-bit processing and a 20-bit digital-to-analogue converter, to give sound resolution comparable to the highest quality digital multi-track recorders, CD players, and DAT machines.

The S-770's standard memory is 2 megabytes of RAM expandable to 16 megabytes with the addition of memory board. A built-in 40 megabyte hard disk drive gives fast storage and retrieval of waveform data. In addition to the hard drive, a floppy disk drive is included to load any available S-series sounds for the S-550 into the S-770 through a conversion process.

The S-770 gives 24-voice polyphony and individual Time Variant Filters and Time Variant Amplifiers are provided for each voice, allowing all filtering and amplitude effects to be processed digitally avoiding any sound quality deterioration.

The S-770 is equipped with digital inputs and outputs, balanced audio inputs and six polyphonic audio outputs.

The retail price of the S770 is £4860.00.

Roland's D-70 Super LA Synthesizer is a 76-key, multi-timbral keyboard. The D-70 enables you to develop complex sounds and provides a new level of creative flexibility, making it ideal for live performers or studio musicians who need instant complete control over sounds.

Time Variant Filters offer high-pass, low-pass and band-pass filtering and the new Differential Loop Modulation process creates random, distorted waveforms, and a wide selection of new PCM samples. The Tone Palette editing system features Level, Panning, Tuning, Cutoff, Resonance, Attack, and Release buttons which allows you to access the main synthesizer parameters. Through these, the Tone Palette's four sliders can modify parameters for any four layered Tones at once in real time, making it easy to create new sounds.

The D-70 contains a wide variety of performance functions including full MIDI controller capabilities and a large 40-digit x 8-line LCD which makes operation and editing easy. The 76-note velocity and aftertouch sensitive keyboard lets you control release velocity in real time and the unit responds to polyphonic aftertouch through MIDI, giving you exceptional expressive responsiveness.

The D-70 also contains PCM wave data, such as white noise and sawtooth waves, that can be used as sound elements. Many of the now standard multi-sampled PCM sounds come with this machine, including pianos, brass, guitars and drums. The unit has two ROM card slots, allowing access for additional new sounds, which can be modified using the various editing functions.

The effects line up includes a built-in digital reverb and chorus effects which can be used simultaneously.

The D-70 retails at £1,799.00.

YAMAHA
SY77

GUITAR PRACTICE AMP

Do you disturb everyone in your house by practicing on your electric guitar? If so, this project by Keith Brindley for a headphone guitar amp is for you!

If you play the guitar and practice at home, no doubt you've often been hassled to turn down your amplifier and give other people some peace. Short of divorce or leaving home, what you want is a headphone amplifier, allowing you to practice in private and let everyone else get on watching *Neighbours*.

But an ordinary headphone amp would sound somewhat lacking. Playing electric guitar through them results in a dead sound; not at all suitable for budding Eric Claptons.

So what you need is a headphone amp complete with reverberation. You only have to compare singing in the lounge with singing in the bath to realise the benefits of reverberation; sound reverberating from the smooth walls of your bathroom makes the resultant song nicer to listen to, whether your voice is in tune or monotonous.

Of course, a normal fifteen inch long spring-line reverb unit is too large to be practical, so a different approach is needed.

Bucket brigade analogue delay lines have been around for a while, so why not make a complete headphone amp unit with such a device in it to give reverb, without all the hassles of a temperamental and large spring-line unit?

Let's go back to first principles for a moment. Reverberation is simply the returned echo of a sound.

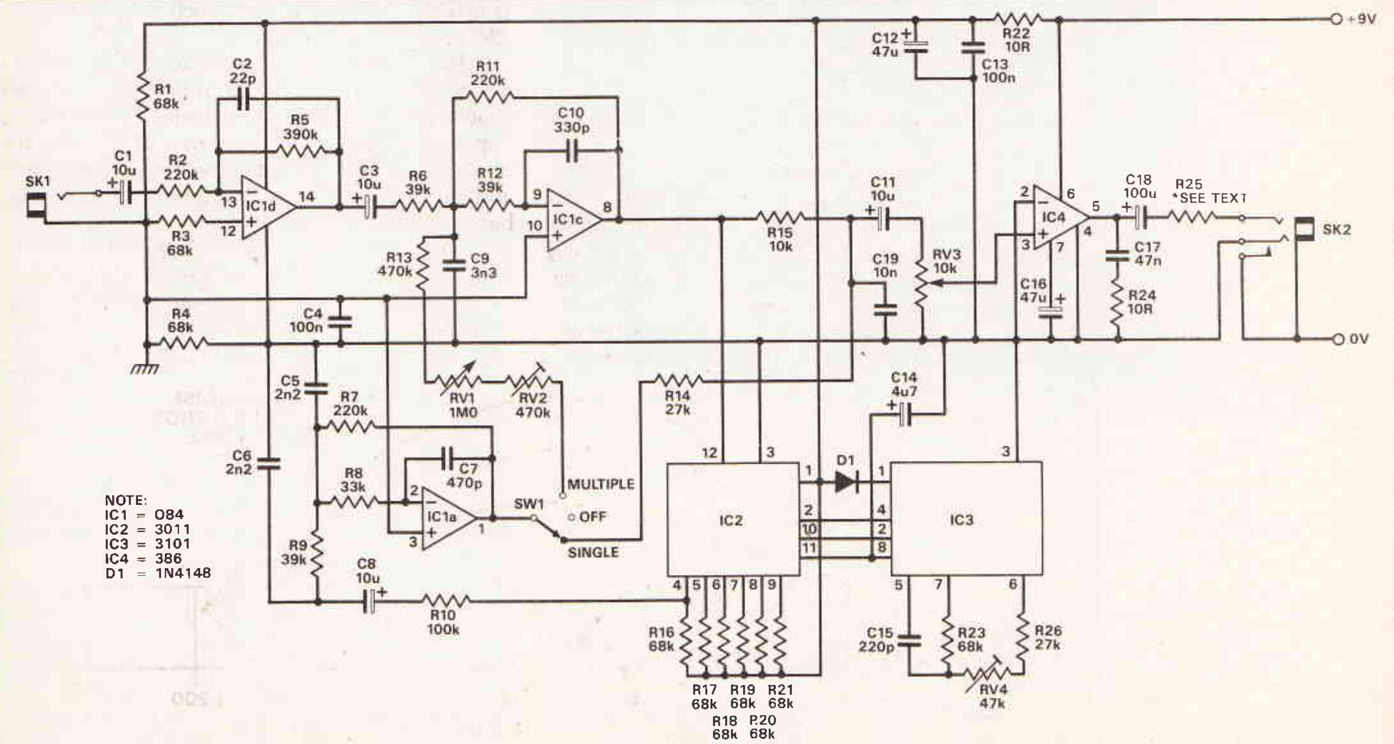


Fig. 1 Circuit of the Guitar Practice Amplifier with reverberation

In an auditorium for example, reverberation is most often heard as the sound from the stage is reflected off the walls, floor and ceiling and returned. The term *reverberation* is therefore pretty loose, as it depends chiefly on the size and shape of auditorium and the surfaces used on the walls, floor and ceiling. Further, reflections in an auditorium are multiple, not just a single echo, typically of many varying time intervals. So to define reverberation in order to reproduce it electronically, we refer to the reverberation time: the time taken for all reflections of a sound to fall in intensity by 60dB below level of original sound. In an auditorium where music is to be played reverberation times of around 2s are considered best, while in a small room where a speaker is to be heard a reverberation time of around 300 ms is preferred.

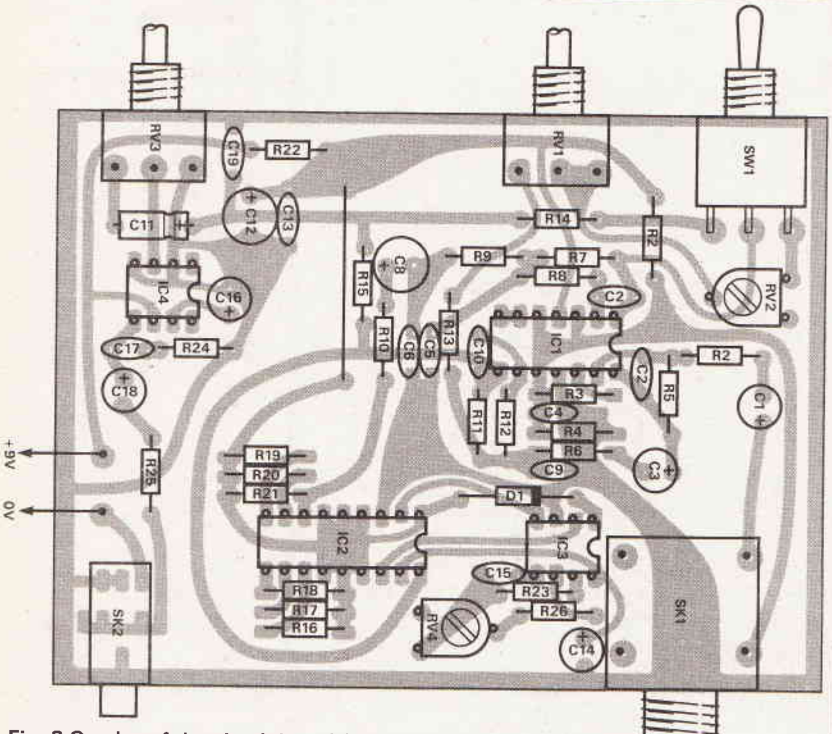


Fig. 2 Overlay of the circuit board for the project

We can use a bucket brigade analogue delay line to perform electronic reverberation, simply by recycling the delayed signal back around the circuit — provided we can recycle the delayed sound around the circuit a sufficient number of times before it decays to a level 60 dB below the originating sound. There is a problem inherent to this approach, however. Noise in the circuit is recycled along with the delayed signal, and every time the signal is recycled, noise is effectively amplified. In other words, the greater the reverberation time relative to the recycled delay time, the greater the output noise level.

Originally bucket brigade devices had an acceptable maximum delay of around only 25 ms, which is not really sufficient because the 2s reverberation time requires that 80 recyclings of the delayed signal take place. Such a circuit would generate so much noise that it's unlikely that the original signal could be heard.

Some modern bucket brigade devices, on the other hand, are capable of delays in excess of 200 ms. Thus only 10 recyclings need take place to create an auditorium-style reverberation effect. With care, sufficient filtering and good luck, noise can be kept reasonably low and a good reverberation effect will result.

Delay through the bucket brigade delay line used in the project is preset between around 20ms and 300ms. However, with a delay of 300ms the internal oscillation frequency is audible (just under 6 kHz). As considerable filtering of upper frequency components is undertaken in all stages of the headphone amplifier, though, this is not unduly obtrusive.

The circuit of the Guitar Practice Amplifier is shown in Figure 1. Reverberation effects are selected with toggle switch SW1. In its central position reverberation is OFF, and the project functions as a conventional guitar headphone amplifier. With SW1 switched to the SINGLE position, the effect is of a single echo at an interval of one complete delay period after the originating signal from your guitar. A *slapback* effect is the result. Switched to the MULTIPLE position, the project recycles the delayed signal, with a decay determined by a front panel depth control potentiometer. By increasing depth (that is, increasing the amount of feedback of recycled signal) the reverberation time is increased. With a reasonably long delay time, say, 200ms, and sufficient depth it's easily possible create an overall reverberation time of 2s. Indeed, if depth is increased further, recycling is permanent, creating a delayed acoustic feedback effect.

The project is designed to fit inside a small case, suitable for clipping to a belt or waistband, and is battery-powered. There's no on-off switch as the headphone jack socket has switched contacts which apply power to the circuit when a plug is inserted, cutting off power when the plug is removed. Simply plug in your guitar, plug in your headphones and play!

Construction

From the outset the project was designed with small size in mind. A size and weight suitable for clipping to your belt or waistband was considered essential.

Consequently, the circuit board (overlay shown in Figure 2) is fairly compact. The board is a fairly tight fit inside the case, and you have to follow a pretty rigid order of construction. Nevertheless, the project isn't too complicated for the average amateur constructor and, as long as you've had a bit experience building projects before, you should have few problems.

Starting with the PCB, integrated circuit sockets are recommended, as these allow insertion of integrated circuits easily without risk of damage from an over-zealous solderer and static. One of the ICs used (the analogue bucket brigade delay line) is pretty expensive and you wouldn't want to damage it. Also, use PCB pins for all off-board connections. Put in PCB pins for connections to switch SW1 and potentiometers RV1 and RV3. Although these components could be inserted directly into the board it's not possible to fit the PCB into the recommended case with them inserted. These components have to be soldered in after the PCB is in place inside the case and, without PCB pins, connection is not possible.

Insert and solder all passive components and the single link. Resistor R25 is determined by the headphones you are going to use. If you intend to use a pair of low sensitivity personal stereo-type headphones R25 is a single link. If your headphones are high-sensitivity can-type 'phones, a resistor of 12R should be used.

Next insert and solder both jack sockets and diode D1. Insert all integrated circuits, temporarily solder on the three front-panel controls, connect a battery, test and set-up the project.

Setting Up

This is a very personal procedure, and ideal settings of reverberation depend very much on personal taste. Initially, set preset resistors RV2 and RV4, and potentiometers RV1 and RV3 at mid-position. Switch SW1 should be in the middle position so that reverberation effects are OFF. Plug in your headphones

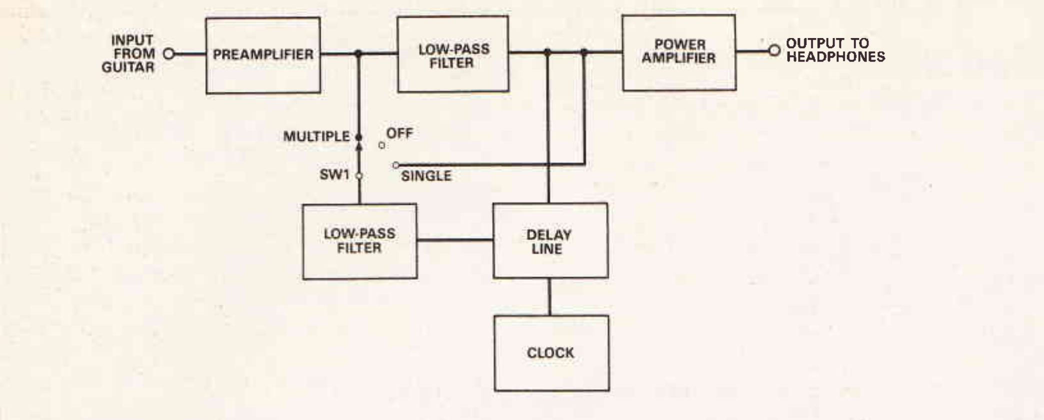


Fig. 3 Block diagram of the Guitar Practice Amplifier

and guitar. You should hear whatever you play on the guitar through the headphones.

Put switch SW1 into the SINGLE reverberation effect position. Now, whenever you play a single note on the guitar you hear it, and a single echoed repeat of that note immediately after it.

Put switch SW1 into the MULTIPLE reverberation position. You should now hear a complete reverberation effect with a reverberation time of around a second. Turn potentiometer RV1 clockwise, whereupon the effect should deepen ending up with a reverberation time over 2s, perhaps spilling over into feedback. Adjust preset RV2 so that feedback cannot occur whatever the position on potentiometer RV1.

Finally, adjust preset RV4 for delay time length. Fully anti-clockwise gives the longest delay time, at which point you will hear (if your upper end hearing is good enough) a high-pitched whistle. Adjust the preset to give the delay you feel best.

Initially, you'll probably adjust the presets to give maximum depth and delay time. After you've used the project for a while, though, you'll realise that too much reverberation and too long a delay time is not the ideal, and you'll want to back off these preset controls.

HOW IT WORKS

A block diagram of the guitar headphone amplifier is shown in Figure 3. In principle, the circuit works in a simple way. A preamplifier formed around op-amp IC1d buffers the input signal and allows some amplification. This stage is followed by a low-pass filter, formed by op-amp IC1c and associated components, to remove high frequency components from the signal.

After filtering, the signal is applied to both a power amplifier (IC4) for application to headphones and an analogue delay line IC2). The power amplifier is a single-chip 325mW device, which provides more than sufficient power to drive a pair of headphones.

The frequency of a clock, formed around IC3, controls the speed with which the signal passes through the delay line. More will be said about operation of the delay line later.

After delay, the signal is low-pass filtered once more and applied to a switch which controls the point where the delayed signal is recycled into the circuit. With the switch in its central position the signal is not recycled, so the project acts as a straightforward headphone amplifier (that is, with no reverberation). With the switch set to the SINGLE position, the delayed signal is applied to the power amplifier after the point where the original signal is applied to the delay line. This creates a single reverberation effect at the output. With the switch set to the MULTIPLE position, the delayed signal is recycled into the circuit before the first filter, and so the signal is re-applied to the delay line. Every time it is delayed, it is re-applied and so a continuous recycling (and consequent re-delaying) of the signal occurs, creating a multiple reverberation effect.

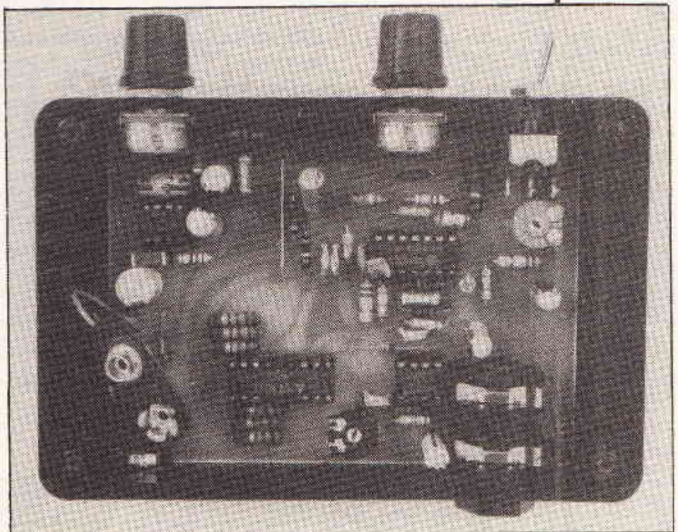
Bucket brigade delay lines take samples of the applied signal (as discrete voltage levels corresponding to the amplitude of the signal), at regular intervals and pass the voltages along a line of storage capacitors. At the end of the line of capacitors the samples are reconstituted to a single analogue signal again. The line of capacitors has often been compared to a line of firefighters, passing buckets of water along the line — hence the name bucket brigade.

This project uses a large number of storage capacitors (3328) and six different outputs along the line. This enables considerably more reverberation and associated effects to be constructed than is possible using the more normal 512-stage, single output bucket brigade devices.

Housing

The PCB is designed to fit the specified case exactly, so housing is a little tricky, especially as front panel controls have to be fitted after the board is in the case.

First, unsolder and remove the three front panel controls. Next, carefully mark and drill the case to suit the two jack sockets on the back panel. The 3.5mm stereo jack socket hole should be filled out to suit the oblong space required.



Now, estimate, mark and drill the front panel to suit the front panel controls. Once done, you can mark the case with whatever transfer lettering you want. Spray with clear lacquer to protect the case.

Fit the PCB into place then fit the front panel controls, finally soldering their connections to the PCB pins in the board.

A belt clip of sorts should be fastened to the lid of the case. Anything from a ball-point pen clip to a purpose-made spring-metal clip can be adapted to suit here. As the lid is reversible, you can choose which way up the clip faces, allowing the project to be clipped to either side of the body, with controls to the back or front, depending on preference.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,3,4,16,17,18,19,20,21,23	68k
R2,7,11	220k
R5	390k
R6,9,12	39k
R8	33k
R10	100k
R13	470k
R14,26	27k
R15	10k
R22,24	10R
R25	see text
RV1	1M lin miniature potentiometer
RV2	470k miniature preset
RV3	10k log miniature potentiometer
RV4	47k miniature preset

CAPACITORS	
C1,3,8	10μ 16V radial electrolytic
C2	22p ceramic
C4,13	100n polyester
C5,6	2n2 ceramic
C7	470p ceramic
C9	3n3 ceramic
C10	330p ceramic
C11	10μ 16V axial electrolytic
C12,16	47μ 16V radial electrolytic
C14	4μ7 16V radial electrolytic
C15	220p ceramic
C17	47n ceramic
C18	100μ 16V radial electrolytic
C19	10n polyester

SEMICONDUCTORS	
IC1	084
IC2	3011
IC3	3101
IC4	386
D1	1N4148

MISCELLANEOUS	
SW1	single-pole, double throw (with centre off) miniature toggle
JK1	in jack socket PCB mounting
JK2	3.5mm jack socket, PCB mounting with single pole, double throw contacts
Case	Verocase 202-21390

PCB, integrated circuit sockets, PCB pins, knobs, belt clip
PP3-sized battery and clip.

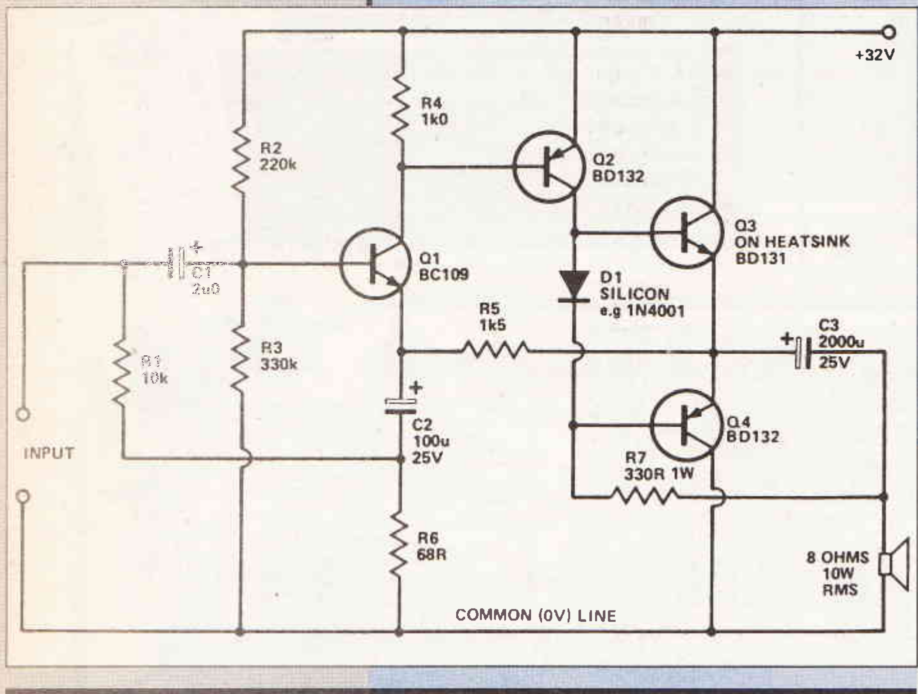
BUYLINES

Most components are readily available from most outlets. Buck brigade delay line (IC2) and its clock (IC3) can be obtained fro Electromail – part numbers 631-294 and 631-301. Jack socket JK can be obtained from Maplin – part number JM22Y. Switch SW1 also from Maplin – part number FH01B.

AUDIO TECH TIPS

Simple Ten Watt Amplifier

This is an extremely simple and inexpensive general purpose amplifier. The design is conventional, the only point of interest being that the output transistors are under-biased. This means that there is no possibility of thermal runaway — it should, however, introduce large amounts of distortion, but in fact, due to the high level of negative feedback employed, the distortion is reasonably low. Frequency response is extremely good.



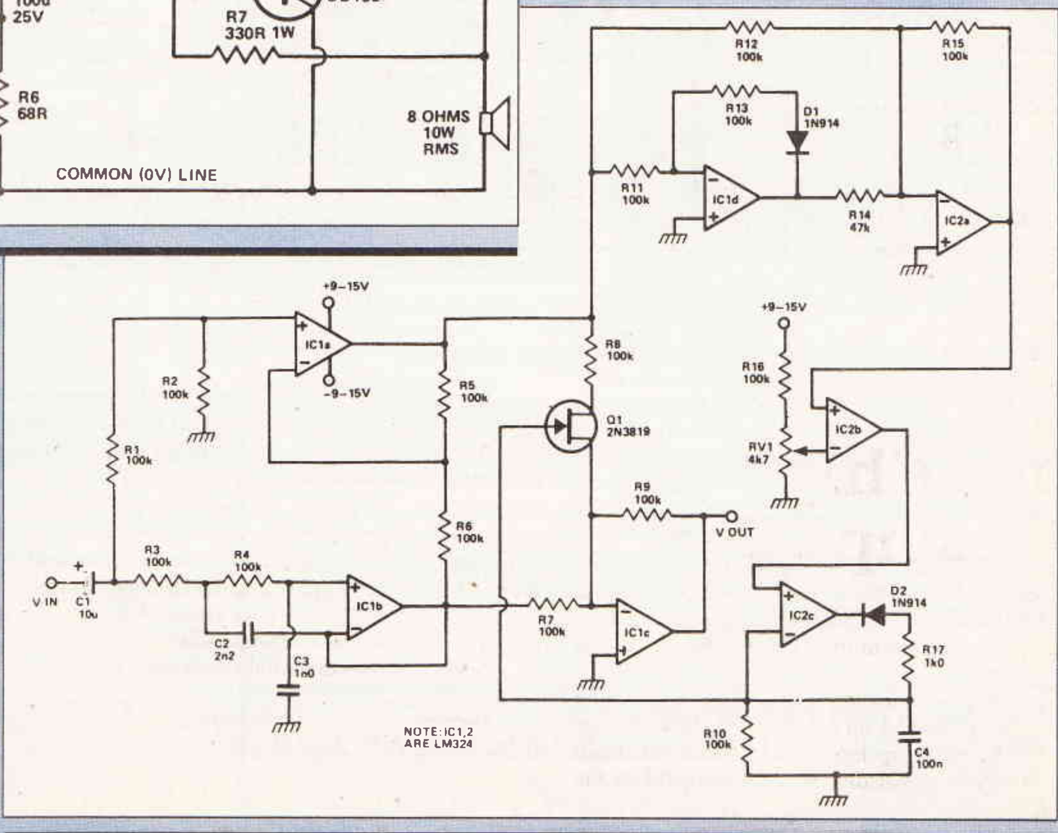
Noise Limiter

This design depends on the masking effect of high frequency signals on the noise. IC1b, R3, R4, C1 and C2 form a second order filter with a turnover frequency of 1 kHz. Differential amplifier IC1a subtracts the bass-only output at the output of IC1b from the full range input signal to leave treble and noise. This signal is full wave precision rectified by IC1d and IC2a and the resulting DC applied to the non-inverting input of IC2b. The inverting input samples a DC voltage from the slider of RV1, which forms a voltage divider with R16.

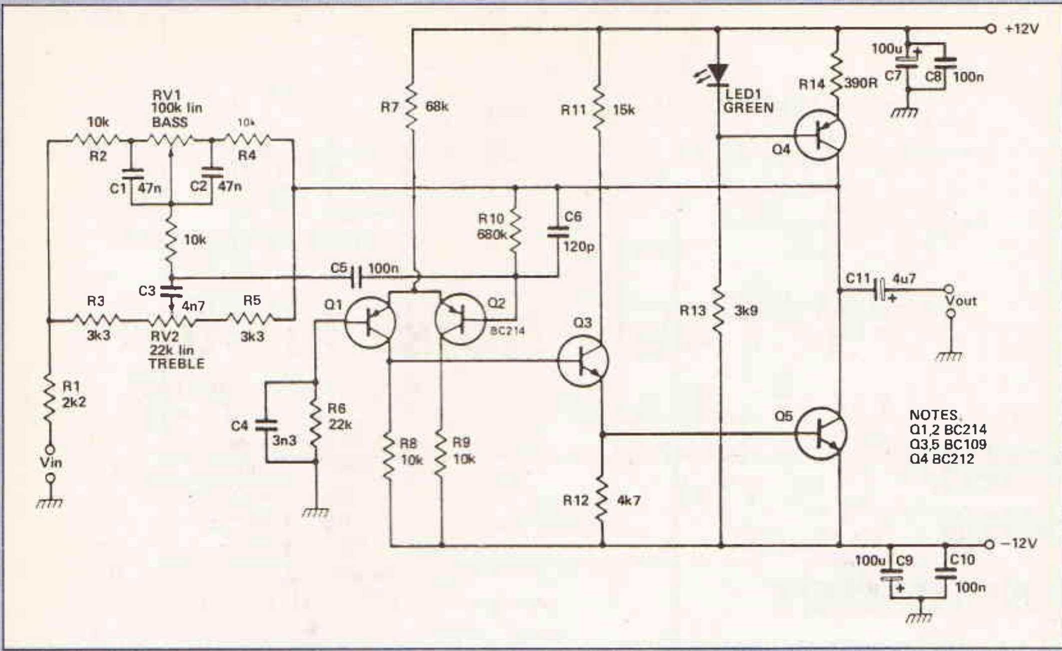
IC2b is used without feedback and thus acts as a comparator. When RV1 is properly adjusted, a positive-going pulse appears at the output each time the treble component of the input signal exceeds the noise level.

This pulse is fed into IC2c which, with the associated components, forms a negative peak detecting and hold circuit.

This in turn is fed into the gate of Q1, which is used as a variable resistance in the feedback loop of IC1c. This last op-amp is operated as a simple audio mixer which recombines the bass and treble components of the input signal. Thus the treble part of the signal is used to switch itself through only when this part of the signal is greater than the ambient noise level. The result is a signal which sounds considerably better than the original, whilst losing the minimum of detail.



CIRCUITS



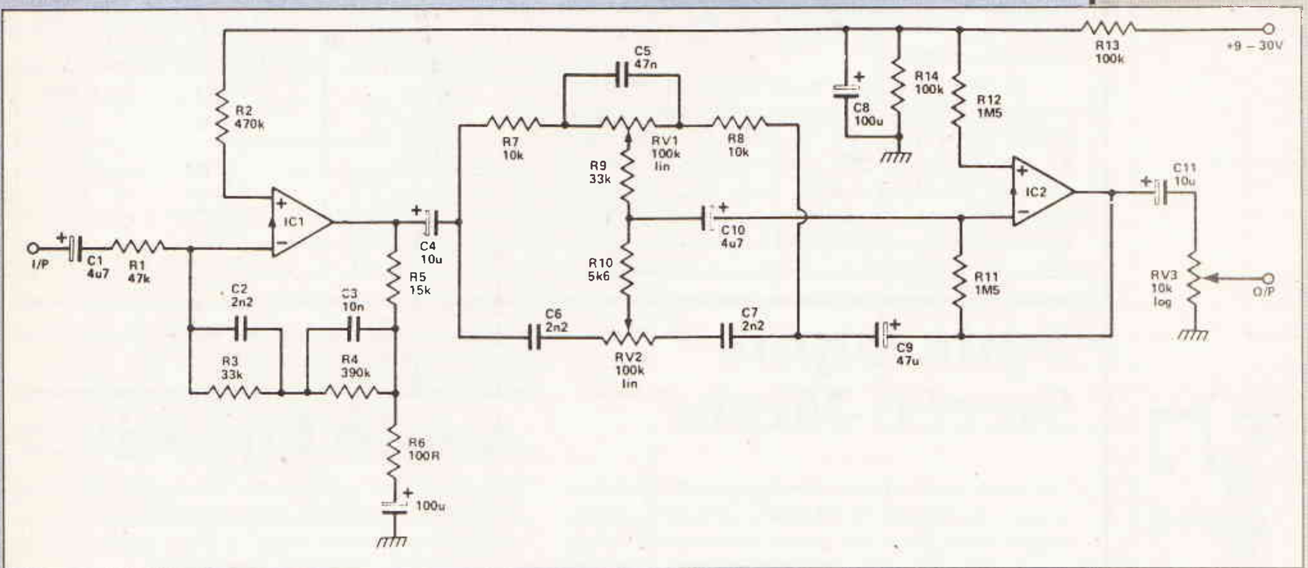
High Quality Tone Control

When designing a high quality pre-amp, the author was faced with the problem of designing a suitable tone control stage. Op-amps such as the 741 are commonly used, but in general have a poor slew rate, fairly high distortion and high noise when used in this application.

The circuit shown is based on an inverting op amp using discrete transistors to overcome the above problems. The output stage is driven by a constant current source, biased by a green LED to provide temperature compensation.

With the controls flat, the unit provides unity gain, so the stage can be switched in or out.

The design is suitable for inputs between 100 mV and 1V0, and provides a good overload margin at low distortion for the accurate reproduction of transients. The usual screening precautions against hum should be carried out.



One Chip Preamplifier

The circuit shown utilises the four Norton op amps contained within an LM3900 to produce a high quality stereo pre-amp, catering for magnetic cartridges.

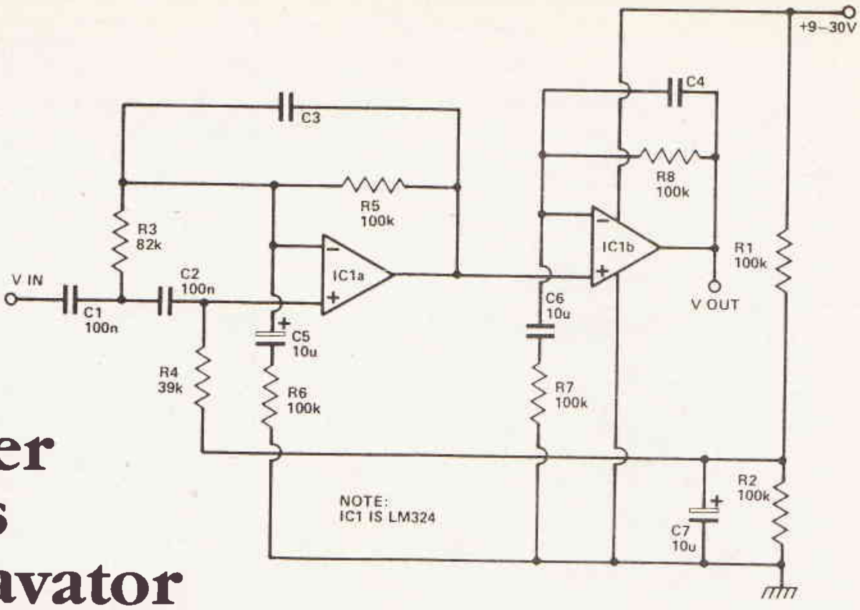
IC1 is used in the inverting mode. Signals from the cartridge are fed via the blocking capacitor and R1 to the inverting input. R1 defines the input impedance and provides the right damping for the cartridge.

R5 and R6 define the midband gain of the stage whilst the network R3, R4, C2 and C3 provide the required RIAA equalisation. From here the equalised signal is fed to a standard Baxendall tone control work built around IC2. This requires little comment although it should be noted that individual volume controls are employed for each channel. This not only reduces crosstalk between channels but also works out cheaper in that only two single gang potentiometers are used.

Performance is good with overall distortion below 0.1% and a S/N ratio of -67dB unweighted, ref 500mV out.

CIRCUITS

Super Bass Excavator



The main problem with small infinite baffle speaker systems is that the bass response rolls off rather sooner than their larger brothers. This circuit overcomes this problem by boosting the deep bass response of the power amp driving the speakers. Certainly this is not an altogether new idea as regular readers of this magazine well know but this particular circuit does the job rather better than most and the audible improvement is well worth the time and money spent.

The circuit is based around the well known quad op-amp LM324. This device contains four independent op amps of the 741 type. Before any purists hold up their hands in horror it should be noted that these are capable of delivering 2V RMS of 20 kHz sine wave without slew rate problems and that is more than enough to drive 99.99% of all known power amps into clipping.

In order to overcome the crossover distortion problems of these op amps the output stage of each is biased into class A by R7 and R10. C1, C2, R3 and R6 form a Butterworth second order filter which removes any signals below 20Hz thus preventing amplifier overload from record warp signals. R5 and C2 in conjunction with R8 and C4 produce a shelf in the circuit's response below the frequency determined by the reactance of the capacitors.

Now it so happens that the rate of roll-o infinite baffle enclosure is 12dB per octave an slope of the filters is the same. Thus by the si expedient of choosing the capacitor values to be e in value and by matching the quoted -3 dB poi the speakers with the +3 dB values in the table extends the lower -3 dB limit of the speakers by an octave.

The device must be inserted between the and power amplifiers and has a unity gain exce the bass. The maximum gain has been set at 6 prevent amplifier overload.

NEW CUT OFF −3 dB POINT	OLD CUT OFF −3 dB POINT	C3,
38Hz	50Hz	47
45Hz	60Hz	39
52Hz	70Hz	33
60Hz	80Hz	27
68Hz	90Hz	22
75Hz	100Hz	18

Four Input Stereo Mixer

The mixer circuit shown was designed to allow four or more inputs to be mixed down, producing a stereo output. Each input has stereo panning and a level control. The gain of the input stages can be boosted according to specific needs by adding Rx, making it possible to use a direct input from guitars, microphones and so on. Note that to avoid poor frequency response, the gain of this stage should be kept below 50 (keep Rx above 2k2). The input impedance is 100k and should be high enough for most applications.

The two output stages have sufficient gain to compensate for the attenuation of the panning controls. If more than four inputs are used it will be necessary to increase the gain of the output stages by decreasing the value of Ry to 6k8 for six inputs or 4k7 for eight inputs.

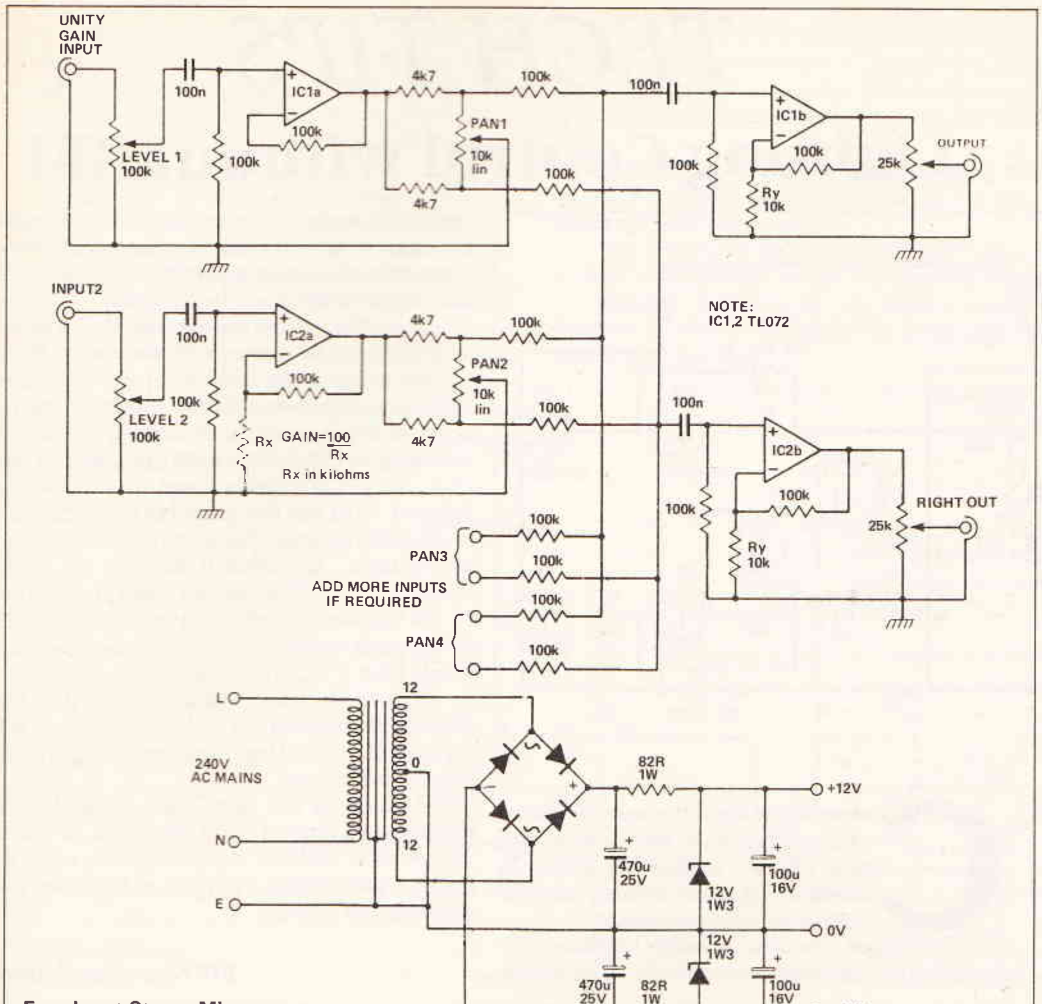
TL072 op-amps are of low noise and have been used throughout the design. The simple zener regulated power supply shown should be suitab general purpose applications.

Audio Equalise

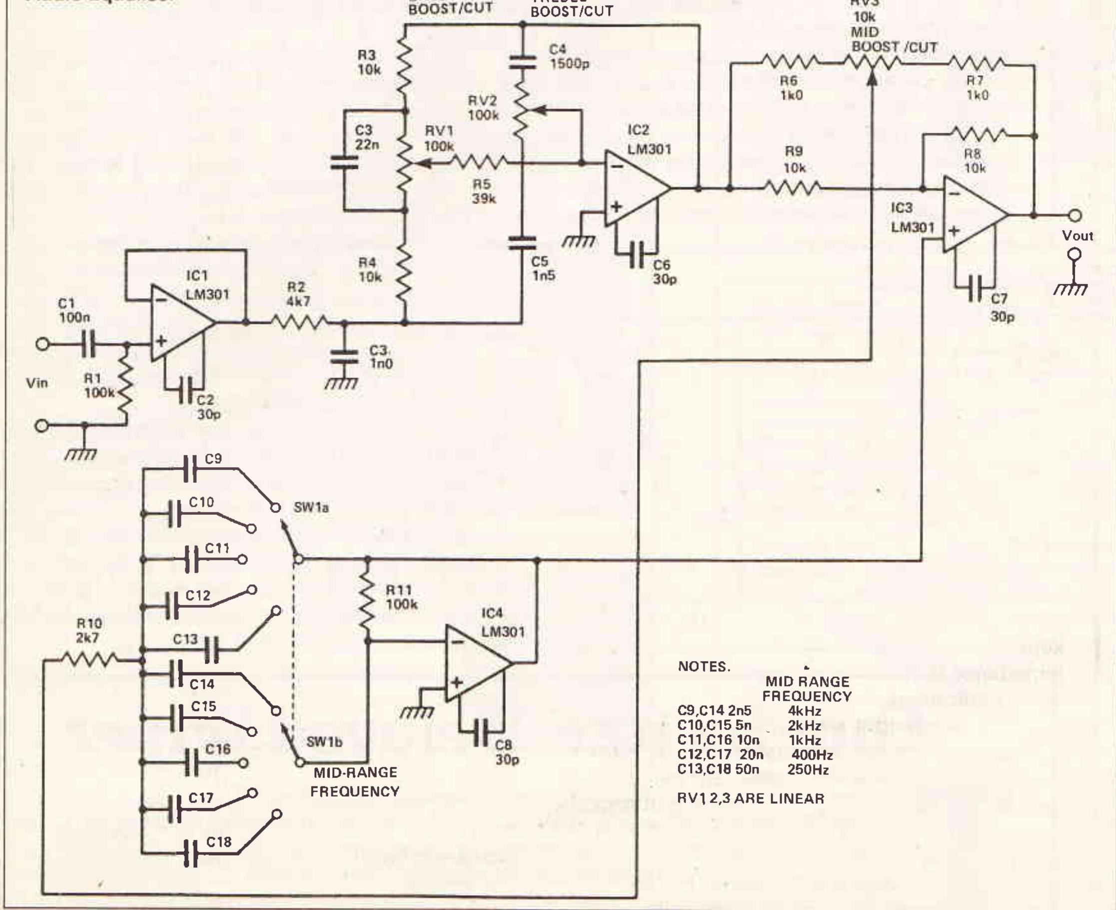
The circuit is a versatile line level audio equ providing many of the useful functions of a r channel equaliser but using only one band pass and, therefore, far fewer components.

IC1 acts as a buffer, providing an impedance of 100k. R2 and C3 give HF roll- around 30 kHz. IC2 and associated components a familiar bass/treble tone control giving 20d boost and cut. IC4 is configured as a multi-feed type band pass filter with a Q factor of 3 and a c frequency selectable by the switched capacitors C18. This band pass filter is connected in a feed path of IC3, giving up to 20dB of boost or cut a centre frequency by varying RV3.

All three potentiometers give no boost or c their centre (midway) positions and give a sm increase in boost or cut on rotation to the right c respectively.

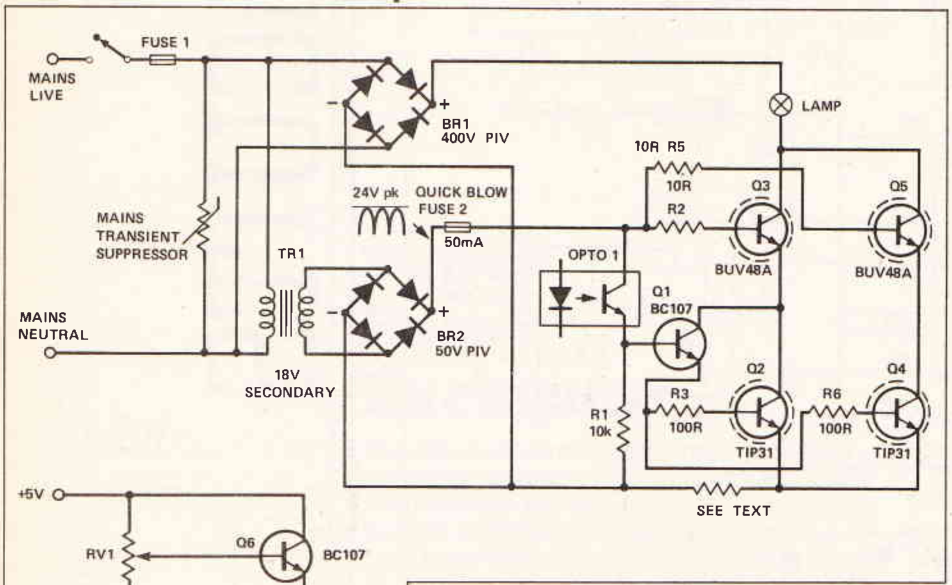


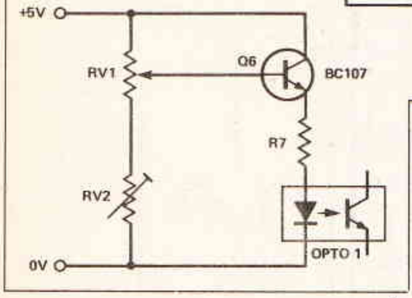
Four Input Stereo Mixer



Audio Equaliser

Lighting Control without RFI





Conventional lighting control works by switching the mains electricity on and off at different positions on the cycle. However this causes interference with audio and radio equipment.

This circuit controls a bulb's brightness by controlling the current through the bulb, via a constant current generator. The current it sinks is controlled by the opto-isolator via Q1. Transistors Q3 and Q5 dissipate excess power and so they must be mounted on a large heatsink and fan cooled.

A small quiescent current must always be drawn to develop a certain amount of resistance in the bulb. Surges occur if the bulb is driven from its cold resistance. The preset (RV2) shown in the figure provides this. It should be set with RV1 at minimum resistance, so that the bulb is just glowing when viewed close up and not visibly bright when viewed at a distance. Note that the ground of the lighting circuit is not mains neutral. This is one reason for using the opto-isolator. The other is that I'm not keen on connecting control circuitry to a mains powered circuit! At the transformer secondary voltage shown (18V RMS), single opto-isolators must be used, as dual and quads have a V_{ce} that is too low.

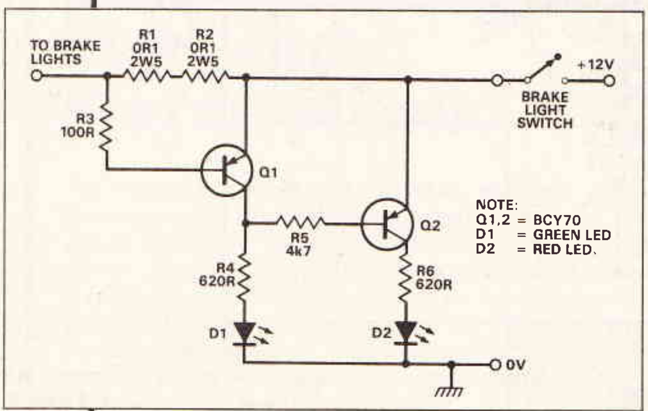
If the bulb blows, all the current will be drawn through the bases of Q3 and Q5, blowing FUSE 2. Q1 and BR2 should have a current rating to take this short-circuit current.

This circuit has been used successfully with measured powers of 40W dissipated in the bulb (R4 = 47R, 25W). It is hoped that by using more efficient heat sinking, it will give an increased power output in the future.

Bill Shaw, Southampton

Brake Light Warning

This simple circuit will detect a failure of one or both car brake-lights, as well as allowing the driver to ensure that the switch itself is operating. The lamps are usually rated at 22W — with two lights this totals 44W meaning that the total current is normally about 4A. If one bulb is defective, the current will fall to about 2A. The circuit monitors the current to the bulbs which flows through R1 and R2. Sufficient current (>3A) will produce a voltage drop of greater than 0.6V, which will turn on Q1, and so the green LED illuminates to indicate that all is well. At the same time the base of Q2 is held at nearly the supply voltage via R5, and this transistor is turned off.



However, if there is insufficient current to turn Q1 on, the green LED will be off, and Q2 can then draw enough base current to turn the red LED on.

In the case of a switch failure, neither light will illuminate when the brake pedal is pressed, and all the driver has to do is check occasionally that the green light is on while braking.

The device can be constructed small enough to be in one unit mounted in a convenient place behind the dashboard. R1 and R2 will be conducting 4A for short periods, and they should be good quality, generously rated components. I used 2.5W wire-wound resistors. Since the brake-light switch normally has push-on spade terminals, it should be possible to wire into the circuit without making any drastic modifications.

One-Switch Delayed Wiper

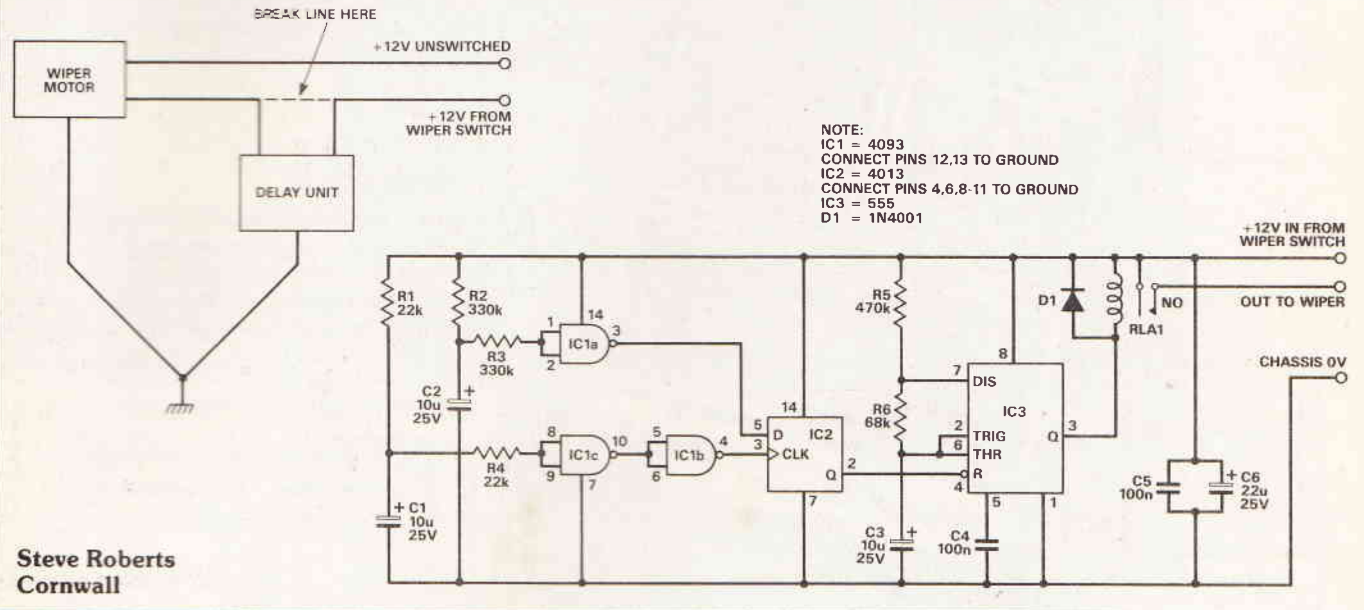
This circuit provides the choice of continuous or intermittent action without additional controls. It was designed for use with a rear wiper on a modern hatchback car but could be adapted for use with front wipers if required.

When the wiper is first switched on, C1 and C2 are discharged. C1 charges up rapidly until the Schmitt IC1(c) goes low. IC1(b) output goes high, and the D-type flip flop is clocked. At this point, the 'D' input is high, C2 not having been charged sufficiently to change the state. The Q output of the flip flop is therefore low, which holds the 555 timer in the reset condition, with its output (Pin 3) low. The relay is therefore energised, and the wiper turned on in the continuous mode.

Capacitor C2 continues to charge via R2 and after about two seconds, the 'D' input of IC2 goes low. If the wiper switch is then turned off and on again immediately, C1 discharges rapidly, and then charges again so that another clock pulse is generated as before. C2 however does not have time to discharge. This takes two or three seconds. This time, a low 'D' signal is clocked in to IC2 so that the $\overline{Q}$ output is high. This removes the reset from IC3 allowing it to free-run in the astable mode with a period of four or five seconds. Thus the wiper now runs in the intermittent mode.

To revert to continuous operation, simply switch off, leave for three seconds so that C2 has time to discharge, and switch again.

The whole unit may conveniently be housed in a plastic box inside the tailgate. It is only necessary to cut one wire, and to make one earth connection. There is no need to dismantle the dashboard, or to replace any switches.



Steve Roberts
Cornwall

DECISION MAKER

If you have trouble making important decisions, then this project by Chris Bowes is for you!

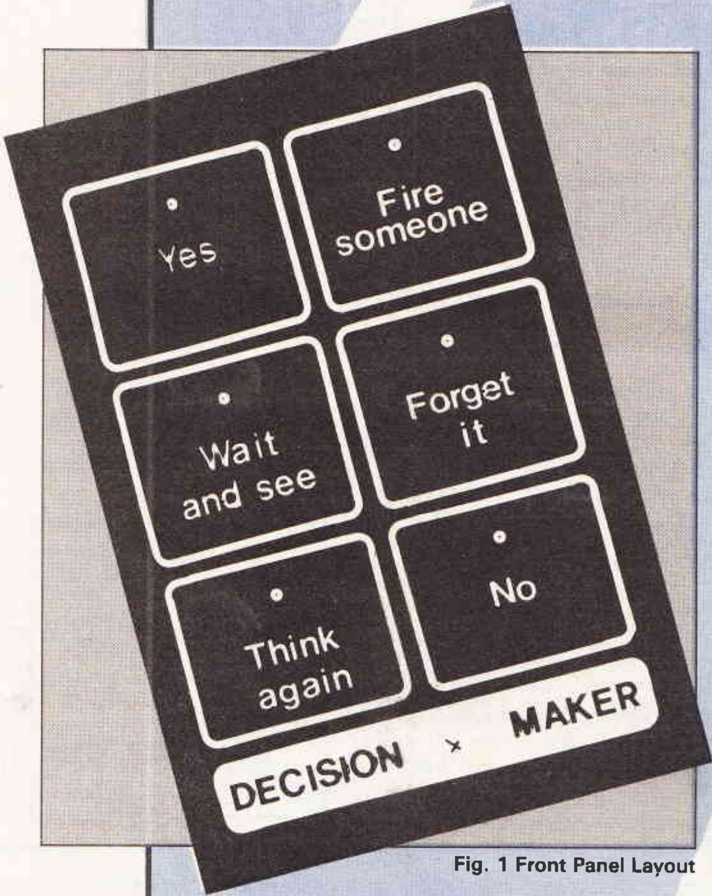


Fig. 1 Front Panel Layout

This project is an electronic version of the spinning 'executive toy' decision makers that you see advertised in catalogues around Christmas time. In these, the decision is made by spinning a heavy brass arrow, which eventually comes to rest at one of six or eight possible courses of action engraved around the circumference of the device. In this version the spinning arrow is replaced by a ring of LEDs which light sequentially.

Though this project should be regarded as an amusing toy rather than as a serious predictor of fates, it does provide a constructional project of some complexity with scope for personalisation.

Construction

This project has been designed to be constructed in the plastic case specified in the components list. If this case is not used you may need to adjust the dimensions of the PCBs and the case lid artwork.

The length of the LED leads depends on the thickness of the case lid and the height of the display board stand-off supports, so it is best to start by preparing the case lid. The holes through which the LEDs protrude and the hole for SW1 should be drilled or cut as appropriate. Carefully position the stick-on standoffs so that the LED mountings on the PCB are correctly aligned. Now remove the PCB so that the components can be mounted and soldered in position. The case lid can then be lettered and SW1 installed ready for connection to the main PCB. The front panel layout is shown in Figure 1.

Display Board

Assembly of the display board is straightforward and should follow the component layout shown in Figure 2a. The six LEDs must be correctly oriented and must have leads of sufficient length for the LEDs to protrude through the case lid. To achieve this, first insert and

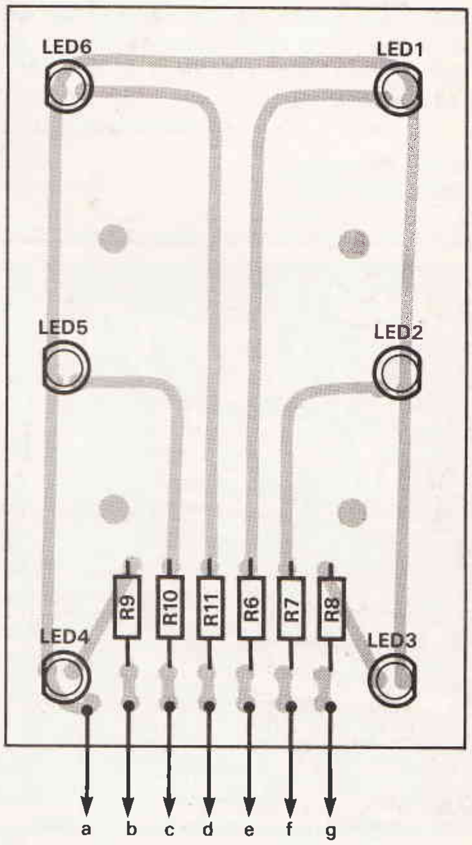


Fig. 2a Display PCB Component Layout

solder the resistors into place and the connecting cable to the board. Then place the LEDs in their correct positions, ensuring that they are correctly orientated, but do not solder them into place. Carefully position the board on the stand-offs and position the LEDs so that they protrude through the holes cut in the case lid. Once the LEDs are in the correct position solder their leads and cut off the excess wire. At this point, test the board by connecting a 9 volt battery between the common (0V) wire and the wires leading to R6 to R11 in turn. In each case the appropriate LED should light.

PROJECT

Main PCB

The main PCB is rather close packed, with a number of tracks passing between IC pins. Take care when soldering to avoid short circuits between tracks. The component layout of this board is shown in Figure 2b. There are also a number of wire links across the board. These should be inserted first and soldered into place. Where the links are terminated beneath other components it is advisable to check that the connections are sound, with a test meter, before installing the other components. Now you can install and solder the remaining components into place, making sure that diodes, capacitors, ICs and Q1 are installed the correct way round. Finally solder into place the wire connections to the battery connector, SW1 and the display PCB and inspect the board carefully for any broken tracks, solder bridges or incorrect components before connecting the battery and testing the circuit.

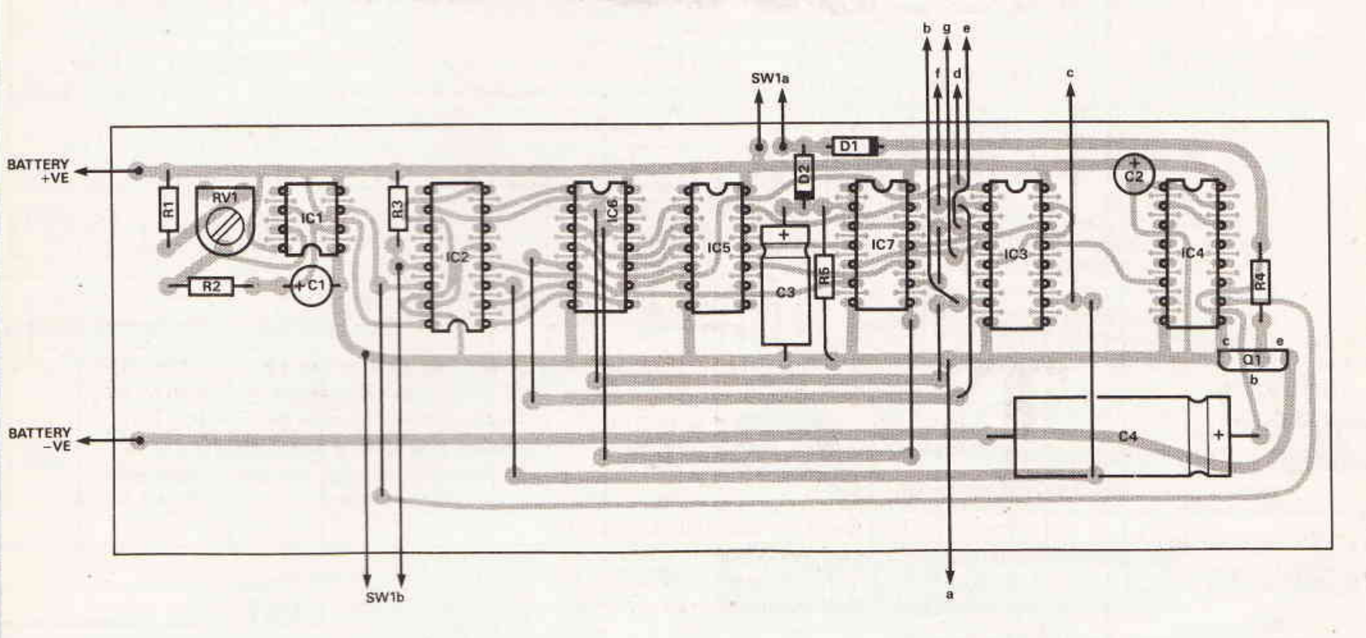


Fig. 2b Main PCB Component Layout

Testing And Final Installation

To test the unit, insert the battery and push SW1. One of the LEDs on the display should light immediately and the display should then pulse round for about ten seconds before stopping. Pressing SW1 again should result in further pulsing round of the display, which should stop at different LEDs in a random sequence. After a time the illuminated LED will fade out. If you do encounter problems you will need to fault-find, using circuit description given in How It Works. This will be easier if you place a temporary short circuit between the collector and emitter of Q1, enabling the operation of the circuit to be checked without having to constantly press SW1.

Once the circuit is functioning correctly, adjust RV1 to give the correct speed of operation of the display and install the completed unit in its case. The main PCB is inserted into a convenient slot moulded in the case side with the battery positioned either between the PCB and the case side or stuck onto the case bottom with double sided tape. Screw case lid into place and the unit is ready for use.

To use the unit, simply press SW1 and read the decision from the legends on the display. When you have finished playing with the unit, it can be left to switch itself off.

HOW IT WORKS

The circuit diagram of the Decision Maker is shown in Figure 3. The circuit consists of two counters, a high speed one which acts as a random number generator, and a slower speed one acts as a display driver. The circuit drives the LED display which stops at the point at which the outputs of the two counters are identical.

Clock Pulse Generator

IC1 is a CMOS 555 timer, connected in the astable configuration. With the components specified the output at pin 3 is a series of high speed clock pulses, which can be varied between about 260Hz and 1kHz by altering the setting of RV1. The frequency of the clock pulses does not affect the operation of the high speed counter (IC2) but the same clock pulses, slowed down by IC4, are also used to drive the display counter IC3. RV1 therefore allows the speed of operation of the display counter to be adjusted.

Random Number Generator

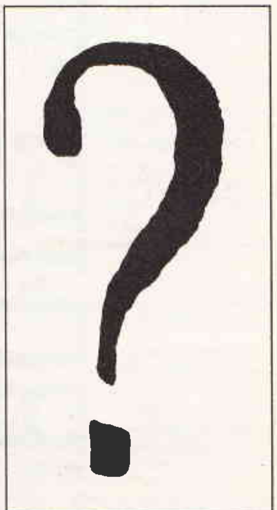
The high speed clock pulses produced by IC1 are fed to the CPO input (pin 14) of IC2, which is a 4017 Johnson counter. The CP1 input (pin 13) is held high by resistor R3 while S1 is open. In this state the counter does not count and any output O_0 to O_5 which is currently high is held high. When SW1 is pressed, pin 13 is forced low. This causes the counter to advance, with the outputs O_0 to O_6 being high in sequence. Output O_6 (pin 5) is connected to the Master Reset input (pin 15) of IC2. As long as this input is low, the circuit counts normally but as soon as this input is raised, the counter is reset to zero with O_0 high. This occurs as soon as O_6 goes high. The effect of the connection is that the counter is restricted to giving high outputs only at the six outputs O_0 to O_5 in sequence with the other outputs always remaining low.

As this circuit operates at a high speed, with the output unknown by the user, it is in effect random number generator. This circuit is used to select the point at which the display driver counter will eventually stop.

Display Driver

The clock pulses produced by IC1 are also fed to the CP1 input of one half of IC4. This is a 4520 dual BCD counter.

The O_3 output of the first counter is connected to the CP1 input of the other counter in the IC, and the O_3 output of this counter is connected to provide the clock pulses to the display driver counter, IC3. The CPO and MR inputs of both halves of IC4 are connected to the 0V rail and cause the cascaded counters to act as a divide-by-256 circuit.



These slow speed pulses are fed to the CP1 input of IC3, another 4017 counter. This counter is used to drive the display LEDs via their current limiting resistors R6 to R11. The MR input of this IC is also connected to the O_6 output, and causes the counter to recycle to the zero state as soon as O_6 goes high. This ensures that the counter cycles only through its first six outputs. The CPO input of IC3 is used as a count enable input and is connected to the output of the display control circuit.

Display Control Circuit

The outputs O_0 to O_5 of counters IC2 and IC3 are connected in complimentary pairs to the NAND gates IC6a, b, c, d and IC7b and c. The outputs from all of these NAND gates are connected to the inputs of IC5 which is a 4068 eight-NAND gate. Two pairs of the eight inputs are paralled together to make the circuit act as a six input gate.

Automatic ON Duration Control Circuit

An automatic on duration circuit comprising C4, R4 and Q1 has been incorporated to avoid the need for two switches. When SW1 is pressed, C4 is charged. The voltage across C4 is fed to the base of Q1 through R4. R4 acts a current limiter and reduces the base-emitter voltage of Q1 to 0,7V. As long as this voltage is present, current can flow through the transistor. As soon as SW1 is released C4 starts to discharge through R4 and the base-emitter junction of Q1 until the voltage across C4 is insufficient to maintain the base-emitter voltage of Q1 at 0.7V. At this point the transistor will cease to conduct and the display will fade.

D1 and D2 are included to prevent the slower discharge of C4 from interfering with the action of the time delay produced by C3.

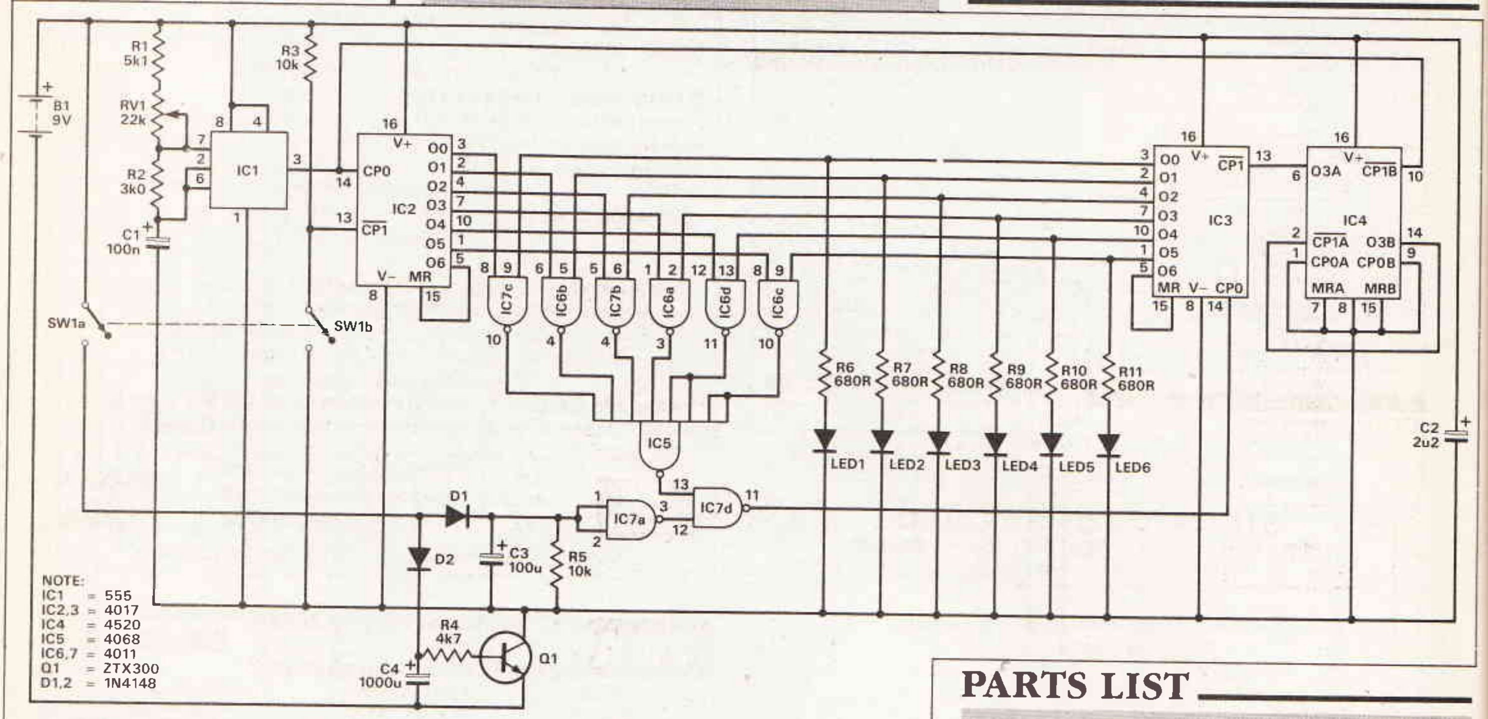


Fig. 3 Circuit Diagram

If both inputs to any of the two input NAND gates mentioned above are high, the output of the eight input NAND will be high. This circuit is therefore a comparator circuit which detects a match in the outputs of the two counter circuits.

If the comparator circuit alone controlled IC3 then the display would cease to pulse as soon as the first match between the outputs of IC2 and IC3 was obtained. However on the mechanical version the arrow usually rotates for more than one revolution. A time delay circuit, comprising C3, R5 and IC7a is therefore included in the display control circuit to make the display pulse round for a longer period of time.

When SW1 is pressed, C3 is charged up and forces the output of inverter IC7a low. The outputs of IC7a and IC5 are connected to the remaining NAND gate, IC7d. In the normal state, when there is a match between the two counters and C3 is discharged, the output of IC7d is high. The output of IC7d is connected to the CPO input of IC3 and is used to control whether the counter advances or not. A low output from IC7d causes the counter to be frozen. As soon as either of the inputs to IC7d goes low then the output of the gate goes high, and the counter will advance.

Pressing SW1 thus causes the slow speed counter to advance illuminating each LED in turn. When SW1 is released current is no longer supplied to C3 and it slowly discharges through R5, causing the input voltage to the paralled inputs of IC7a to slowly fall. When the voltage falls below 50% of the power supply voltage the output of IC7a goes high. If the output of IC5 is also high, then the output of IC7d will go high. If the outputs of IC2 and IC3 are not yet matched the output of IC5 will be low. As soon as this state is achieved the output of IC5 goes low which inhibits IC3 from advancing.

PARTS LIST

RESISTORS (all ¼W High Stab types unless otherwise stated)

R1	5k1
R2	3k
R3	10k
R4	4k7
R5	10k
R6,7,8,9,10,11	680R
RV1	22k horizontal mounting miniature skeleton preset

CAPACITORS (All 10 volt working)

C1	100n 1 MDC or Tantalum
C2	2µ2 Tantalum
C3	100µ Electrolytic
C4	1000 µ Electrolytic

SEMICONDUCTORS

LED 1-6	T 1.5 LEDS
Q1	ZTX 300
D1,2	1N4148
IC1	555 CMOS Timer
IC2,3	4017 Johnson Counter
IC4	4520 Dual BCD Counter
IC5	4068 Eight input Nand Gate
IC6,7	4011 Quad two input NAND Gates

MISCELLANEOUS

SW1	DP Push-to-make switch
	PCBs with track patterns shown in Fig. 2.
	Case (Farnell MB5)
BATT1	9 volt Battery. Battery clips.
	Self Adhesive Standoffs (4 off)

ONE POUND BARGAIN PACKS

All packs are £1 each. Note the figure on the extreme left is the pack ref number and the next figures is the quantity of items in the pack, finally a short description.

BD2	5	13A spurs provide a fused outlet to a ring main where device such as a clock must not be switched off
BD9	2	6v. 1A mains transformers upright mounting with fixing clamps
BD11	1	6½" speaker cabinet ideal for extensions, takes your speaker. Ref BD137 + 50p.
BD13	12	30 watt reed switches, it's surprising what you can make with these — burglar alarms, secret switches, relay etc. etc
BD22	2	25 watt loud speaker two unit cross-overs
BD30	2	Nicad constant current charges adapt to charge almost any nicad battery
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch
BD42	5	13A rocker switch three tag so on/off, or change over with centre off
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day.
BD49	5	Neon valves, with series resistors, these make good night lights
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through on pole
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variations such as water level in water tanks
BD103A	1	6v 750MA power supply, nicely cased with input and output leads
BD120	2	Stripper boards each contains a 400v 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers etc
BD132	2	Plastic boxes approx. 3" cube with square hole through top so ideal for interrupted beam switch
BD134	10	Motors for model aeroplanes, spin to start so needs no switch
BD139	6	Microphone inserts — magnetic 490 ohm also act as speakers
BD148	4	Reed relay kits you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets
BD149	6	Safety cover for 13A sockets — prevent those inquisitive little fingers getting nasty shocks
BD180	6	Neon indicators in panel mounting holders with lens
BD193	6	5 amp 3 pin flush mounting sockets makes a low cost disco panel — need cable clips
BD199	1	Mains solenoid very powerful has 1" pull or could push if modified
BD201	8	Keyboard switches — made for computers but have many other applications
BD211	1	Electric clock mains operated put this in a box and you need never be late
BD221	5	12v alarms make a noise about as loud as a car horn. Slightly solid but OK
BD242	2	6" × 4" speakers 4 ohm made from Radiomobile so very good quality
BD252	1	Panostat, controls output of boiling ring from simmer to boil
BD259	50	Leads with push on ¼" tags — a must for hook ups — mains connections etc
BD263	2	Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress
BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor
BD283	3	Mild steel boxes approximately 3" × 3" × 1" deep — standard electrical
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Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder — a complete mains operated kit, case included. **£18.** Our ref 18P2.

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SINCLAIR C5 WHEELS
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ORGAN MASTER is a three octave musical keyboard. It is beautifully made, has full size (piano size) keys, has gold plated contacts and is complete with ribbon cable and edge connector. Can be used with many computers, request information sheet. Brand new, only £15 plus £3 postage. Our ref 15P15.

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HIGH RESOLUTION MONITOR. 9in black and white, used Philips tube M24/306W. Made up in a lacquered frame and has open side. Made for use with OPD computer but suitable for most others. Brand new, £20. Ref 20P6.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape 41/2in × 41/2in × 13/4in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each.** Our ref 8P26.

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POPULAR ITEMS — MANY NEW THIS MONTH

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20 WATT 4OHM SPEAKER With built in tweeter. Really well made unit which has the power and the quality for hi-fi. 6½in dia. Price £5. Our ref 5P155 or 10 for £40 ref 40P7.

MINI RADIO MODULE Only 2in square with ferrite aerial and solid dia tuner with own knob. It is a superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1. Our ref BD716.

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MICROPHONE. Low cost hand held microphone with on/off switch in handle, lead terminates in one 3.5 plug and one 2.5 plug. Only £1. Ref BD711.

MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES 140v 100w pair made by Hitachi. Ref 25K413 and its component 25J118. Only £4 a pair. Our ref 4P42. Also available in H pack Ref 2SJ99 and 2SK343 £4 a pair. Ref 4P51.

TIME AND TEMPERATURE LCD MODULE. A 12 hour clock, a Celcius and Fahrenheit thermometer, a too hot alarm and a too cold alarm. Approx 50 × 20mm with 12.7mm digits. Requires one AA battery and a few switches. Comes complete with full data and diagram. Price £9. Our ref 9P.

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LCD DISPLAY. 4½in digits supplied with connection data £3. Ref 3P77 or 5 for £10 Ref 10P78.

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MICROPHONE STAND. Very heavy chromed mic stand, magnetic base. 4in high. £3 if ordered with above mic. Our ref 3P80.

SOLAR POWERED NI-CAD CHARGER. 4 Nicad AA battery charger charges 4 batteries in 8 hours. Price £6. Our ref 6P3.

MAINS SOLDERING IRON. Price £3. Our ref 3P65.

SOLDERING IRON STAND. Price £3. Our ref 3P66.

SHARP PLOTTER PRINTER. New 4 colour printer originally intended for Sharp computers but may be adaptable for other machines. Complete with pens, paper, etc. Price £16. Our ref 16P3.

KIT to convert the above Printer to Centronics parallel. £4. Ref 4P.

CAR IONIZER KIT. Improve the air in your car, clears smoke and helps prevent fatique. Case req. Price £12. Our ref 12P8.

NEW FM BUG KIT. New design with PCB embedded coil 9v operation. Priced at £5. Our ref 5P158.

NEW PANEL METERS. 50UA movement with three different scales that are brought into view with a lever. Price only £3. Ref 3P81.

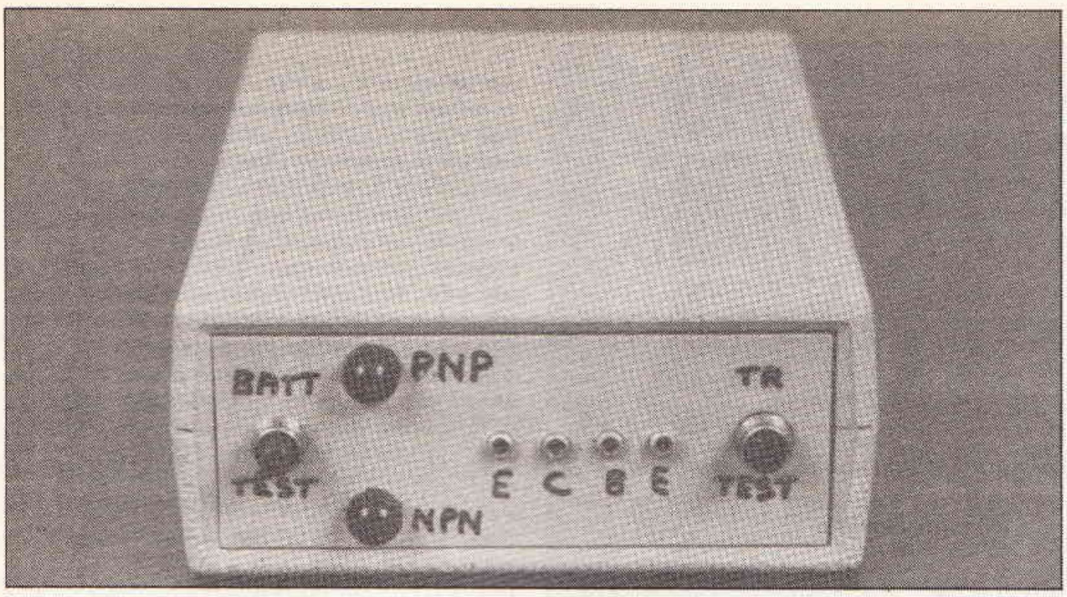
STROBE LIGHTS. Fit a standard Edison screw light fitting 240v 40/min flash rate, available in yellow, blue, green and red, complete with socket. Price £10 each. Ref 10P80 (state colour reqd).

ELECTRIC SPEED CONTROL KIT. Suitable for controlling our powerful 12v motors. Price £17. Ref 17P3 (heatsink required).

EXTENSION CABLE WITH A DIFFERENCE. It is flat on one side, making it easy to fix and look tidy. 4 core, suitable for alarms, phones etc. Our price only £5 for 50m reel. Ref 5P153.

METAL PROJECT BOX. Ideal for battery charger, power supply etc., sprayed grey, size 8" × 4" × 4½", louvred for ventilation. Price £3. Ref 3P75.

PROJECT



TRANSISTOR TESTER

Mike Barwise presents the first project in his basic range of test gear.

It is possible to test whether a transistor is functional by checking the condition of the virtual diodes of the base/collector and base/emitter junctions with a multimeter on a low ohm range. However, this can be a fiddly job. It would be very nice to have a simple, cheap plug-in-and-test tool which would verify transistors as good or bad for us quickly and conveniently.

This project, the first in a range of basic test gear to accompany the Testing Testing series, does just that. At the push of a button, this transistor tester tells you whether a transistor is good or duff and whether it is PNP or NPN, provided you know its pinout. Various standard failure modes are also identifiable. The design emphasis is simplicity and convenience, including the ability to run off a single PP3 battery for well over a month in continuous use. The trade-off is that the tester will check bipolar transistors, but cannot handle FETs.

To operate the tester, the suspect transistor is plugged into a panel socket, and the test button (actually the on/off switch) is pressed. The condition of the two LEDs indicates the test result (Table 1).

Table 1

PNP LED flashes	good PNP device
NPN LED flashes	good NPN device
both LEDs flash	C-E short circuit
one LED ON	B-C short circuit
no LEDs ON	B-E short or B open or totally open circuit

The tester works by applying varying bipolar signals to the collector and emitter of the transistor under test in a common base circuit, causing current to flow in the LEDs when the transistor is conducting. A battery test button is included, to distinguish between a dead battery and an open circuit transistor. This button simulates a C-E short, flashing both LEDs provided the battery is OK.

The tester uses an 8 pin dual op-amp chip, in my case the 1458, which is a dual 741 equivalent, but many pin compatible devices will do instead, including the 353 dual J-FET amp.

For the indicators, I finally used two green 0.2 inch LEDs, and labelled them NPN and PNP. An earlier prototype used a green LED for NPN and a red one for PNP, which looked much better, but it is *essential* if you want the dual-colour display to use *intensity-matched* LEDs. I abandoned the effort when I found my new batch of red LEDs were much dimmer for the same current than the green ones. Guaranteed intensity-matched LEDs cost more, so an alternative is to get ordinary LEDs with specification table, and choose red and green with the same average light output (in mcd: millicandelas) and forward current (I_f in mA). This is important, because when a brand-new battery is installed, the other LED may flash very dimly when a good transistor is under test (due to reverse conduction), and if the proper one is comparatively dim, it could prove confusing.

Construction

Circuit construction is straightforward. My prototype was built on stripboard, but a PCB layout has been produced. In either case, the board carries everything except the LEDs, switches and test sockets, which are mounted and wired on the front panel of the case. Quite a few components are mounted vertically on the board, but this should not pose any problems. Make sure that the IC1 pin1 end of R7 is upwards, to give you a test point at the output of IC1a. Other than this, nothing is critical.

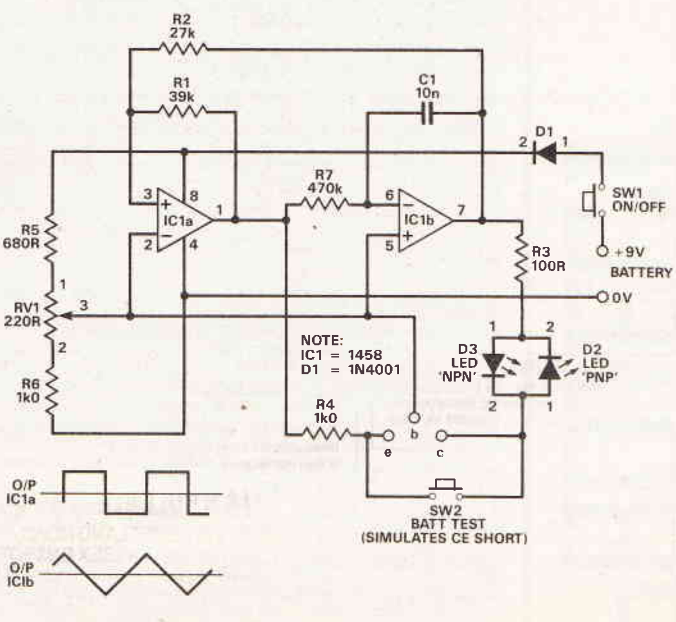
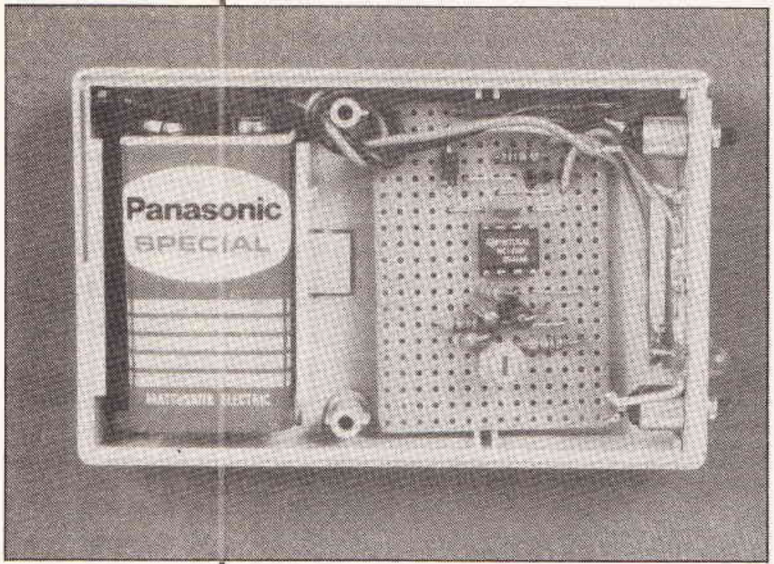


Fig. 1 Circuit diagram of the transistor tester.



The board is connected to the front panel by four short leads, and to the battery clip by one. I made these from 1/0.6 solid wire, and they proved stiff enough to hold the board in place inside the case, but a double sided sticky foam patch could be used.

The case has an integral PP3 battery compartment and a slot-in front panel, and is held together by two self-tapping screws. The exact front panel layout is a matter of choice, but the one given here seems to be the best compromise between convenience in use and ease of wiring. The following points are important:

- The transistor test sockets should be 0.2 inches centre to centre to accommodate transistors in T0-218 and similar packs;
- The LEDs should be at least 0.5 inches apart to avoid confusion by cross-lighting;
- The transistor test and battery test switches should not be side-by-side. This is to prevent you pushing them both at the same time by accident.

The front panel is the only moderately tricky part of the project. It must be drilled very accurately, particularly for the test sockets, and the soldering must be done very quickly to avoid melting the plastic of the panel. It is best to drill the panel from the back, using a very sharp 1/16 inch drill in a hand-held pin chuck (turn the drill with your fingers!), and then open out the holes with a drill of the final size. If you are lucky enough to own a fine tapered reamer, the LED and switch holes can be opened out by trial and error until the devices are a tight push fit, but in any case, a little touch of superglue will hold them in. The switches are push button types, but any sub-miniature panel mounting normally open pushbutton will do, although the panel is too thick to accommodate the conventional mounting nut, hence the superglue!

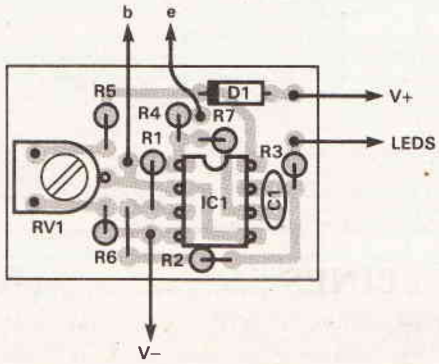


Fig. 2 Component overlay for the transistor tester.

The transistor test sockets posed quite a problem. The solution had to be relatively cheap, compact and capable of accepting a wide range of leads from the fine wires of T0-18 to the 1mm flat strips of T0-218. 3 pin DIN sockets were tried, but they generally use a split fork contact, which makes unreliable connections to the fine wires of T0-18 and similar small transistors. What was needed was a tubular contact of some sort. Early prototypes used four-way 5mm pitch 16A screw terminal blocks with PCB pins, but these were rather bulky and it proved difficult to ensure good connections to the transistor under test without doing up the screws, which was a waste of time. The final solution, which, as far as I know is only available from RS (Electromail), uses PCB mounting push-in sockets designed for 1mm diameter, shorting plugs. These are fine, but they need accurately drilled panel holes if they are going to stay in place, particularly as they have to be soldered to (which will tend to soften and expand the holes in the panel).

The panel wiring is done in 24swg tinned copper and 1/0.6 insulated wires. Connections to the test sockets are by looping the wire *once* tightly round the back of the socket and then soldering very quickly.

Flexible battery clip leads should be tied in a single overhand knot which is threaded over one of the screw pillars of the case. This will provide an adequate cord grip should you drop the lot while changing batteries. A final refinement would be to label the panel in a neat permanent fashion. Ideally, you could get it engraved by one of those companies which make plastic nameplates, and then fill the engraving with model enamel. However, as this is cheap test gear, rub down lettering protected by a coat of varnish will do just as well, but you should do it before you install any panel components or wiring.

Setting Up

There are two ways of setting up the transistor tester: a crude one and a more tricky but more reliable one. In both cases the trimpot RV1 is adjusted until the circuit works as required, and in both cases the very first test of your circuit should be a simulated C-E short (push the battery test button). The two LEDs should flash alternately at around 3Hz. If not: you've made a mistake somewhere. Supposing they do, read on.

The crude way is to use a set of known good transistors and adjust RV1 until the correct response is obtained for all devices. A typical set would consist of BC184, BC214 (high gain NPN and PNP small signal), TIP31, TIP32 (3A NPN and PNP medium gain power), TIP3055, TIP2955 (15A NPN and PNP low gain power). RV1 is set to nominal mid-position. The transistor is inserted in turn into the socket and the test button pressed. RV1 is then adjusted *slowly* until the LEDs show the correct sequence. The order of use of the transistors is important: first use the BC184 and BC214, adjusting until the tester indicates both correctly, then the TIP31 and TIP32, making a finer adjustment, and finally the TIP3055 and TIP2955, making a really tiny final adjustment. Rechecking with any transistor at random should then produce the correct result.

The limitation of this method of setting up is that it takes no account of performance drift as the tester battery ages. A new PP3 may deliver as much as 9.6V into a low current consumer like this circuit, and we would like the tester to go on working for as long as possible on one battery: say down to about 8V, which is as low as we really dare.

The delicate and preferred setup procedure is as follows: interrupt the battery positive supply with a 1k pot wired as a variable resistor. This effectively simulates battery ageing. Set the variable resistor to minimum resistance, and set RV1 to mid-position. Apply a temporary base-collector short. One LED should light continuously. Now increase the variable resistor until the LED just turns off. Reduce the variable resistor again *gently* until any LED lights again, and then adjust RV1 to turn off both LEDs. If both LEDs will not stay off together, adjust RV1 in the opposite direction *by a very small amount*. If it proves impossible to adjust both LEDs off at once, increase the variable resistor a little bit and try the whole procedure again. This whole routine should be repeated until both LEDs can only be turned off together by an *extremely small* adjustment of RV1. You will then find that the transistor tester is set up to operate with battery voltages as low as just over 8V. Remove the base-collector short.

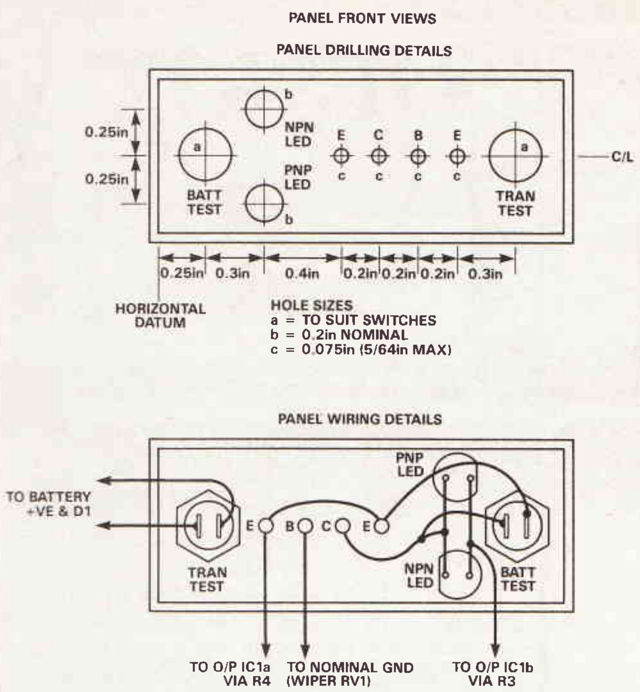


Fig. 3 Front panel details and back panel wiring.

I am indebted to Richard Cripps, who works at the Dept. of Metallurgy, Oxford University, for this setup procedure, and also for some clever ideas which helped to run my preliminary prototype into this final project.

Finally: the whole unit should cost no more than about £8.50 to build, including the case.

HOW IT WORKS

IC1a operates as a Schmitt trigger, and IC1b as a linear integrator. The uncommitted inputs of both op-amps are held at a nominal ground of mid-supply potential set up by R5, RV1 and R6.

When the supply is switched on, the output of IC1a is at maximum positive potential. This output passes a current via R7 into the virtual earth at the inverting input of IC1b. The output of IC1b sinks an equal current via C1, charging it to produce a linear negative voltage ramp. This signal is fed back to the input of the Schmitt trigger, and when the total voltage at the non inverting input of IC1a (vector sum of IC1a feedback and IC1b output voltages) is just less than the nominal ground, it causes the Schmitt trigger to change state smartly, its output landing at maximum negative potential. This causes the output of IC1a to sink a current through R7, causing an equal current to be sourced by IC1b, charging C1 and producing a linear positive going voltage ramp. As soon as the total voltage at the non inverting input of IC1a becomes a little bit positive of the nominal ground, the Schmitt trigger flips, and the whole process repeats. The result is a free-running oscillator with frequency determined by the time constant of R7 × C1, which produces square and triangle waves of similar amplitude and in quadrature (phase shifted by 90°). To make this oscillator test transistors, we connect the device under test in common base configuration, with its base at nominal ground (mid-supply voltage), its emitter to the square wave via a current limiting resistor (R4) and its collector to the triangle wave via a pair of back-to-back LEDs and LED current limiting resistor (D2, D3, R3). As shown in the timing diagram (Fig.1), the emitter and collector of the transistor are alternately driven positive and negative with respect to each other, and with respect to nominal ground: a good transistor of a given type will be in conduction for one quarter cycle of the oscillator, during which time its collector current will be varied from zero to maximum in a linear fashion. The relevant LED (determined by direction of current) will light up for the quarter cycle. Any open or short circuit in the device under test will cause LEDs to light (or not to light) in a manner different from this. If the transistor is open circuit base, totally open circuit or base-emitter short, no collector current will flow, and no LEDs will light. A collector-emitter short will allow conduction in both directions, so the LEDs will flash alternately. A collector-base short will cause large currents to flow into or out of the nominal ground, which will disturb the mid rail potential by approaching or exceeding the 4.5mA or so flowing the mid rail potential divider. This will prevent the Schmitt trigger making its transition by spoiling its reference voltage. The net result will be a stopped oscillator with one (random) LED continuously on.

The transistor test is set by R4, and is low (around 3mA maximum emitter current) so no damage is likely to even the most sensitive of transistors. The LED limiting resistor (R3) is present so that the LEDs are protected in case of a hard collector-base short circuit. D1 is an 'idiot diode'. It protects the circuit against reversed connection of the battery. It also reduces the supply voltage provided by brand new 'enthusiastic' batteries (D1 replaces a resistor used for this purpose in early prototypes).

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1	39k
R2	27k
R3	100R
R4,R6	1k0
R5	680R
R7	470k
RV1	220R min horizontal
SEMI CONDUCTORS	
IC1	1458 or LM353 dual op amp
D1	1N4001
D2,D3	LED 0.2" (2x red or green, or intensity matched red/green pair)
CAPACITORS	
C1	10n miniature ceramic
MISCELLANEOUS	
SW1, SW2	miniature push to make single pole
CASE	RS 502-095
CONTACTS	RS 434-712

BUYLINES

Everything except the case and the test socket contacts should be available from almost anywhere. These two can be bought through Electromail (RS Components).

PCB DESIGN SOFTWARE

Looking for a PCB drawing package? David Silvester reviews some of the products on offer.

REVIEW

In the last year, a number of changes have taken place in the range of computer aided PCB design software packages available to the amateur.

For amateur or semiprofessional use the package has to be reasonably cheap, and to keep hardware costs low there has to be a way of getting a usable output from a dot matrix printer. However for high quality output it is essential that a plotter is used so that the artwork can be used directly to make the PCB.

The following is a review of four PCB design packages of varying cost and sophistication. In all cases the software was run on an AT compatible with an EGA monitor, a Genius mouse and a Roland plotter.

PC-B

We'll look at two Labcentre packages: the simple PC-B itself and the more sophisticated PC-B PRO.

The Labcentre offerings are will only draw PCB layouts. There is no facility to draw schematics, although there is separate package offering that option.

The PC-B basic program is very easy to use. The startup screen leads to the layout editing screen, which is divided into five sections. The main part is occupied by the work area, with other areas for layout overview, icon table, symbol list and the message panel. The maximum layout size is 12 by 10 inches and the icon table has three pad sizes and four track widths. It uses two trackable layers and a single silk screen. At just £70 it offers extremely good value for the occasional user of a PCB drawing program.

PC-B PRO

For £230 Labcentre has the PRO package (PRO stands for *professional*). This package adds a number of facilities but does not compare well with the facilities and pricing of Easy-PC and Boardmaker. PC-B PRO has six track widths and six pad sizes selected by icons, and a range of component symbols which may be added to by the user. The PRO package adds box editing functions and a set of flexible copy, move and delete actions. The maximum board size is 24 by 20 inches, but with no extra layers.

This package has a lot of potential but lacks the range of facilities that we can find in Easy-PC at half the price.

Easy-PC

Easy-PC comes from Number One Systems and is part of a range of software packages for electronics design. The package is now rather old, and this shows even with the new EGA display software. When loaded the initial page is in low grade graphics but this jumps to a better initial menu offering PCB design, PCB symbol manufacture, Schematic design, and Schematic symbol manufacture. Thus Easy-PC offers the important schematic drawing package as well as the PCB drawing package and as such must be judged on a different scale.

Selecting any of the options brings the user immediately into the full view of the 17 by 17 inches drawing with a small cursor cross at the centre. From this stage pressing any of the number keys from 1 to 7 initiates a redraw at a scale set by the number and centred about the cursor. There are three unmarked hatched squares at the top of the screen and if the cursor enters the left one of these hatched areas it pulls down a menu that lists the drawing and library options available, whilst the right pulls down a number of user default selections.

Easy-PC can deal with up to 8 copper layers and in addition both an upper and lower silk screen, so it is suitable for the low cost professional market. There are a vast range of both pad sizes and pad shapes. 16 pad types, 8 track widths and 8 text sizes are allowed per PCB drawing. There are about 50 symbols in both the layout and schematic libraries but you can add to either of these libraries as well as creating specialist libraries if required. There are surface mount symbols as well as normal 0.1 inch pin types.

As for on-screen colour Easy-PC only offers blue for one of the copper layers, red for another and white for both the silk screen and items such as pads that go through all of the layers, a throwback to the CGA graphics. To display other layers you have to use either blue or red, which conflicts with the layers presently being shown, or reassign the blue or red colour. However, this method loses the display of one layer from the screen (although not of course from the computer memory).

In all cases the pads, symbols and tracks snap to a grid point, or to half or a quarter of that value depending on the mode chosen. Tracks can also be forced to follow 90 degree or 45 degree angles only, or can be left to take the shortest route, as selected by the drawing menu.

Recently the price of Easy-PC has crashed from £275 to £98. This new price includes software both for the plotter and Gerber photoplotter. In all I think that Easy-PC is a good package, but is now showing its age. In many respects it is badly in need of upgrading.

EasyPlot is the plotter package for the Easy-PC drawing package. I have tried running this software package and the output gives some cause for concern. When EasyPlot draws, say, a pad it draws a series of short lines in either the horizontal or vertical axis lifting the pen to avoid the central hole. Thus the pen thumps up and down which makes it extremely noisy.

Boardmaker 1

Boardmaker comes in two versions, Boardmaker 1 which is similar to an improved version of EasyPC, and Boardmaker 2 which has added facilities for netlisting and ratsnests. Both versions have a better title page as the software is designed for EGA/VGA displays rather than CGA. The startup page gives the options of PCB drawing or schematic drawing whilst the library route leads into the symbol creation. After the initial selection the screen changes to a wide view of the full 17 by 17 inch drawing screen.Although it comes from Tsien, Boardmaker is similar to Easy-PC and will read and convert EasyPC files for reworking.

Seven indexes lead to the next area in the drawing hierarchy. The menus can be activated either from the mouse or from the keyboard.

Boardmaker makes much better use of colour. There are seven colours. The defaults are yellow for both silkscreen layers, red for the lower copper layer, blue for the upper copper layer and white for items such as pads that extend to all 10 of the layers. Thus on screen it is easier to see in which layer any item lies. The remaining colours are unassigned so that the user can select the additional layers to which the draftsman wants to refer. I tend to use green for one of the silkscreens as it makes the drawing easier to understand. All reassignments can be saved to a configuration file.

The plotter driver is included with the Boardmaker main program and as far as pen tip life and noise is concerned it seems much better than EasyPlot.

With a range of features and at a cost of just under £200 which includes both plotter and Gerber photoplotter drivers, Boardmaker offers extremely good value for money for the amateur who wants more than a simple PCB package.

Boardmaker 2

Boardmaker 2 has added facilities for netlists and ratsnests. The netlist is a list of the components on a PCB layout that need to be connected and the ratsnest is the visualisation of the netlist. When drawing the board all of the components are placed on the board and the ratsnest is formed by thin lines connecting all of the points that need to be connected by tracks in the final layout. From this stage a component can be taken up and moved with all of the ratsnest details being redrawn continuously. Changes to the orientation can be seen to allow the best position for each component prior to drawing the tracks. When the board is completed then the netlist checks that all has been drawn correctly. As an extra feature the connected tracks can be highlighted to check that, say, every IC has power and ground connected to it. The cost of Boardmaker 2 is £295 plus carriage and VAT.

Netlist information is the raw data for autorouting and Tsien say this is coming soon. I shall look forward to trying this out.

Conclusion

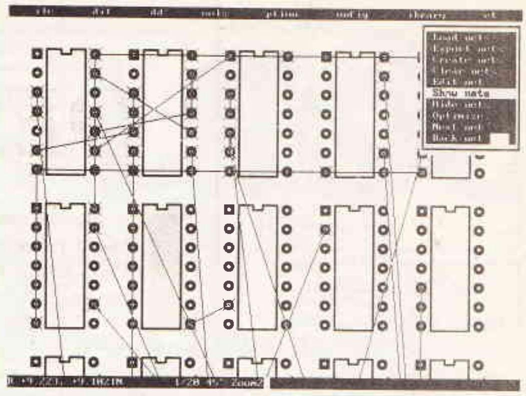
If you are in the market for such a PCB design package all of the manufacturers offer demonstration software and it is best to contact them to get a hands on feel to see which suits you best. With such a fast moving market this is the only way to see what the latest revisions offer.

Addresses

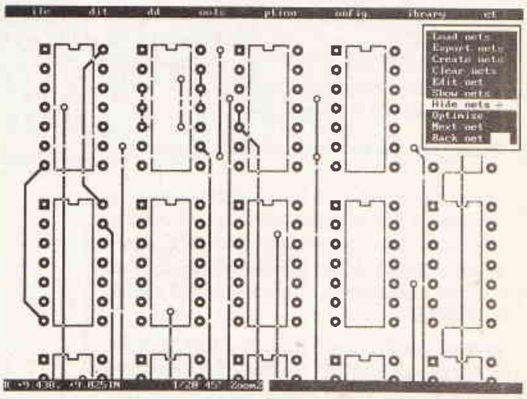
Labcentre Electronics, 14 Mariners Drive, Bradford, BD9 4JT. Tel: 0274-542868. PC-B, PC-B PRO.

Number One Systems, Harding Way, Somersham Road, St. Ives, Huntingdon, Cambridgeshire, PE17 4WR. Tel: 0480-61778. Easy-PC and EasyPlot plus many other electronics packages.

Tsien UK Ltd, Cambridge Research Labs., 181A Huntingdon Road, Cambridge, CB3 0DJ. Tel: 0223-277777 or 0223-276444. Boardmaker plus many other electronics packages.



A simple example of part of a ratsnest



The same circuit routed

ETI

OOPS!

Some new corrections . . .

Fecko Box (June 1990)
The foil pattern is printed at 50% actual size, and component side up. The correct foil pattern is included in this issue.

Elements Of Radio, Part 3 (May 1990)
On Fig. 2, the resistor on the output of F2 should be 1k5, not 10R. On Fig. 20, the top of the CT should be connected to switch SW1b, and the label 6 is missing from L13.

Business Bass Amp (March, April, May 1990)
In March: On Fig. 2 HI and LO inputs are wrong way round. The north button increases volume, the south button decreases it, and both buttons together zeros volume. Hitachi devices are rated for zero temperature coefficient. Q1-4 should be 2SK135.

In April: On Fig. 1, C5 should be 100p. On Fig. 2, Q2 should be PNP. On Fig. 3, the positions of the gyrator board should be:
Z8 Z9 Z10 Z11 Z12 Z7
Z1 Z2 Z3 Z4 Z5 Z6.

In May: On Fig. 2, pin 20 of IC1 also connects to the 5V supply, and C1 is the wrong way round. On Fig. 8, all dimensions except the fan hole are in inches, and should be divided by 10. A symmetrical supply of +63 and −63 should be on C1 and C2.

Superscope (February 1990)
Q302, 303 should be BC109C.

And some we've printed before . . .

Quad Power Supply (April 1990)
In the parts list, IC2 should be 7905 and IC 4 should be 7912.

Navigate (April 1990)
Fig. 1a Maximum/minimum signal captions should be reversed.

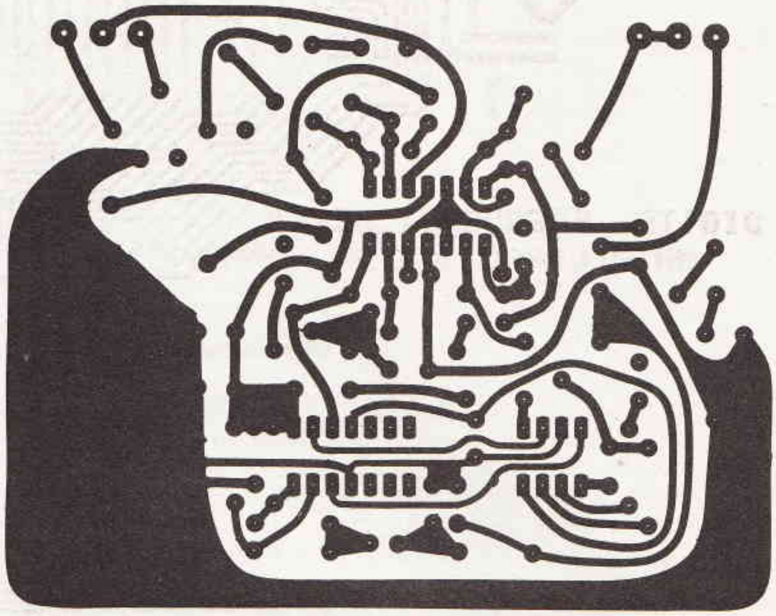
Oscilloscope (February 1990)
Fig. 3. does not show the polarity of diodes D105,6. The cathodes point up the page. Diodes D304 is a 1N4148. Capacitors in the deflection amplifiers parts list are incorrectly numbered and should be C205, 206, 213 and not C105, 106, 113.

Text refers to inductors L203, 204; these should be L201, 202. Inductors L101, 102, 201, 202 are wound on 100k 0.5W resistors. The value of R201 should be 820R. The PCB track connecting RV301 to R313 should be extended to the pad of link 17. The foil on page 60, for the motherboard is at 95% of full scale. TS2 should have 550 turns, giving 110V rms.

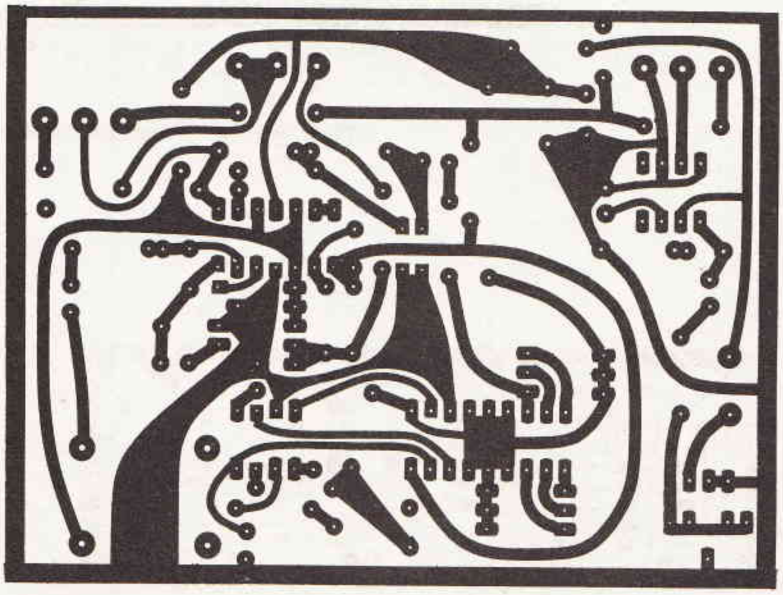
Motorcycle Intercom (January 1990)
D1-D12 should be IN4148.

Wavemaker FG (January 1990)
R24 (82k) should be shown instead of the wire link below R29 on the Component Overlay (Fig 2). R9 on the Circuit Diagram (Fig 1) should be R31, and should be connected to the −12V rail. The resistor connected to IC2a pin 4 on Fig 1 should be R9.

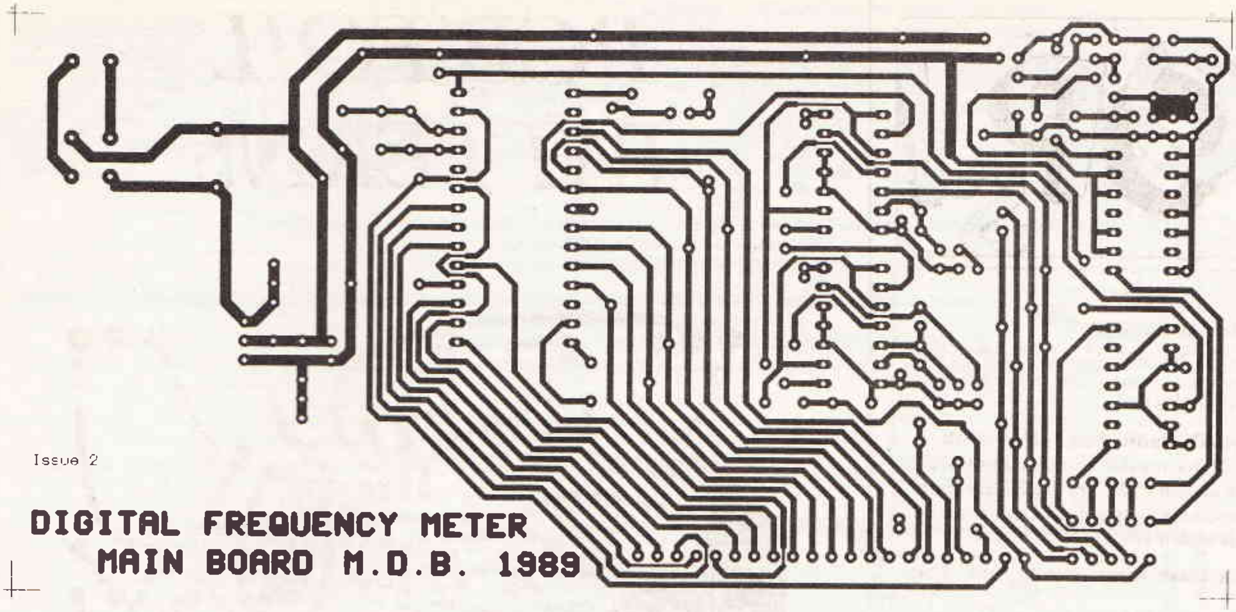
PCB FOIL PATTERNS



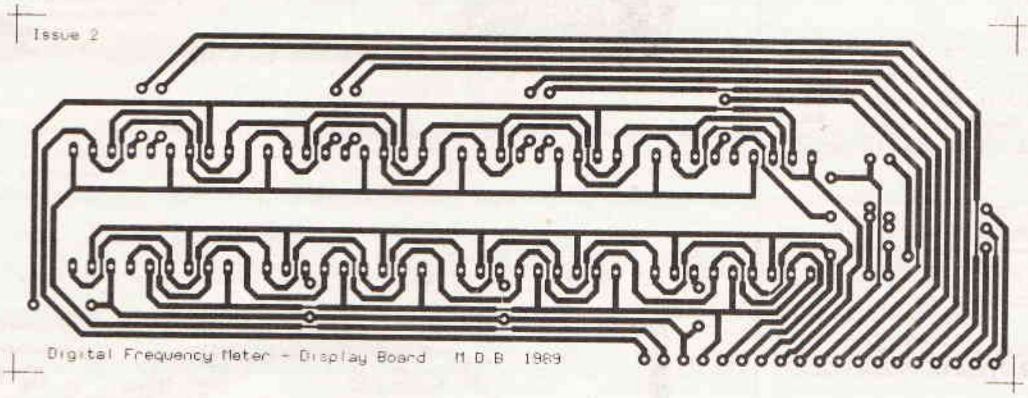
Fecko box (ETI June 90)



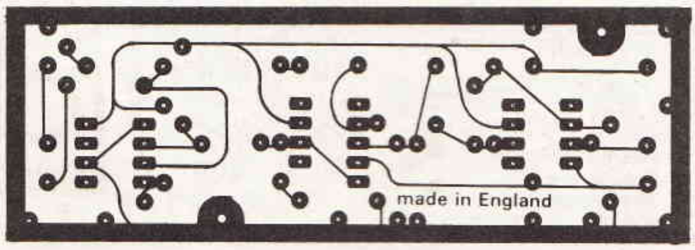
Guitar Practice Amp



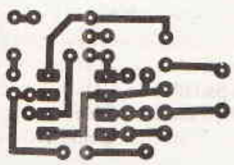
Digital Frequency Meter Main Board



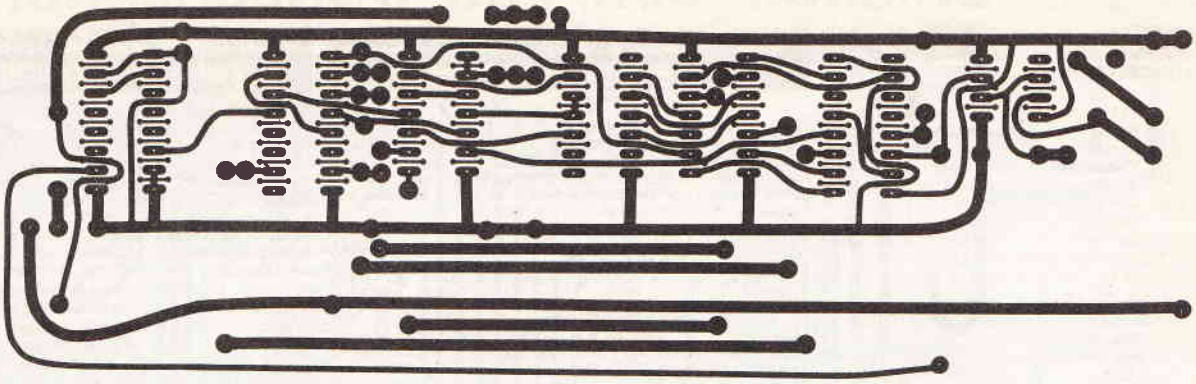
Digital Frequency Meter Display Board



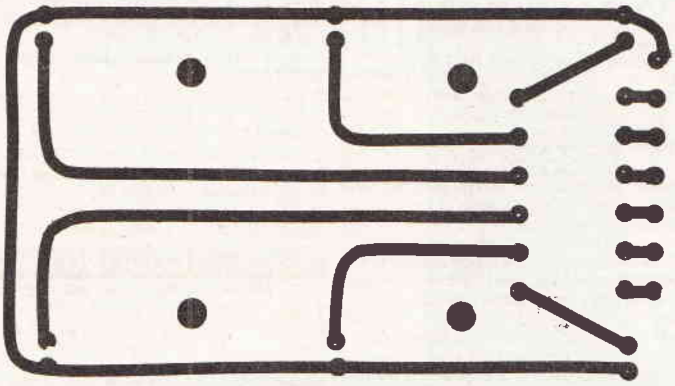
Footstep Alarm



Transistor Tester



Decision Maker Main Board



Decision Maker
Display Board

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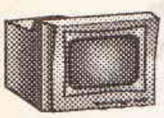

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NOT suitable for IBM or Clone type colour monitors.
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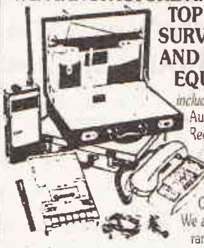

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NEXT MONTH

In our September issue, we feature an article on the technology of transmitting national news information to the blind via a talking newspaper with a difference.

The second in our series on renewable energy sources will be on the benefits of extracting power from water through barrage, tidal or wave motion.

Our Audio section contains an article on the workings of the most recent of developments in synthesiser technology together with an update on a Sample-and-Hold stereo tuner featured in February 1987 by John Linsley Hood.

Not forgetting our projects, we show you how to build a high performance AC millivoltmeter and a versatile temperature controller unit. These, and all our regular items will be on sale at your newsagent on July 6th. You might need to order a copy from your newsagent as ETI is now very much in demand.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

In June, we covered the life and achievements of Nikola Tesla, eccentric genius and inventor of the Tesla Coil. And we looked at technology used to give car travellers a quieter ride — active noise cancellation. Our Audio Supplement reviewed a 12-channel mixing desk, and provided a project for creating fuzz and echo effects on your guitar. Another feature in the June issue described the history of the telephone and its operation, and we started a new series on the use of the diode in electronic circuits.

If you missed the June issue, a limited number of back copies are available from Select Subscriptions (address on contents page).

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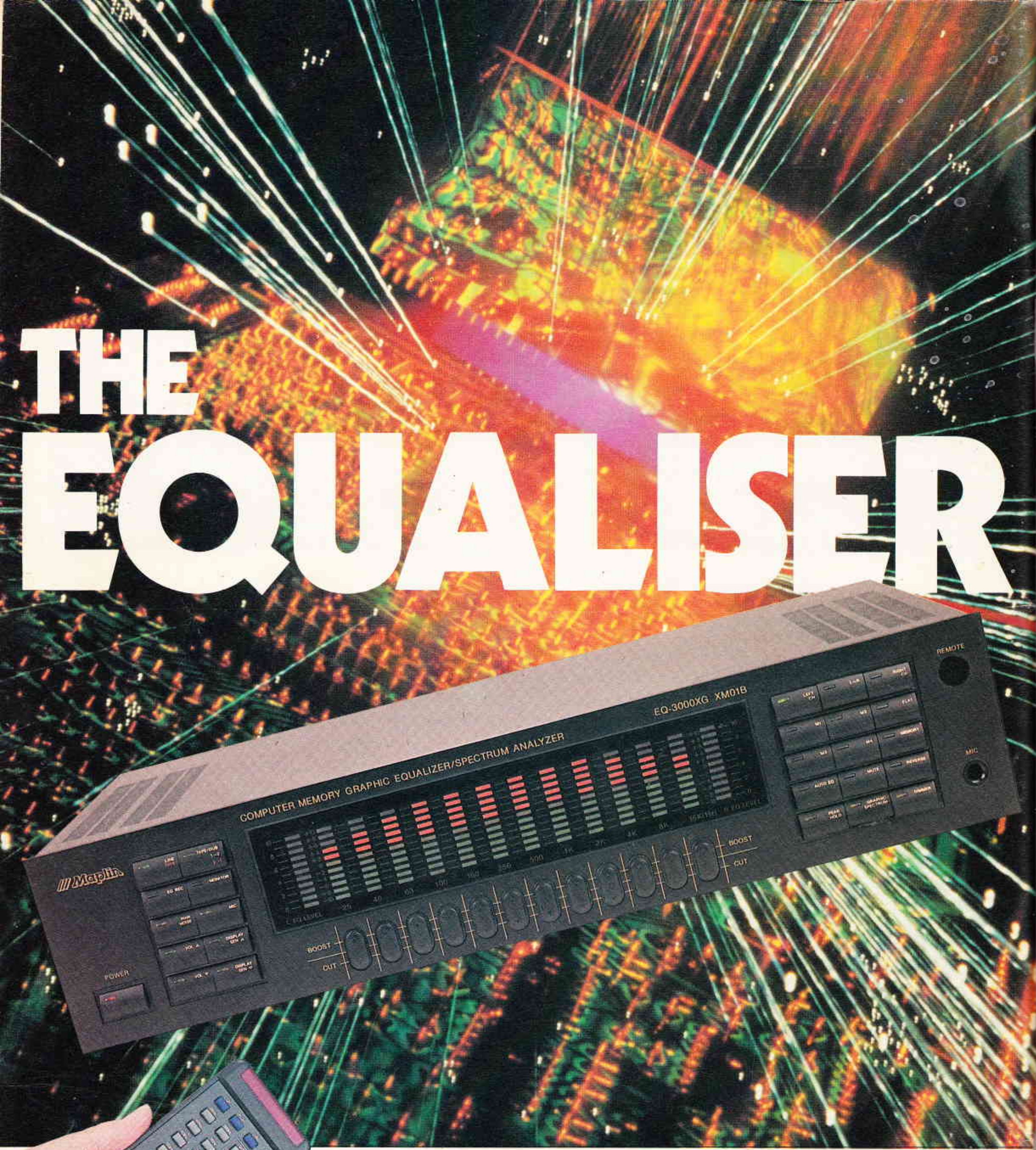
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