ETI
ELECTRONICS TODAY INTERNATIONAL

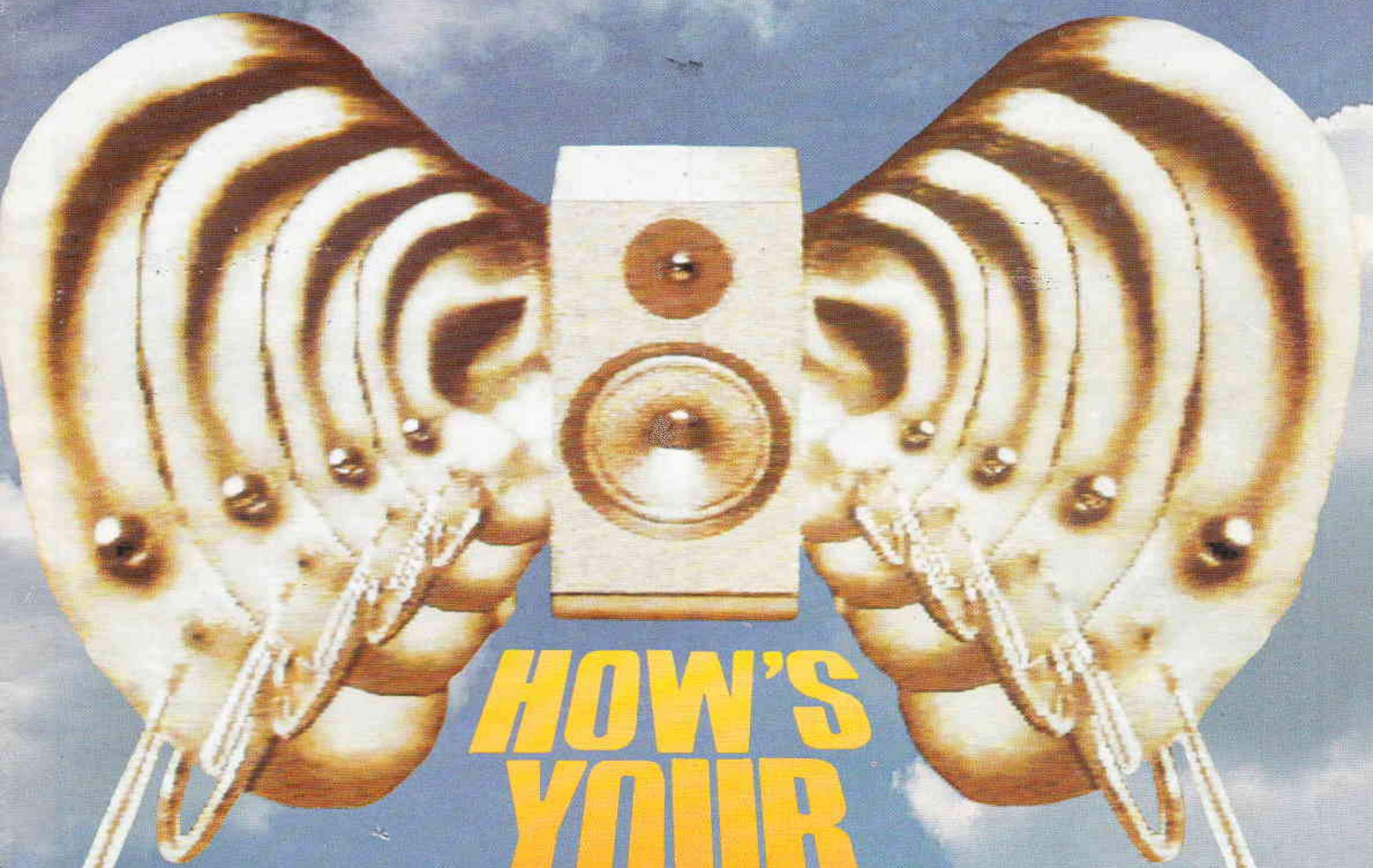
THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

MAY 1991 £1.60

FREQUENCY PLOTTER
Oscilloscope displayed response

CIRCUIT FILE
Constant Current Generators

SIGNALS AT VLF



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Designer Iain Houston
Technical Illustration Jerry Fowler
Photography Manny Cefai

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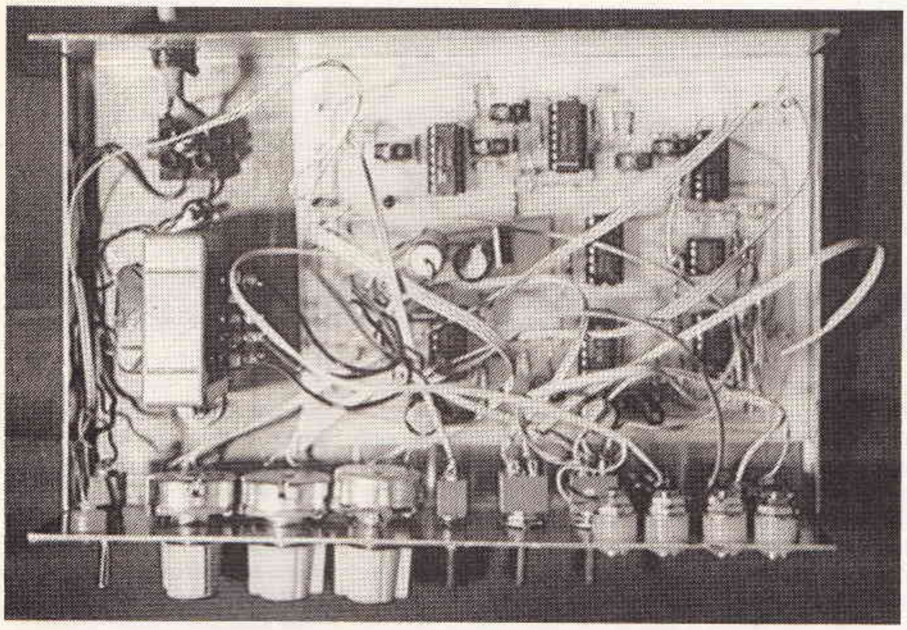

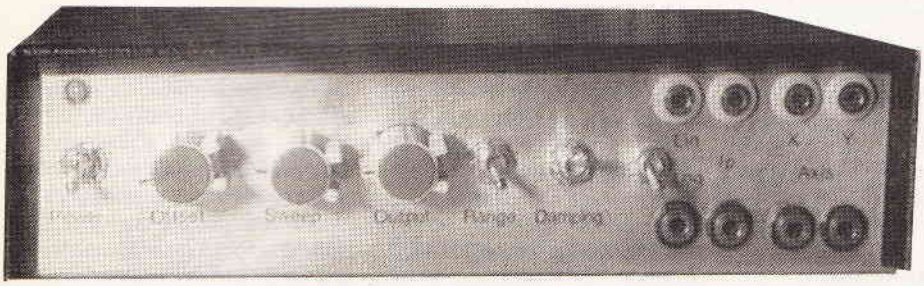

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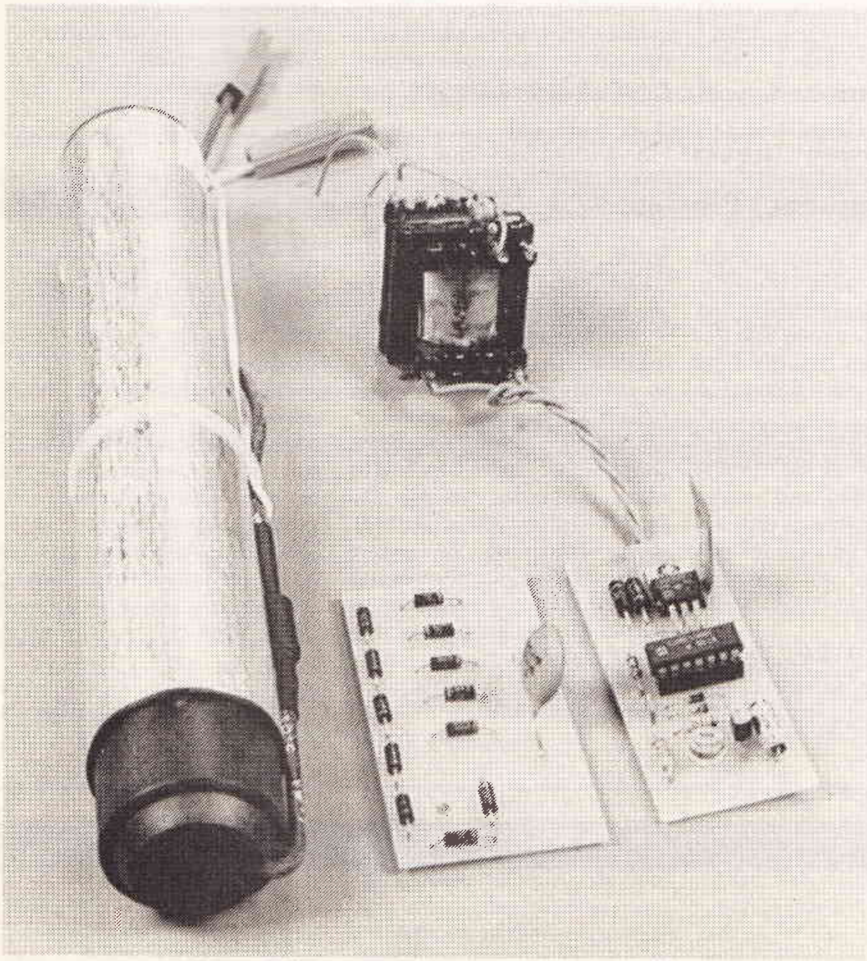


Amplitude Modulated Laser Page 30

Editorial

You have probably noticed ETI has and is undergoing a change in layout. The latest change is as you see within the contents pages including an editorial. Comments on the style and contents are always welcome and you have the chance to express your requirements soon through a readership survey. It has been three years since you last had the opportunity to do so. If pencils are kept sharpened and poised to fill in a form, there may be a prize in store for you if they are returned quickly. More details later.

Mathematics

We must be one of the few newsstand magazines to present mathematics, not 'sums' within our features and projects and 'get away with it'. It is often said that for every mathematical equation that appears in a publication for general release, sales will halve. Professor Stephen Hawking through his very successful book: A Brief History of Time, said as much but felt he ought to use one, the famous Einstein equation, $E=mc^2$. Perhaps those in control of publications have misjudged the general public. Could they now be bold enough to take on other similar ventures.

Society says technical subjects including Mathematics are taboo at parties and those that attempt such a bold venture are written off as the 'bore' of the party. Not that I'm advocating such a move as I have known some that could speak of nothing else. It is strange because mathematics is the language of life. If only men and womens cognitive response to numeral and symbolic logic was as straight forward as our verbal language and the written word then mathematics would also be a pleasurable subject. Until then it seems doomed to remain in that allocation of life called work. On this basis, it seems remarkable that magazines like ETI have survived against all the odds.

Paul Freeman.

Cover: Computer Art by Manny Cefy

READ\WRITE

ETI LETTERS

Erroneous RIAA

I refer to the article on RIAA equalisation in the March edition which I read with much delight, until I realised the approach the network and what was offered. I realise that anyone may produce a circuit of their own design to produce a particlular need but to offer a design and claim it complies with RIAA requirements when it does not, must be misleading to your readers.

Looking at iFigure 6(e), when the network response is carefully calculated, the 1kHz gain is found to be 16.5 and not '20' or 21 claimed, whilst the VLF gain is 21.7dB above that at 1kHz (RIAA requiremnet is 19.9). The response and errors are given below in relation to RIAA.

	VLF	50	100	1k	10k	20k	30k
	+21.7	+17.8	+13.5	0	-11.77	-16.95	-19.6
	+19.9	+16.9	+13.1	0	-13.72	-19.6	-23.1
Error	1.8	0.6	—	—	1.95	2.65	3.5

Some may consider this 'good enough' whilst other will take the view that 'good enough' is not good. The error occurs in considering the break points individually and using a 'rule of thumb' to determine values. To achieve an accurate response, it is essentiol to consider all three together as they interact. The author is not alone in this as similar designs in ETI March '86 and August '86, both of which were rectified in June 87. Design of RIAA networks is not as easy as it seems, the best step is to use the recognised component ratios which have been known since 1957, but not always remembered.

W Harms,
Bexhill East Sussex

David Silvester replies:

I was aware that there were errors in the calculations that are caused by the availability of components and the tolerances that they are subject to. Taking the 'nearest value to' throws out the calculations at every stage to some extent. The article was not to be a rigorous treatment of the subject with calculation to the n'th degree for that I feel is a fruitless task, and the original request was to answer why it is needed at all. In addition, we must end up with a circuit that we can actually build with components purchased from one of the common suppliers, and those components will only be available with specific values and will also have tolerances.

I would like to see one of Mr Harms designs along with his calculations to find out where in his opinion I have gone wrong. However I would insist that all of the component values he uses are available in the Maplin catalogue or he names his source. I certainly do not have the money to go out and buy a large number of components just to select the one with the value the circuit needs then throw the rest away. Using mathematics he might then like to work out his circuit using the worst case component tolerances and see what he gets. I shall be most interested in the results. As a final point I have used the circuit shown for a number of years and the reproduction that it gives suits me admirably. It seems strange that having calculated the RIAA equalisation that the 'corrected' output should then be allowed to be distorted by tone controls or graphic equalisers, in the final trial it is the ear that tests the result not the calculator.

David Silvester,
Southampton.

Advantage GN

I was quite disturbed when I found the ETI's letters section which sort of attacked Mr Graham Nalty for his comments suggesting ways to improve some designs sound quality through the upgrading of certain parts, particularly resistors, capacitors and cables.

As I have been following Mr Nalty's articles and notes, in ETI and several other magaines, I do have to say that those letters were at least very unfair. As fairness is supposed to be a British 'invention': lets be fair.

Even so, this seems to be just another subjective/objective discussion continuing to sparlkle on both sides of the Atlantic. "How can you listen to a difference when you cannot measure it? I'd say something is wrong with the instruments then because I do hear the difference. It is slight but it's there.

In ETI, Mr Nalty published a series of articles for his VIRTUOSO Project (pre and power amp) which he shared with us. He also had the courage to back his construction project with a recognised critic's test on that very same project.

He certainly has the right to suggest on ways he believes to be the best to improve the sound of audio projects, his or others particularly when they are on that stage of being built as usually ETI's projects are.

His findings and opinions on 'passive' parts: that he described to us in ETI's VIRTUOSO notes (which I judge as a generous attitde are a quest for a better sound which has been backed by other magazines. People like Martin Colloms: Ben Duncan:, Richard Marsh and Carl Jung are always looking for new measures or tests as sensitive as our hearing system (or should I say our feelings system), to prove to an unbelieving 'Audio Scientific Community' that amplifiers might not sound the same even if they measure the same, or that amps do not have any sound of its own, as 'they' defend. For 'them', CD is the "perfect" medium, their panacea.

To suggest that Mr Nalty might advise on improving certain parts because he sells them, not considering his background, is like somebody being attacked as an ecologist because he sells flowers. I should say he believes on what he says and invests on it, helping other people secure hard to find parts. Think of it.

Carlos Martinez, Rio de Janeiro

High Lights

Having just read your latest (March '91) edition of ETI, I must say that the project by Kevin Kirk proved to be most interesting. The idea of a light show is not one which is unique but his personal interpretation of the idea is most interesting. Please pass on my thanks for an excellant project to both the ETI editor and to Kevin Kirk.

J P Brister, Somerset.

Advantage JLH

I refer to the correspondence from Graham Nalty, Audiokits, Derby. In an article of approximately 20 years ago (Wireless World) by Mr Linsley Hood, the following appeared — "Unfortunately, it is not possible to simulate under laboratory conditions the complex loads or intricate waveform structures presented to the amplifier when a loudspeaker system is employed to reproduce the everyday sounds of speech and music; so that although the square wave and low-distortion sine wave oscillators, the oscilloscope, and the harmonic distortion analyser are valuable tools in the design of audio circuits, the ultimate test of the final design must be the critical judgement of the listener under the most carefully chosen conditions his facilities and environment allow". Also, Mr Hood referred to in the same article — "listener fatigue", Therefore, I must assume that Mr Nalty failed to 'read between the lines'!

Obviously, one would tend to conduct both 'listening' & laboratory tests subsequent to any component substitution experiment — possibly, the latter would provide some enlightenment on the validity of certain previously held beliefs? ...Further, in the same article (a transistor Class A design); Mr Hood refered to, and I quote "...but they appeared also to give a fuller, 'rounder', quality, the attractiveness of which to the author much outweighs the incidental inconvenience of the need for more substantial power supply equipment and more massive heat sinks,". I wonder, has any reader a suitable circuit diagram for a 'Roundness' Analyser? Also, Mr Hood referred to 'the time interval between listening tests' (in connection with comparative tests conducted in the absence of 'A/B' switching facilities). Enough said!

Of Hart Electronics, may I simply say that 99,99% of commercial audio equipment is of a considerably lower standard — in terms of layout, printed circuits, components and the like. In fact, I have just got round to building one of Hart's Mk1 Cassette Recorder Kits (bought back in 1976) — a design by Mr Hood. The equipment worked first time — despite using the 14 year old electrolytic capacitors! (although I did connect them across a DC supply via a 18k resitance, and carry out a few basic tests). I can only say that if Hart Kits (and instructions) have only improved 1% over the last 14 years, their products are beyond reproach!.

Of my opinions on the quality of Hart products, I can only say that my one-offs exceed the sort of standards associated with the bulk of commercially available audio equipment (including the 'stuff' praised by 'Golden Ears'!) However, to be fair, I must state that I have not constructed one of Mr Nalty's amplifiers ,......., possibly, my obcessionalism with internal detail in this respect; would be described by a psychiatrist as some sort of compensation for an imperfect self?!,

The internal construction of some of the equipment reviewed by 'Golden Ears' — inc, £1000+ all-American power amplifiers, is typically 'bird's nest' in it's executions — indeed, some of it would not meet with the approval of the Hook & Crow population!, In fact, I had the opportunity to dismantle a pair of £1000 so-called monitor loudspeakers, but the internal assembly was appalling — particularly the soldering (the plastic enclosure of one of the tweeters displayed much evidence of soldering iron contact, and many joints appeared 'dry'! Also, sound quality failed to approach that of my own DIY transmission line design (a modified version of A Bailey's 1966 (?) Wireless World design!). Of the associated woodwork I suspect that the corner joints will probably 'move' within five years (moisture absorbtion in unsuitable particle board — or treatment)

M J Evans, Worcester

Micros With Macro Contribution

Though having taken ETI for about fifteen years this must be the first communication with you, so some reader feedback might be in order.

I have constructed a great number of projects over the years and learned much from both them and the editorial content of the magazine. The micro-processor and micro-controller projects hold most interest for me at the moment — I feel there is a very secure future for their application to improve basic electronic equipment used in all areas of life. Your magazine continues to provide excellent value for money.

R Ludlam, Ascot, Berks

Valve Affordability

I was delighted to read, in ETI Feb 91, that Velleman Kits have introduced a high quality valve amplifier that "most of us can afford". Sadly I can't agree that it is affordable.

Would it be possible for ETI to feature a valve amp as a project? I am sure it would be of interest to a lot of readers.

R White,
Truro,
Cornwall.

We will do our best to satisfy the needs of a new growing band of constructors who want to return to valve technology — Ed

SBC09 Alternative

You may be interested to know of a simple way to improve the SBC09 (ETI Jan 91) without the use of an add-on card. The 6821 Parallel Interface Adaptor IC (IC4) can be exchanged for the more capable 6522 Versatile interface adaptor The 6522 has the same 2 × 8bit parallel ports of the 6821 with the added advantage of 2x16Bit timers and an SIPO and PISO shift reqisters.

To fit the 6522, first remove the 6821 then cut the tracks leading to pins ,21,22,37 and 38 of IC4. Connect pin 21 of IC4 to the IRQ pin of IC1 (pin 3 of the 6809), Connect pins 37 and 38 of IC4 to pins 11 and 10 of IC1 respectively, Connect pin 22 of IC4 to pin 32 of IC1 (R/W pin of 6809). Some of these links can he made to tracks running close to IC4.

After carefully soldering the links (I recommend using fine wire-wrapping wire) the 6522 can he fitted to the IC4 socket. The Parallel I/0 lines have the same configuration as those of the 6821 and it will require little programming to adjust to the 6522's different register structure.

The Address lines A0 to A3 are not connected in numerical order to pins RSO-RS3 of the 6522 so the registers will appear in a different order to that shown on the 6522 data sheet. For those using a cross assembler this be no problem, the following is a list of .EQU lines' to use in each program.

```
.EQU ORB, h'8000
.EQU IRB, h'8000
.EQU ORA, h'8004
.EQU IRA, h'8004
.EQU DDRB, h'8008
.EQU DDRA, h'800C
.EQU T1CL, h'8001
.EQU T1CH, h'8005
.EQU T1LL, h'8009
.EQU T1LH, h'800D
.EQU T2CL, h'8002
.EQU T2CH, h'8006
.EQU SR, h'800A
.EQU ACR, h'800E
.EQU PerCR h'8003 ; PCR cannot be used as a label
.EQU IFR, h'8007
.EQU IER, h'800B
.EQU ORA2, h'800F ; Second ORA and IRA
.EQU IRA2, h'800F
```

I hope this will be of some use.

A Bardsley,
Fallowfield, Manchester.

OPEN CHANNEL

For some reason, all stories I cover in this month's column report possible death knells for systems which have been regularly in the news during recent times. The three systems considered — digital cellular telephones; telepoint telephones; and digital audio tape — have been much vaunted by their proponents and indeed at least one of the three, it has been suggested, we simply cannot do without.

Cells of resistance

In July a new pan-European digital cellular telephone service is due to begin operation. Technically, it is a much superior system to current cellular systems in use here in England and on the Continent. It has the ability to allow inter-country roaming — so 'phones can be used anywhere in Europe and car drivers will be able to drive from country to country without a break in a 'phone link. Being digital it offers much improved communications quality, too; a fact many users, fed up with current speech-link quality may be pleased to hear.

However, there is a distinct possibility the new system won't take to the road for a while. Indeed, its launch in July is being viewed with some scepticism. Some operators of current networks believe it's not a viable alternative to analogue systems, yet. July is looked on as a symbolic start-up date, and it will be around a year before it starts to operate at all successfully. At least one current operator is advising its customers against moving to the new systems, saying 1996 is a more advisable date to consider changing. Significant investment has been put into current systems, they work (albeit with a few hiccups), and a change simply for change's sake isn't going to go down well with anyone.

Is There Any Point

Of course, I've been saying it for a while in *Open Channel*, but it seems even the industry is starting to realise it too — not many people want a Telepoint telephone. Telepoint is, of course, the system where small cordless telephones can be used within sight of a telephone point, to make out-going calls into the public network. Despite significant development investment costs and consequent marketing, sales of these pocket-sized portable telephones are in just thousands, not hundreds of thousands people were hoping. It's not the first time I've said it, but I certainly wouldn't dream getting such a 'phone, considering their operational costs. And I'm a self-confessed gadget-lover, not at all typical of the man-in-the-street.

A report published recently by Communications and Information Technology Research predicts only around 280,000 UK subscribers will be using the telepoint network by the end of the century. With only these numbers involved for four competing operators licensed by the Government are going to find it hard to recoup initial costs, let alone make a profit.

DAT's Enough

There's been a large amount of hype in hi-fi publications recently, regarding digital audio tape (DAT) systems. It's almost as if the cock-up the hi-fi pundits made over compact disc (remember, there was once a time when no self-respecting enthusiast would dare upgrade a scratchy old analogue transcription deck to a CD player — some even swore blind they could hear the CD's binary digits being reproduced!) was simply too much to take, and so they must throw themselves in wholeheartedly this time to make amends.

Well the latest news from Philips (yes, the company which gave us compact disc in the first place) is of a digital cassette tape system, comparable in performance to DAT, and available from next year. It uses a thin-film playback head, capable of reproduction in both analogue and digital modes. Tapes are identical in size with standard compact cassettes (they were developed by Philips as well, by the way!) and so, yes you've guessed it, existing analogue cassettes are playable, thus beating DAT's inherent incompatibility hands-down. With DAT now on the endangered species list, I give it just two years to become as extinct as a dodo.

Fatal Flaw

These three systems considered this month are examples of a marketing philosophy used in product development which defines a potential customer then makes the product which the customer supposedly wants. Such a market-led design philosophy is, of course, successful when it works. Videocassette recorders form possibly the best example of successful market-led design. Who could have foreseen, ten years ago, nearly all the population of, say, such a conservative nation as ours having one? Yet someone, somewhere in Japan realised it could be possible. And, having seen the possibility, went ahead and designed, developed and produced a product which has sold in its millions worldwide. Although technically quite a complex task, development of videocassette recorders hinged on there being no viable alternatives if a customer wants to record and replay television programmes, or hire films for home use, the customer needs a videocassette.

Where digital cellular, telepoint, and digital audio tape market-led designers may have got their philosophies wrong is in their presumption that customers will want to spend a lot of money buying a product which is either (1) already available in one form or another (2) simply too expensive for the convenience it offers, or (3) bettered by an alternative developed by someone else. Where a market-led product like the videocassette recorder is developed, price is of secondary concern. If customers want to do what a videocassette allows them to do, there is no alternative but to buy a videocassette recorder.

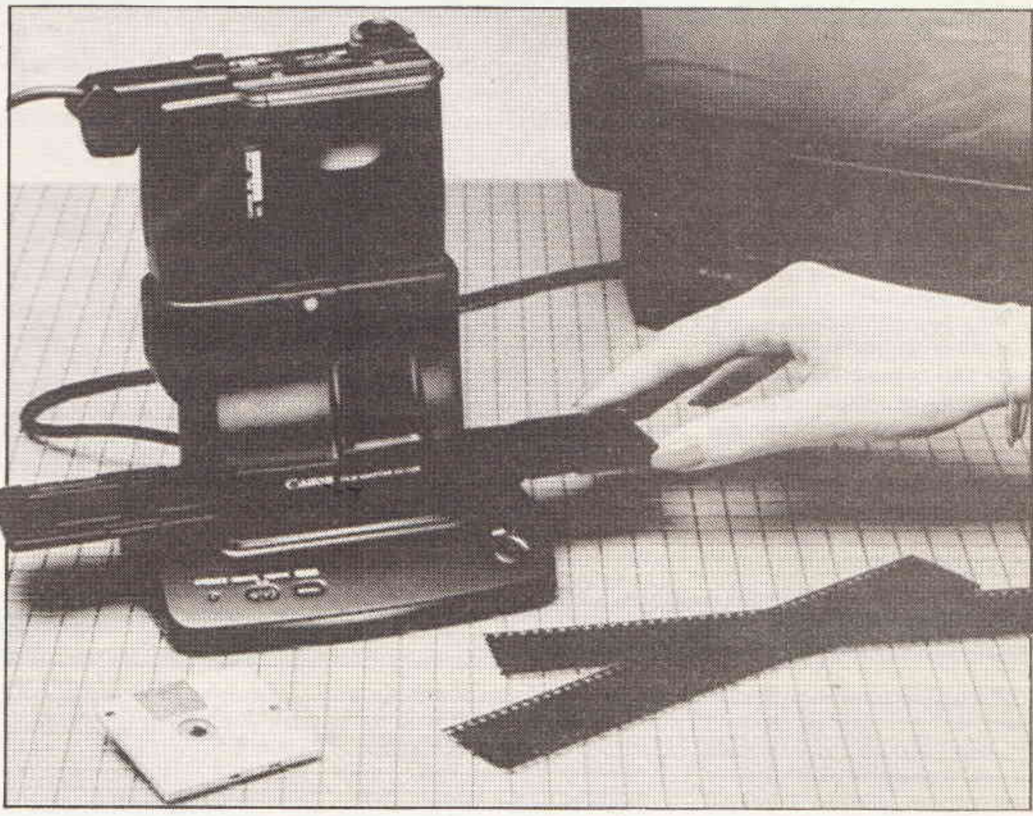
Nobody denies these new products are better than their older counterparts, but the fact must be faced: older counterparts exist. Are the new products sufficiently better — and sufficiently cheap — to win the customer over? Time might prove me wrong, but I think not.

Keith Brindley

![ETI NEWS]

ETI NEWS

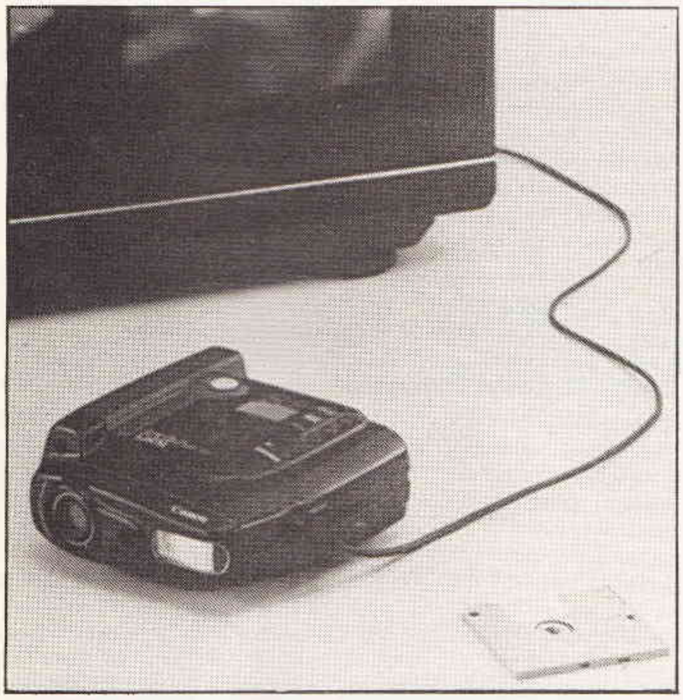
STILL CAMERA FROM CANON



Canon has introduced its second ION still video camera. The RC 260 has the ability to capture images electronically on 2" floppy disk, and view them on TV.

Used with the optional film adapter, the RC 260 can also be employed as a device for converting existing collections of slides or negatives to ION images.

Consumer-still video technology was pioneered by Canon with the launch of the RC251 in 1989. Already, the ION has gained substantial interest in both this field and the industrial field. The company has taken this development one step further and has reshaped the new ION using a smaller, more compact design and relocated key controls, for ease of use.



New features include: Interval shooting for time lapse photography; interval playback; preview facility, enabling pictures to be seen on as they are being taken; infra red remote control; macro facility; backlit compensation feature; a wider angle 9.5mm lens; optional date/time feature on images and individual or all track erase function.

The body shape and size has been re-engineered and is now smaller and lighter than the previous model, weighing only 410g.

The camera is fully automatic with a fixed focus lens, a self-timer, automatic exposure and flash using rechargeable batteries and can take single, continuous (three per second) or interval shots. It can be set to shoot automatically from 1 to 99 minutes and play back every 3.5 seconds for time lapse photography or for making presentations.

An infra red remote controller allows users to change tracks, control on screen date/time information and control interval playback.

The RC-260 can be used as part of a system according to the application. It links with a VCR (for alternative storage of the image) with portable liquid crystal TVs and a video printer and also with Canon's colour laser copier CLC 500 for hard copies.

As an input device, the RC 260 can be connected via various interfaces to IBM, Macintosh, Amiga, and Atari computers for applications such as desktop publishing. It is available from March at a cost of £499.99.

LANDMARK

Landmark Computer Systems Limited has today launched itself as a distributor of UNIX-based systems, to provide resellers and UNIX software houses with an unrivalled level of technical and marketing expertise.

Based in Worthing, the new company will market a range of UNIX-based systems using the Motorola 88000 RISC processor, together with products from leading software vendors such as Cincom, Uniplex, Oracle and Informix.

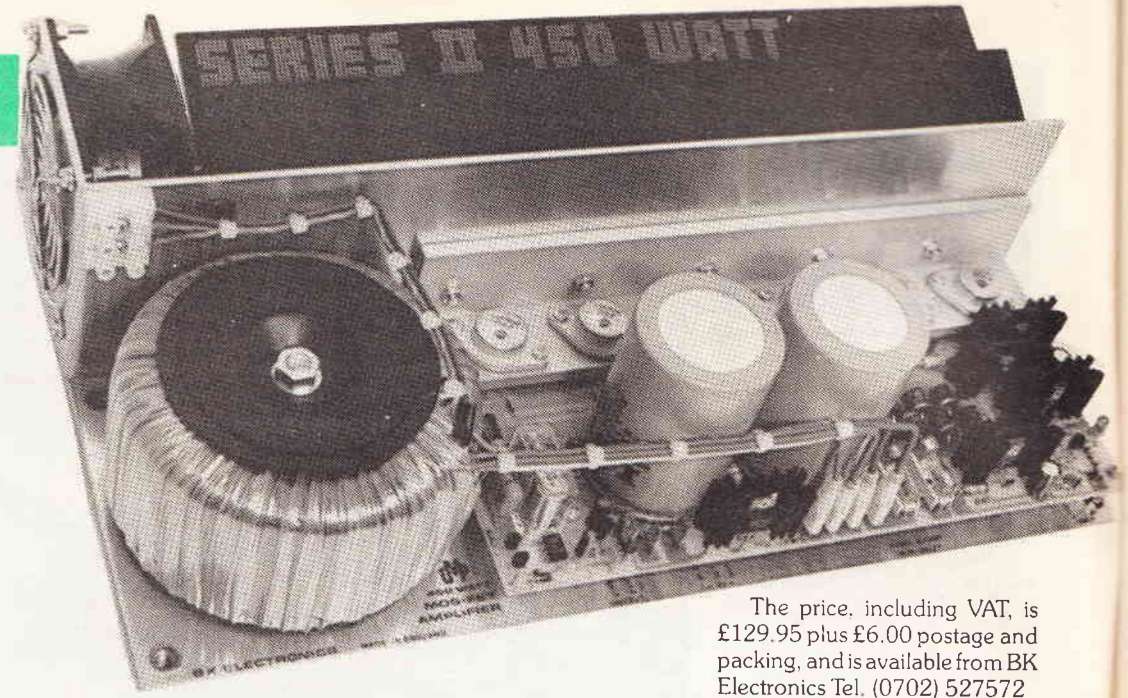
The company has already entered in to an exclusive marketing and distribution agreement with Cincom to port a UNIX version of Cincom Supra onto the Motorola 88000 processor.

Graham Clarke Landmark's marketing and sales manager explains "In the United States, Motorola is the fastest growing manufacturer of UNIX based computer systems and are currently the sixth largest supplier of UNIX systems worldwide.

The 88000 RISC processor is arguably the leading RISC based processor currently available. Motorola has established itself in international markets as a leader in electronics development.

Other products to be supplied by Landmark will be an extensive selection of terminals, communications and peripheral products from leading manufacturers, to enable the company to provide complete solutions.

MORE POWER FROM BK



To compliment their range of MOSFET amplifier modules, BK Electronics have introduced a 450 Watt RMS version. This features an integral power supply including a toroidal mains transformer, on board DC loudspeaker protection, two second delay anti-thump circuitry and a built in cooling fan.

The new amplifier delivers 460 Watts RMS into 4R and 315 Watts into 8R. As with their other amplifier modules a choice of input sensitivities is available. The standard version utilises a 500mV input and the professional equipment compatible version features a 775mV input for full power.

The price, including VAT, is £129.95 plus £6.00 postage and packing, and is available from BK Electronics Tel. (0702) 527572

SHARP END OF RESEARCH

The new Sharp Laboratories of Europe Ltd (SLE) research and development establishment is now under construction following the official ground breaking ceremony on the Oxford Science Park on 19 February 1991.

The building, representing an investment of over £3m, will be one of the first on the site sponsored by Magdalen College, Oxford and is due for completion in March 1992.

Already working in temporary accommodation in Abingdon, SLE has been formed to conduct fundamental research in opto-electronics and information technology.

With an initial capital 75% provided by Sharp Electronics (UK) Ltd and 12.5% each by Sharp Electronics (Europe) GmbH of Germany and Sharp Electronics Espana SA of Spain, SLE is committed to contributing to the European community in an effort to develop basic technology for future products and systems suitable for the European market.

Managing director of SLE, Dr Clive Bradley, was previously head of Secretariat of the Advisory Council of Science and Technology, Cabinet Office. He has extensive electronic research experience, spent six years in Japan at the British Embassy as Counsellor (Science and Technology), and has a wide knowledge of scientific policies in the UK and Europe. Deputy Managing Director is Dr Yoshiharu Nakajima, who had extensive experience of work in Japanese, German and US universities before joining Sharp Corporation.

SLE will recruit most of the employees from within Europe, particularly the UK and has already been successful in reversing the brain drain by attracting British scientists back to the UK. It will also form partnerships with British and European research organisations including universities.

SOFTWARE THEFT ACTIONS IN LONDON & PARIS

The Business Software Alliance (BSA) and the Federation Against Software Theft (FAST) have announced the filing of legal action against Marconi Instruments Ltd for the alleged unauthorised copying of software. The BSA simultaneously announced in Paris, in conjunction with the French Association Francaise des Editeurs de Logiciels (AFEL), that it had conducted court-ordered inspections concerning the alleged unauthorised copying of software against two French companies — Rhone-Poulenc Films and France Distribution Systems.

The BSA and FAST announced that four software companies — Ashton-Tate, Lotus Development, Microsoft and WordPerfect — obtained authorisation from the High Court in London on 21 November 1990, for an 'Anton Piller' order, permitting an inspection of the personal computers at two Marconi Instruments Ltd facilities at Stevenage and St Albans. The solicitors for the parties conducted this inspection on 22 November, and following the review of the results, legal proceedings alleging copyright infringement were issued and served on Marconi Instruments Ltd. An application for an interim injunction was heard on December 7th but adjourned until the New Year on certain undertakings given by Marconi Instruments Ltd.

The BSA announced that its actions in the UK and France were the first step in a new wave of legal actions throughout Europe.

"The piracy problem is causing the software industry serious damage, and we have therefore decided to move forward on a pan-European basis with co-ordinated action against software piracy in corporations," BSA managing director Robert Holleyman said in Paris. "We have several other cases already underway in the UK, France and other European countries, and between now and the Spring of 1991 we will proceed with additional legal actions."

Fox Borgerhoff Mulder, vice-president of BSA and FAST board member, stated: "To our knowledge, this is the first time that the industry has successfully obtained an Anton Piller order in the UK."

An Anton Piller order aims to prevent the destruction of evidence and thus permits a copyright holder to inspect without advance notice the premises of a company suspected of engaging in piracy.

The European Community's Council of Ministers met in Brussels to decide whether to approve a new directive for the legal protection of computer programs. The BSA, FAST and AFEL have praised the proposed directive's provisions, which will require all EC member states to establish strong remedies against software piracy.

The BSA represents eight software companies for personal computers — Aldus, Ashton-Tate, Autodesk, Digital Research, Lotus Development, Microsoft, WordPerfect and XTree.

Over the past six months FAST has stepped up its efforts to raise corporate awareness of software theft, following a survey conducted by MORI which showed that 55% of those senior managers using PCs at work have copied software illegally. Over £300,000,000 is now known to have been lost in illegal software copying last year, a 100% increase on estimates of four years ago.

MAPLIN SALES

It's good news time for MAPLIN shop customers. But there is not too much time to loose. Until 13th April 1991, 1000's of prices are being discounted -some by up to 50%. The sale covers not only existing goods, but seconds and returned items. A whole range of electronic products and components will be available at all the local MAPLIN shops.

Discounted components in particular will appeal to the rapidly expanding number of Maplin Professional Supplies customers, who increasingly will find that Maplin shops are incorporating a special trade counter. Maplin shops can be found in: Birmingham; Brighton; Bristol; Leeds: London — Burnt Oak and Hammersmith; Manchester; Newcastle-upon-Tyne; Nottingham; Reading; Southampton and Southend-on-Sea. Other MAPLIN shops planned to open in 1991 include: Cardiff, Chatham, Glasgow, Liverpool and Sheffield.

ISDN NEW LINES OF COMMUNICATION

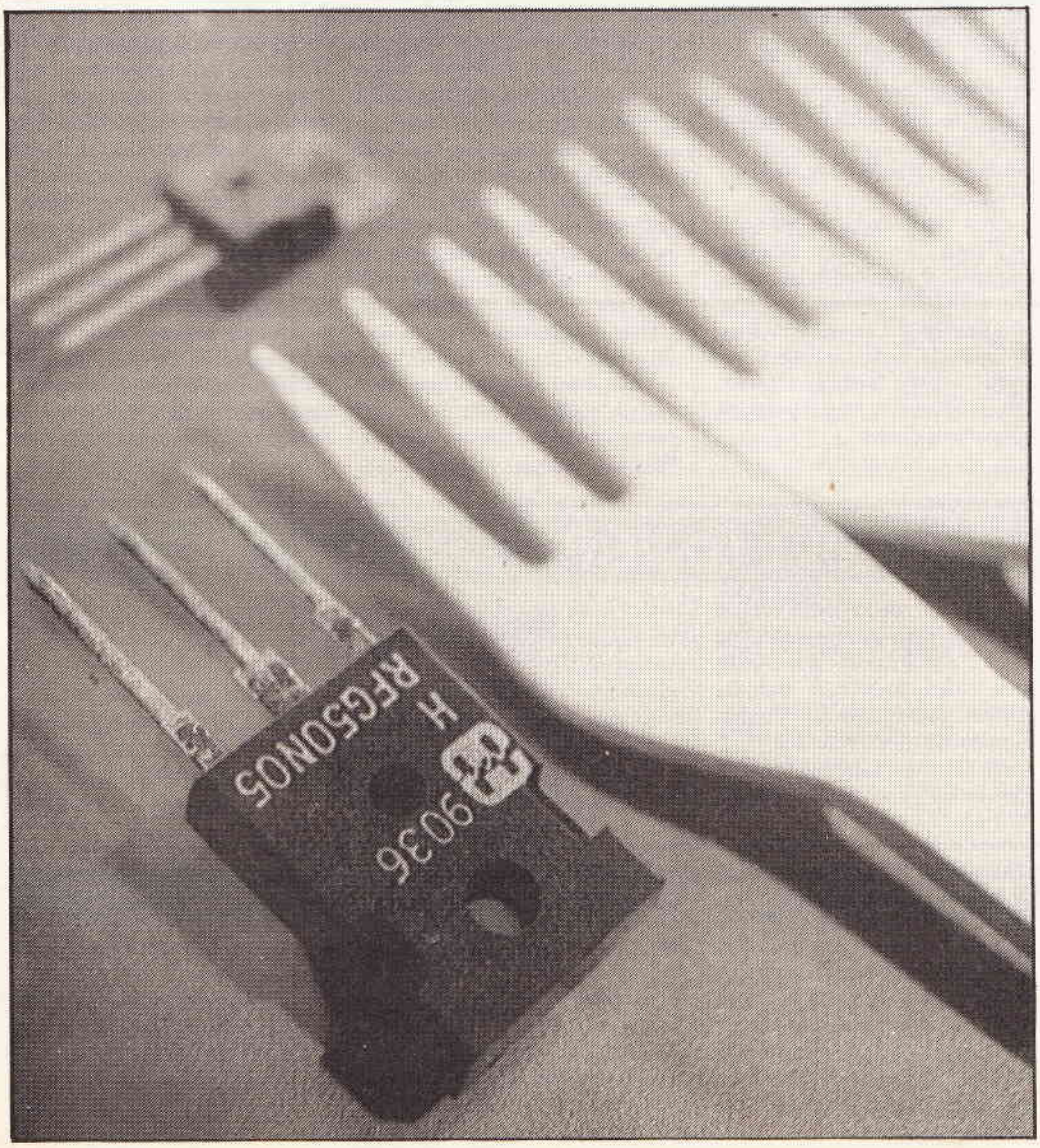
British Telecom have launched ISDN 2 — a new communications service that will revolutionise the way businesses operate. Aimed at the small to medium-sized business and branch offices of larger companies, ISDN 2 (the Integrated Services Digital Network) will open the doors to a number of new applications as well as enhancing existing services. These include the transmission of an A4 sized page in a couple of seconds by facsimile, faster data communications, low cost video links, and clearer speech for normal telephone use.

BT has made available more than 20,000 ISDN lines to cover most major cities throughout the UK. It is also intended to cover all high streets and business areas by the end of the year when more than 90,000 lines will be available.

A similar service, called ISDN 30 and aimed at large businesses, has been upgraded and is now available on BT's System Y digital exchange as well as System X. This means even more large businesses will be able to use the service.

Image transmission could open up several possibilities for estate agents, travel agents, design engineers and many others who need to show images and moving pictures to clients over the phone.

JERMYN POWER MOSFET FEATURES LOW ON-RESISTANCE



Now available from Jermyn is a new MegaFET aimed specifically at cost sensitive high power switching applications in automotive, industrial control and power supply circuits.

Known as the Harris Semiconductor RFP/RFG50N05, the device has been electrically ruggedised for use in this type of application. The device has a low resistance when in the on-state with only 22mΩ for the full drain current of 50A. The on-state resistance is one of the lowest for any power MOSFET and has been achieved using MegaFET technology, which uses smaller die sizes to achieve the on-resistance ratings of larger conventional power MOSFETs.

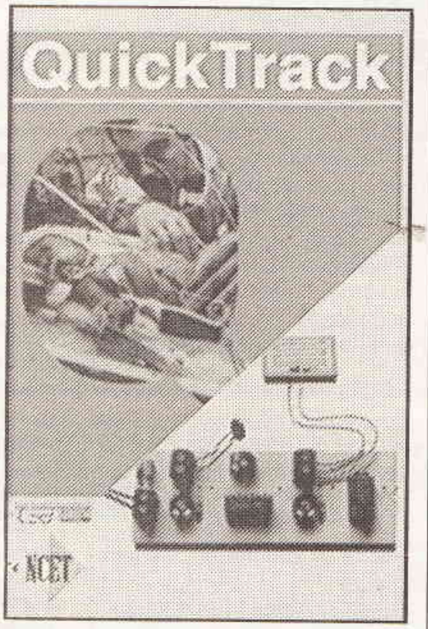
The process employs VLSI ground rules and processing techniques to pack almost 2 million cells per square inch of active silicon area. This is four times greater than conventional power MOSFET processes.

The new RFP/RFG50N05 offers the high switching speeds characteristic of power MOSFETs. Typical turn-on delay and fall times are 15ns and typical turn-off delay and rise times are 50ns typical.

Contact: Jermyn Distribution, Telephone 0732-450144

CIRCUIT DESIGNER MAKES TRACKS

Building small electronic printed circuits has been made easier for schools and colleges with the Quicktrack program for the BBC Master. This computer aided design (CAD) program was refined by trials in schools and colleges and is now sold by the National Council for Educational Technology (NCET) for £25.00. Pupils will often start the design cycle by building a prototype circuit with a systems kit. The development of that prototype into their own printed circuit is where pupils have difficulty. Quicktrack has been shown to help pupils of all abilities overcome that problem.



The young circuit designer uses the computer to assemble pre-designed circuit units on the screen. Components can then be listed from a datafile containing details from the catalogues of well-known suppliers. The final circuit will be small and suitable for fitting into a product design. In one of the trial schools, girls and boys built circuits based on the theme of controlling a premature-baby incubator.

Younger pupils do not need to know a lot about components and circuits, and they can use printed output from the computer to identify the necessary components. Older pupils can do more intensive design work just as easily.

Easier electronic circuit design is only part of the benefit Quick-Track brings. Unlike the way other programs have been used, this method takes a systems approach and tries to integrate electronics into the design and technology curriculum. Educators should note the National Curriculum science order prescribes that all pupils should be familiar with electronic control.

The pack includes 80-track ADFS disc, an 84 page teacher-pupil user guide, and data sheets. It is £25.00 including VAT and p&p from NCET sales, Sir William Lyons Road, Science Park, Coventry CV4 7EZ Tel 0203 416994. The datafiles on components can be easily updated.

DESOLDER STATION

The Litesold DSU50 is a British-made de-solder station. The fully earthed metal power unit contains a powerful diaphragm-type vacuum pump remotely controlled from a finger-switch on the de-soldering tool, with an automatic delayed pump shutdown circuit.

The 50 watt, electronically controlled de-soldering tool is connected to the power unit by an anti-static 5mm bore silicone rubber air tube, to a filter mounted in the front of the case, and a multi-way power cord and DIN plug. Power is supplied to the tool at 24V AC.

The de-soldering tool is fitted with a quickly-detachable glass reservoir, to catch removed solder. Special design of the interchangeable de-soldering tips ensures that solder removed is kept molten during transfer to the reservoir to prevent blocking. The bores of the tips are lined with stainless steel. Four tips and a set of cleaning tools are provided. An unusual feature of the system is that a vacuum reservoir, closed by a solenoid valve, is pumped down and held until operation of the finger-switch simultaneously opens the solenoid valve and starts the pump. This provides a high vacuum at the nozzle.

Temperature selection of the tool is made from a calibrated scale at the control panel, over the range of 120° to 4200°C. and control is via a closed-loop, fully electronic system.

COMPUTER EXPORT TO VENUS AND JUPITER

An advanced microcomputer called ATAC is helping to guide NASA's Magellan spacecraft on a 15-month, 300 million mile journey to Venus and is now keeping the Mission Galileo probe on course to Jupiter.

The ATAC on-board the Magellan probe kept the vehicle on course by computing data from the spacecraft's star sighter and then provided vehicle attitude corrections and control outputs that guided the spacecraft on its journey to the planet. The spacecraft was launched by NASA from the shuttle Atlantis in the spring of 1989 to map the surface of Venus. The Magellan mission was ATAC's first use in outer space.

Mission Galileo is a six-year, 2.4 billion mile journey that took the spacecraft on a looping path past Venus in February 1990 and back within 620 miles of Earth in December. Two years later the space vehicle will pass Earth again at 200 miles altitude. It will reach Jupiter in December 1995 for a two-year orbit.

BUSINESS WOMEN OF THE YEAR

Awards were presented by Esther Rantzen in February to 13 of Britain's most enterprising women, who have shown outstanding determination and initiative in building successful small businesses, often against great odds.

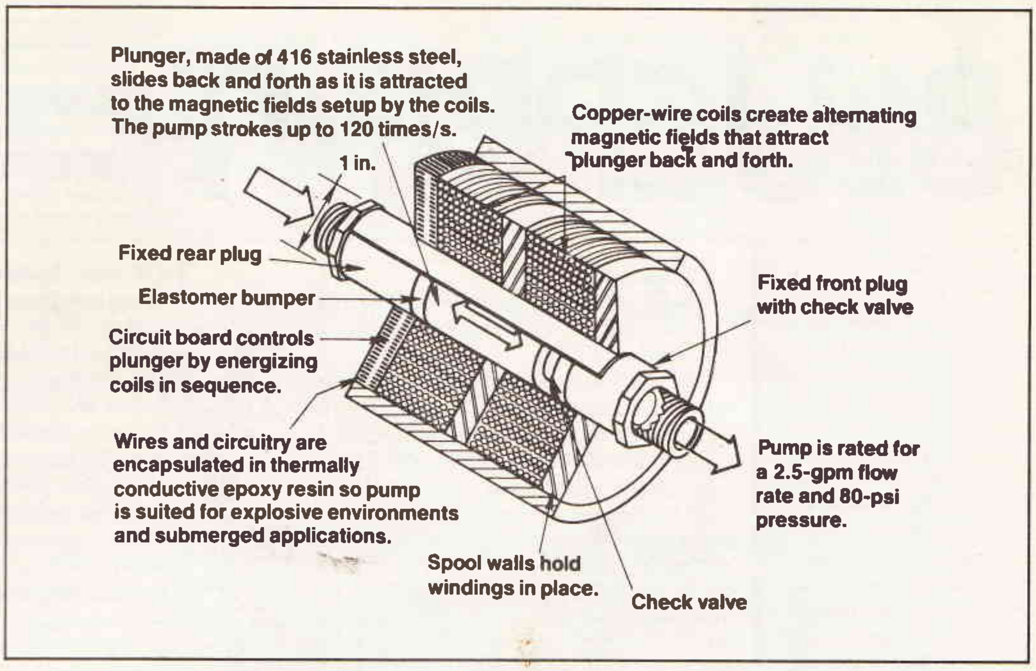
The overall winner, Pat Meyrick from Plymouth who runs an electronic assembly business received a cheque for £5000 from Barclays Bank to boost her business. Pat set up the contract assembly service in 1988 and now employs 18 people. She now plans to move into a purpose-built factory.

The national awards scheme, presented by Prima magazine and sponsored by Barclays Bank, was launched last October to highlight the numerous examples of ingenuity and innovation and encourage Britain's new enterprising women.

Applications were invited from all on-going businesses between one and three years old.

ETI NEWS stateside

Pump driven by dual solenoids



Creating opposing magnetic fields that attract a piston back and forth within a cylindrical housing of a new type of pump enables it to be suitable for submerged applications and explosive environments. Electric current, sent at different times through two side-by-side coils ensures this effect.

The piston, the only moving part in the pump, is driven at up to 120 strokes per second. A circuit board controls the on-and-off sequencing for each coil, so the pump also functions in variable-flow applications. Fluid direction is maintained with check valves on both the inlet plug and the plunger. No seals are used.

Copper windings and circuit board are encapsulated in a thermally conductive epoxy resin. The unit can also function as an air compressor

Chip may automate many areas of life

A new chip will help designers to create a new generation of smart products and applications to automate almost every area of life.

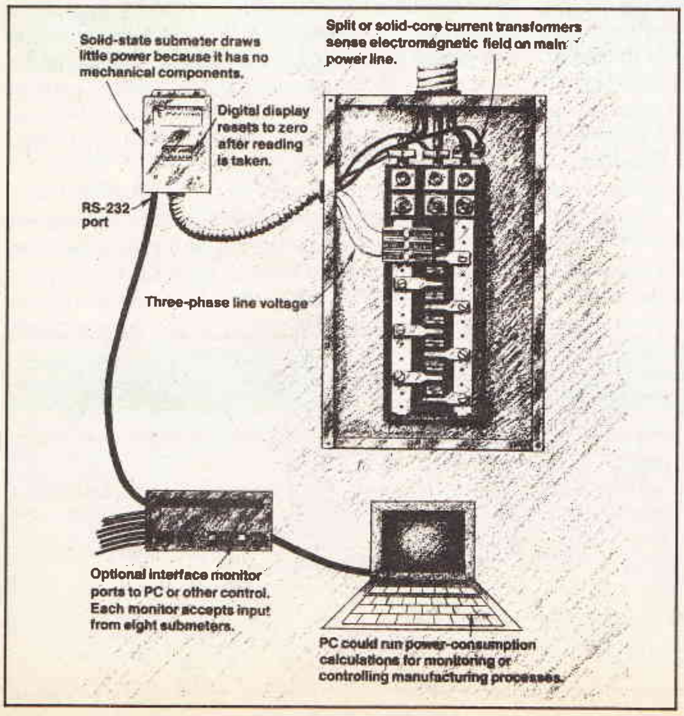
The manufacturers say the chip, called Neuron, is not just another embedded micro-controller, but rather the foundation of an embedded operating system of distributed intelligence and control. Like the nervous system of a living organism, a Local Operating Network associated with the chip extends through the entire appliance or component. The network carries back sensor signals to the Neuron brain, which transmits commands over the LON to actuators and other outputs.

LON technology, in addition to revolutionizing product design, may also bring about changes in personal computers. Less processing power will be needed at the central controller as more intelligence is distributed to peripheral components. Computing power will be redirected to simplify and animate the user interface, which will likely turn home and office PCs into multimedia control consoles.

The Neuron is described as a communications system on a chip. The IC can sense, count, measure time, and monitor and control switches and relays. These special capabilities stem from a merged CMOS/EEPROM/analogue process that packs three CPUs, RAM, ROM, and EEPROM on a 32-pin small-outline package.

Up to 32,000 Neuron-based applications can be linked by the LON to form intelligent systems within cars, homes, buildings, and factories. Interface transceiver chips that allow Neurons to talk over various media will be available for twisted-pair wire, coax, power line and fibre-optic cable. The Neuron has been developed by Echelon Corp. of Palo Alto, California.

ETI will feature an article on the subject of LONs in the near future.



Calculating Power Consumption

A device that has applictions for submetering in process control, monitoring consumption, and electrical invoicing, a new electronic submeter with a digital display can fit into a smaller area than conventional electromechanical devices. It uses U-shaped transformers that clip on the outside of power lines to sense the electromagnetic field, and thus occupies a smaller area. Traditional current sensors are much larger than those used in the submeter.

A microprocessor in the unit calculates power consumption from current power and voltage readings taken from the transformers and directly from the power lines. The integral computer also controls the digital display, which is easier to read than the dials on electromechanical devices.

Called the D-Mon, it operates on single-phase, split-secondary, and three-phase voltage inputs, both grounded and ungrounded. The unit handles up to 600V and 3,200A RMS AC.

E-Mon Corp., Skillman, New Jersey.

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.

Dear Blueprint,
I would like a design for a cascadable timer. I have seen many designs for timers, but none that were cascadable.
My application is to control the automatic watering of plants in a greenhouse. I have four hoses, controlled by four solenoid valves, but the water supply is only adequate for one at a time. I should like to be able to run them sequentially using a timer adjustable from 0-15 minutes on each one.
Yours sincerely
David Lamer

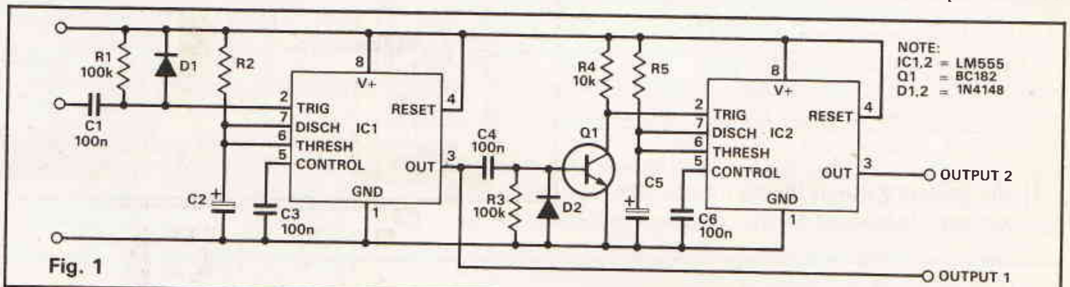


Fig. 1

There are many approaches to your problem, some of which do not involve timers. For example, a moisture detector could be used to regulate the watering time, and a simple sequencer used to select which of the four is in use. A solution using timers is likely to be effective, so three types of circuit are shown here. Only the principles are illustrated; the details are left for the reader to add.

The circuit of Figure 1 shows how 555 timers can be cascaded. Only two stages are shown, but as many as required can be added. This is the first circuit covered because it is probably the most obvious approach to the problem. A completely separate timer is used for each stage so that all times can be chosen independently.

In order to obtain delays of up to 15 minutes, it would be necessary to use large value electrolytic capacitors charging via high value resistors as the timing element. Any leakage current in the board can prevent the capacitor from charging to the threshold voltage. Equally, leakage in the capacitor could cause this problem. Even if the circuit worked when built, changes due to temperature could stop it working reliably. For this reason, it is probably not practical to use this sort of timer for periods of more than three or four minutes, and even then only after careful consideration. Still, there are applications in which this maximum time period does not represent a problem, and where this sort of cascaded timer can be valuable.

It works as follows: when a negative-going trigger pulse is applied to the input, the output switches low. C2, which had been held discharged by the discharge pin, is now permitted to charge via R2 from the power supply. At the end of the time period, the output switches high again, which momantarily switches on Q1, so triggering the second 555 timer. The trigger pulses are coupled via capacitors because, in order for the output to be able to switch back to the inactive state, the trigger pulse must disappear before the end of the time period.

The circuit shown in Figure 2 demonstrates how binary counters can be used as timers and cascaded. When the input goes to logic low, IC1 is allowed to start counting from zero. When the Q output selected by the switch goes to logic 1, the clock input is disabled, and further counting is prohibited. This same logic 1 signal is inverted and fed to the input of an identical counter stage which commences to count in its turn.

Any number of these counters may be cascaded, and the time for each stage may be selected in binary increments. If the range of selection required is very limited, and the clock frequency is chosen to be low enough to generate the required time period in just a few counts, then a stage may be made from each counter rather than from each pair of counters. In this way, the four-stage timer required could be provided using two 4520 dual counters with the associated decoding logic.

When each counter reaches its end-point, its output remains at logic one. In order to generate a definable time period starting with the arrival of the input signal, and finishing at the selected end-count, extra logic is required. This must be duplicated for each stage. In this circuit, the input signal must be maintained for the whole operating period, because the counter is reset immediately that the input signal disappears.

A suitable clock signal can be generated by a 4060 oscillator/counter. If timing component values of 100n for the capacitor and 200k for the resistor are used, and the output is taken from the lowest frequency output (Q13, pin 3), this will clock the counters of Figure 2 at the right frequency to give approximately 15 minutes maximum time period.

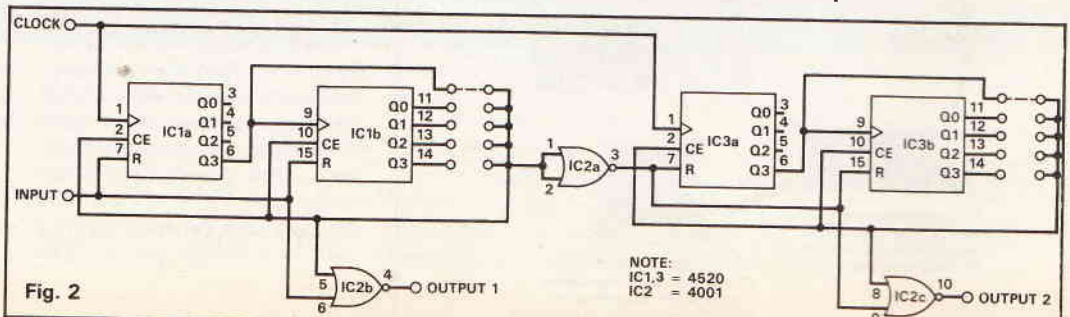


Fig. 2

4

Back to Basics

ELECTRICITY

Paul Coxwell deals with simple AC circuits this month.

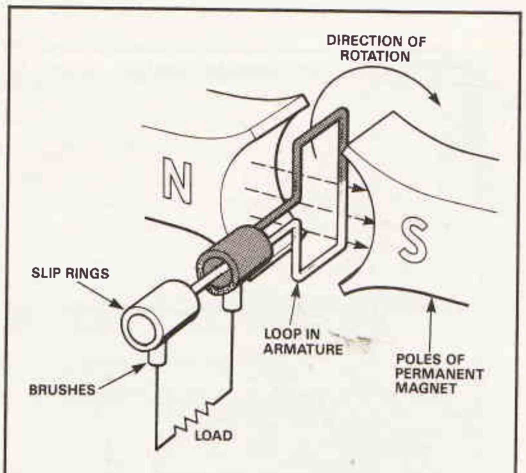


Fig. 1 The basic AC generator

In the first three parts of this series it has been assumed that the power source for a circuit is a battery. In such a circuit the chemical action in the battery ensures that the negative terminal maintains a surplus of electrons and the positive terminal always has a deficiency of electrons. Current flow in the circuit consists of electrons flowing from the negative pole of the battery, through the wires and load, and back to the positive pole of the battery. Such a current flow is called direct current, or DC.

Another very important type of electric current, is known as alternating current, or AC.

Figure 1 shows a very simple form of an AC generator. The loop of wire is rotated in the magnetic field, and two slip rings fitted to the shaft allow brushes to connect external wiring to the loop. Recall the right-hand generator rule discussed in part 2 of this series and apply it to the diagram as you follow this explanation. Assume that the loop is rotating in a clockwise direction as viewed from the end of the shaft carrying the slip rings and brushes.

For a current to be induced in a conductor it must cut across magnetic lines of flux. In the position shown, both the top and bottom parts of the loop are moving parallel to the flux lines; the conductor is not cutting through the magnetic field and no current is induced. As the top of the loop (shown shaded) starts to move toward the south pole of the magnet, it will cut across some lines of flux and a small current will be induced in the loop. Application of the right-hand rule shows that the front end of the shaded portion of the loop will be positive.

At the same time, the unshaded portion of the loop is moving toward the north pole of the magnet, and this also causes a current to be induced. This side of the loop is moving up through the magnetic field instead of down, so current will flow in the opposite direction. Because of the way the conductor is looped, it can be seen the two induced currents are actually flowing in the same direction, and aid each other.

By the time the loop has rotated through 90°, each half of the loop is cutting perpendicularly through the magnetic field, and maximum current is induced. As the conductor continues to turn, each side of the loop are moving parallel to the magnetic field once more, and current is zero. Notice the way in which the current starts at zero, gradually increases as the loop turns through 90°, and then decreases to zero again as the loop has completed a half-turn.
in which the current starts at zero, gradually increases as the loop turns through 90°, and then decreases to zero again as the loop has completed a half-turn.

During the second half of the loop's revolution a similar increase and decrease in current will occur, but with one difference: The side of the loop which was previously moving *up* through the magnetic field will now move *down*, and vice versa. This causes the direction of current flow to be reversed (confirm this by applying the right-hand rule once again).

One revolution of the generator has resulted in a complete cycle of alternating current; the current flowed one way during the first half-turn and the opposite way during the second half-turn. As the generator continues to turn, this cycle will be repeated indefinitely. It is usual to show alternating current by way of a graph (Figure 2). The horizontal axis represents time and the vertical axis shows either voltage or current flow. The part of the cycle above the zero line represents the current flow during the first half-turn of the generator; that below shows the current

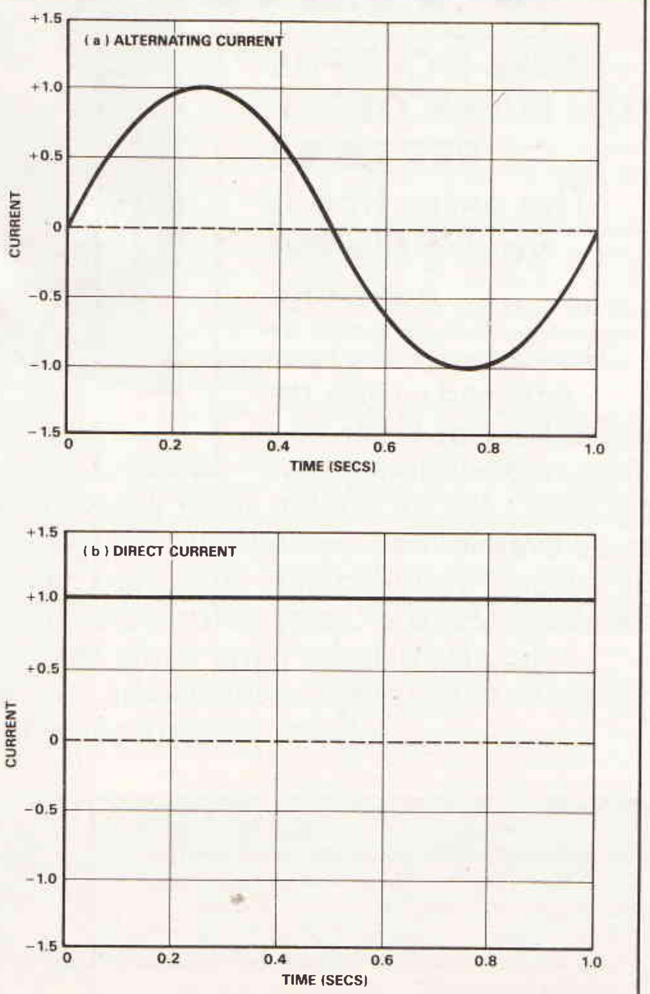
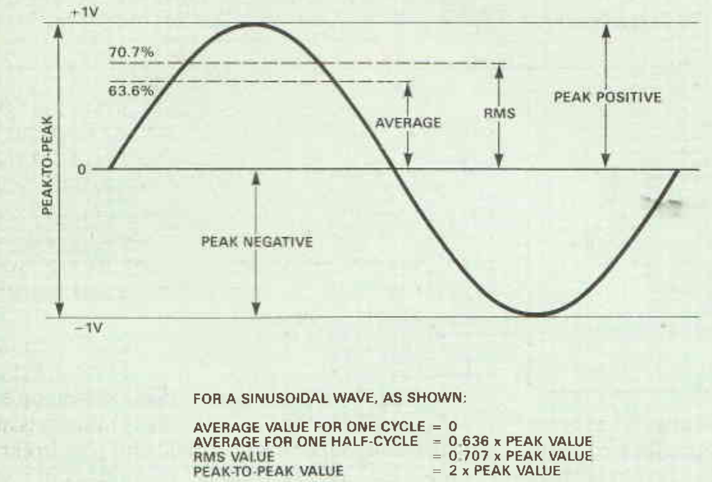


Fig. 2 Graphs of AC and DC

during the second half-turn. The negative values on the graph simply indicate that current is flowing in the opposite direction.

The graph shown assumes that the generator shaft is turning at a rate of one revolution per second. One cycle of alternating current then lasts for one second, as shown on the horizontal axis. If the generator were speeded up to four revolutions per second, the resulting AC output would be at a rate of four cycles per second or 4Hz. The number of cycles per second produced is called frequency.

Fig. 3 Alternating Current Values



Most practical AC generators run at much higher frequencies than those shown here. The power distributed to your home, has a frequency of 50 or 60Hz depending upon the part of the world in which you live (50Hz is the standard in Britain; 60Hz is normal throughout North America).

For comparison, Figure 2 shows how a direct current would appear graphically. Notice how the current never fluctuates, but remains fixed at one level.

AC Values

When examining direct current, we saw four important quantities which may be measured: voltage, current, resistance, and power. If you look at the graph of an AC waveform, it may seem difficult to measure the exact value of voltage or current, because they do not stay at one fixed level.

There are several different measurements that may be made with AC and these are shown in Figure 3. The simplest two to understand are the peak value and the peak-to-peak value. In the example shown, the highest point that the AC cycle reaches is marked as 1V on the graph's vertical scale. The peak positive value is, therefore, 1V. Similarly, the lowest value reached by the cycle of AC is −1V, so the peak negative value is also 1V. In many cases the peak positive value and peak negative value will be equal, but not always. This brings us to an important point.

The cycle of AC shown is sinusoidal; that is, the graph shows a single cycle of a sine wave. This is the shape of AC from a standard generator, and many calculations only work correctly on sinusoidal waveforms. Alternating current may be of different wave shapes; the "alternating" part simply means that the direction of current reverses at some point during the cycle. As this series is only examining electrical basics, we shall not be seeing any non-sinusoidal AC, so the peak positive and negative values will be equal.

To return to Figure 3, we have seen that the peak value is 1V. The peak-to-peak value, is the difference between the positive peak value and the negative peak value. In a sine wave which has equal positive and negative peak values, the peak-to-peak value will be double the peak value. The AC shown has a peak-to-peak value of 2V.

The average value of a complete cycle of AC is zero; the positive and negative peak values are equal and therefore cancel each other out. It can be shown mathematically that the average value of one half-cycle of a sine wave is 63.6% of its peak value. A peak value of 1V, therefore, results in an average value of 0.636V. Average values are not used extensively, because they complicate power calculations.

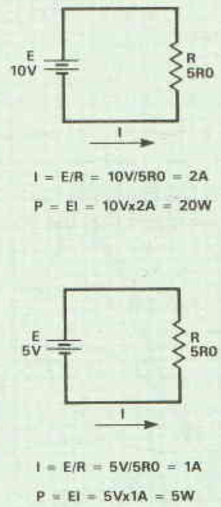


Fig. 4 DC power calculations

In last month's article, we saw that power is directly proportional to both current and voltage. Ohm's Law tells us that in a circuit with fixed resistance, current is directly proportional to the applied voltage. The two formulae required are shown in Figure 4; apply them to the first circuit (which is DC, remember), and determine the current flow and power dissipation for the load resistor. (The calculations are shown in Figure 4, but try to perform them by yourself first).

The second diagram shows that the 10V battery has been replaced by a 5V type; the value of resistance has not been altered. Perform the calculations again to determine the new values for current and power.

You should now notice two things: Having the supply voltage has resulted in half the original current, but has caused the power to be reduced to one quarter of its former value. This is to be expected — power is proportional to both voltage and current and both have been halved. We can now state that in a circuit with constant resistance, the power increase varies with the square of the voltage increase (i.e. doubling the voltage increases power by four, multiplying the voltage by three would increase power by a factor of nine, and so on).

The next step is to apply this principle to an AC circuit (Figure 5). Assume that the resistance is the same as before (5R) and that the peak value of the AC voltage is 10V. Ohm's Law may be applied to AC circuits as well as DC ones, so long as you remember that using peak voltage will give peak current, or average voltage will give average current, and so on. The peak value of the AC is calculated as for the DC circuit in Figure 4, and the result is 2A peak.

Because the value of the AC supply voltage is fluctuating, the current will vary in direct proportion. When the voltage is at 2V, for instance, the current will be 0.4A (confirm this with Ohm's Law). The graph in Figure 3 shows voltage and current plotted on the same axes (the curves are labeled E and I, respectively). Notice how when voltage is at its peak, so is current. The two waveforms are said to be 'in-phase', meaning that they both reach their positive peak at the same time, both reach their negative peak at the same time, and both cross the zero line at the same time. The scale for the vertical axis is not marked with any units: the numbers represent volts for the voltage waveform and amperes for the current waveform.

The third waveform on the graph represents power. You have learned that power is equal to the product of voltage and current, so the power curve may be plotted by taking a number of points along the time axis and finding the product of the E and I curves at that point. It should be fairly obvious that the power will be zero when both voltage and current are zero, and that the power will be at its maximum value when voltage and current are also. Look at the second half-cycle carefully, and notice how the product of two negative numbers (i.e. voltage and current) gives a positive value for power. A negative value would imply that the resistor is supplying power rather than using it, which is impossible.

You should see that the power curve is also a sine-wave. It differs from the voltage and current curves in that it does not go below the zero line to a negative value. Its minimum value is zero, and its maximum value is 20 watts, so the average power must be 10 watts.

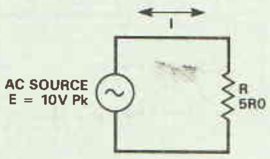
If you compare the first circuit of Figure 4 with that of Figure 5, you should see that 10V peak AC only provides half the power of 10V DC. Clearly, it would be much easier if the figures could be made to correspond.

RMS Values

At first sight, it may appear the average AC value of 63.6% of its peak value would work. Applying these figures to Figure 5 would give an average voltage of 6.36V and an average current of 1.272A. Calculating the average power from these figures gives the incorrect result of a little over 8 watts. The error has come from the fact that both current and voltage have been reduced to 63.6% of their peak value, which when combined has reduced the power to under 41% of its peak value (0.636 squared is 0.405).

The examples above have shown that AC power is half the DC power if the peak AC voltage is equal to the DC voltage. Figure 6 shows a formula which appeared last month — it shows that power is equal to the square of the current multiplied by the resistance. Using this formula and some simple algebra, the effective AC current can be calculated. The last line gives the important point to remember: The effective value of an AC sine-wave is 0.707 times its peak value. This effective value is called the 'root-mean-square', or RMS, value.

In Figure 5 we saw that the average power dissipated by the resistor was 10 watts. Figure 7 shows the same circuit but with the RMS value of the voltage



I = E/R = (10V Pk)/5R0 = 2A Pk

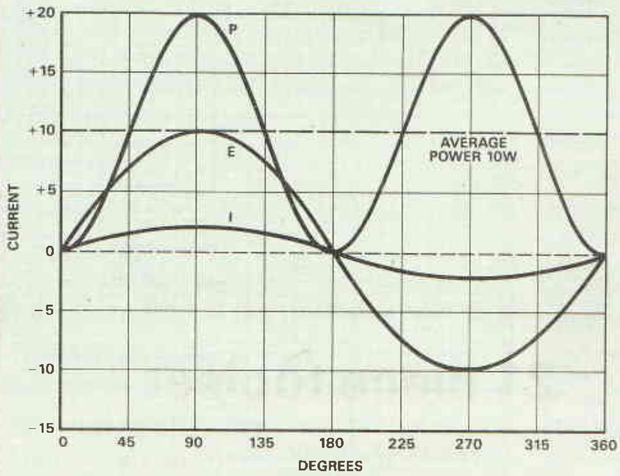


Fig. 5a Calculation of current in simple circuit
b Power, voltage and current sinusoidal waveforms showing phase relationships

Fig. 6 RMS values for voltage and current

FIG 6. RMS VALUES FOR VOLTAGE AND CURRENT

GIVEN

$P = I^2R$ AND $I_{peak} = I_{dc}$

BY SUBSTITUTION:

$I_{dc}^2R = I_{peak}^2R$

FROM FIGURE 5:

$I_{ac}^2R = \frac{1}{2}I_{ac}^2R$

SO

$I_{ac}^2R = \frac{1}{2}I_{peak}^2R$

THEREFORE:

$I_{ac}^2 = \frac{1}{2}I_{peak}^2$

OR

$I_{ac} = \sqrt{\frac{1}{2}}I_{peak}$

I_{ac} or $I_{rms} = 0.707 \times I_{peak}$

ELECTRICITY

source shown (7.07V). Ohm's Law shows that the RMS current is, therefore, 1.414A. If these values are now applied to the power formula, the same answer of 10 watts is obtained. More importantly, it should now be clear that in order to get a power of 20 watts (the power in our original DC circuit), the AC voltage must be increased to 10V RMS. An AC source of 10V RMS, therefore, provides the same amount of power as a DC source of 10V. We have now made the values conveniently coincide between AC and DC circuits.

It is RMS values that are most often used when dealing with AC circuits, and it is usual to speak of '100V AC', meaning 100V RMS. If an AC voltage or current is given without any reference to it being a peak, peak-to-peak, or average value, it should be assumed to be a RMS value. The voltage of normal household supplies in Great Britain, for example, may be specified as 240V. The figure of 240V is in terms of RMS, which can be converted to a peak value by multiplying by 1.414 (which is the same as dividing by 0.707). The peak value of the supply is 1.414 times 240, or 340V. The peak-to-peak value is double the peak value: 680V.

Summary

We have covered some important ground in this discussion of alternating current. The following are the key points which should be remembered.

In an AC circuit with resistance, Ohm's Law applies just as it does to DC circuits. Using the basic equation:

$I = E/R$, for instance, gives rise to formulae such as

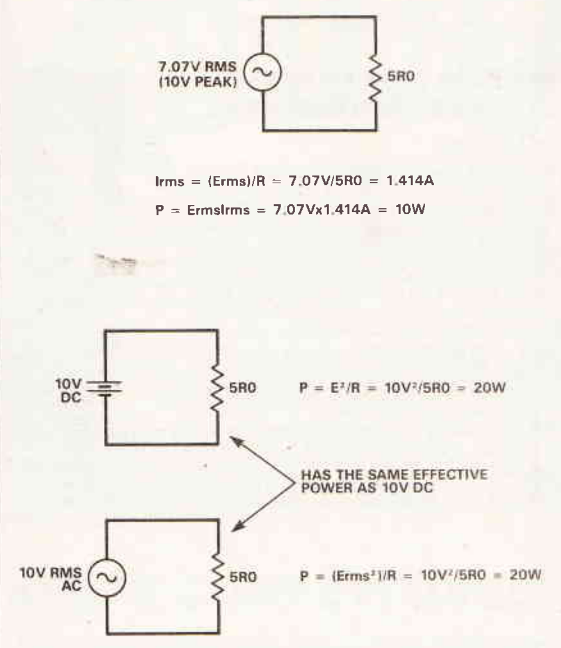
$$I_{RMS} = E_{RMS}/R$$ and
$$I_{peak} = E_{peak}/R$$

The average value of a complete cycle of regular sinusoidal AC is zero. The average value of one half-cycle is 63.6% of its peak value.

The effective, or RMS value of AC is 70.7% of its peak value. The RMS value of AC gives the same amount of power as a DC source of the same voltage, e.g. 10V AC, RMS gives equivalent power to 10V DC.

When dealing with AC, RMS values should be assumed unless stated otherwise.

Fig. 7 Using RMS values



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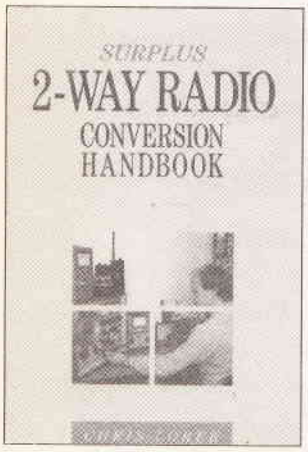

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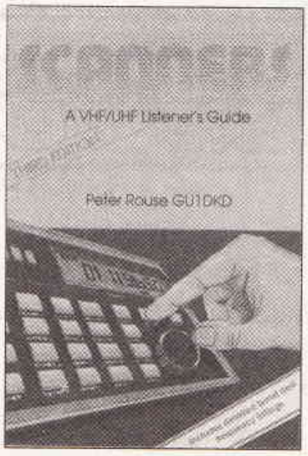

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The physics of how we hear stereo images by Ronald Wagner.

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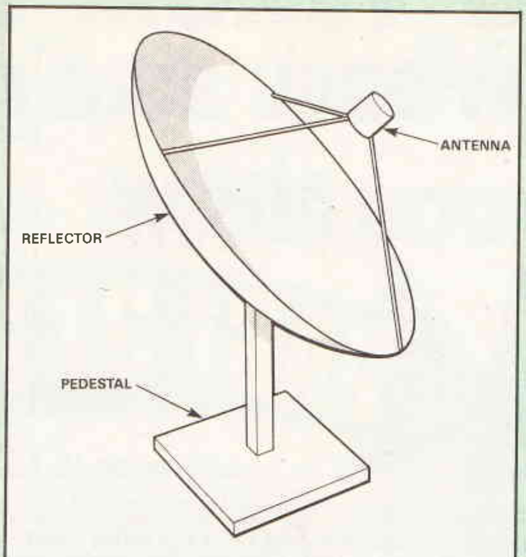

Fig. 1 Typical Antenna dish

The word image has several definitions. It may, for instance, be used to describe how close one object resembles another. In business, many corporations and privately owned companies have an image. In this situation, the word is used to indicate that they are diversified, progressive, technically competent or have the ablity to provide products and services of the highest quality. Most of them are extremely conscious of how this projected image affects their customers, creditors and investors. Because it is an important factor in their business operation, they also spend large sums of money to maintain the desired effect.

In addition to the examples already mentioned, individuals can also have a simulcrum. In this case, the picture might be one of wealth, physical fitness or education. The common link between the commercial and the individual image is their creation. Both are manufactured by the mass media.

Stereo Imaging

The word stereo is from the Greek word that means solid observation. People obtain stereo imaging in two ways. In the visual system, our eyes are about 65mm (2½ inches) apart. This physical separation produces a slightly different view of the same thing. Each eye is connected to an optic nerve transfering the image to the brain. Here, sensory signals are combined to produce a visual picture that has three dimensions.

Sonic Imaging

Auditory images are produced by a similar process. Our ears are 150-200mm (6-8 inches) apart and they receive slightly different auditory stimulation. Their separation however, is not the only factor that affects auditory imaging. Others are related to the hearing process, the characteristics of the source and in many instances the environment where the sounds are produced. Before discussing the later two, it helps to understand the physiological concepts that contribute to our sense of hearing and how it affects this type of stereo imaging.

The Auditory Systems

The human hearing mechanism can be divided into four main sections. These are: the external ear, the ear canal, the middle and the inner ear. Their combined function controls the performance of our auditory system and each of them serves a specific purpose.

External Ear

As a beginning, suppose we start with the most obvious part. In many ways our external ear is similar to a satellite television antenna. The large dish or reflector gathers in the very small satellite signals, and focuses them on to a receiving antenna (Figure 1). The major characteristics that are important to an operating antenna are its frequency response, gain and directivity.

To obtain maximum performance, antennas are built for a specific range of frequencies. For satellite reception this is approximately 3-6GHz. Although these frequencies are very high, their range or bandwidth is limited to approximately one octave.

The gain of an antenna is a number that indicates how its performance compares to a reference antenna. If a certain antenna has a gain of 3 dB, then its output would be twice that of the standard antenna. High gain antennas are often used to improve a systems signal to noise ratio.

Directivity, on the other hand, is an indication of how the gain varies around the antenna's central receiving axis. When the antenna is pointed directly at the source, it obtains the maximum signal. If the antenna is positioned so this axis is at right angles to

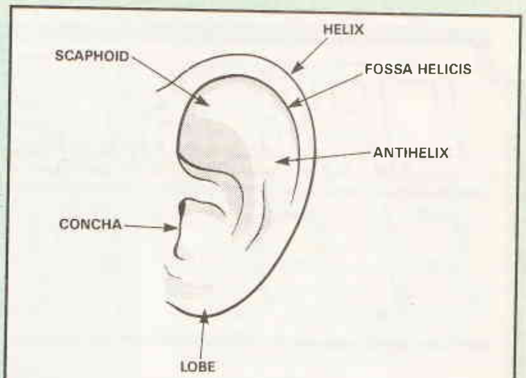

Fig. 2 The outer ear

the satellite signal, its output would be zero. The maximum signal strength is maintained by mounting this type of an antenna on a rotating mechanism and turned for best reception.

Although the external ear, called the auricle or pinna, is smaller and has a different shape to the satellite antenna, it also functions like the reflector. If you look at your ear in a mirror, you will notice that it contains several ridges and valleys (Figure 2). This rolling surface, together with parts of the body, reflects

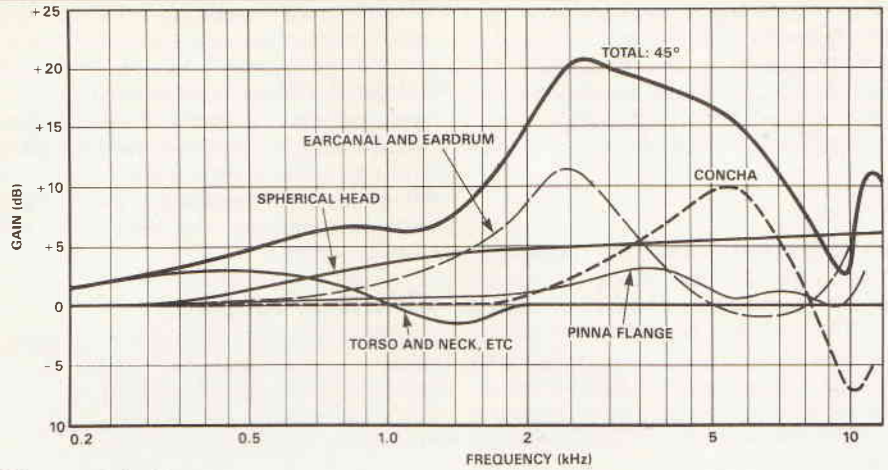

Fig. 3 Response of outer ear

the sound waves toward the ear canal.

The ear drum is at the other end of the canal. Its purpose is similar to the receiving antenna. Reflections from the head and body increase the signal at the ear drum by approximately 15 to 20 dB. The acoustical contribution obtained from some of the significant parts of our anatomy is shown in Figure 3.

The ridges and valleys of the pinna also perform another important purpose. When a sound strikes the ear, the undulating surface creates an acoustic pattern similar to the original sound. These distinct patterns are used by the auditory system to establish the source location[1&2]. As indicated in Figure 4, the maximum auditory gain is obtained when the source is located at an angle of 45° with respect to our ears.

While the size is the most obvious difference between a satellite antenna and the ear, the frequency range and bandwidth of operation are also different. As already stated, the antenna's frequency range is very high, but its bandwidth is low. Just the opposite is true in the auditory system. The frequencies we hear are low, but they cover a bandwidth of 10 octaves.

The directivity of the satellite antenna is determined by the shape of its reflector. The ears directivity is determined by two different mechanisms. When a sound is produced in the lower portion of the audible range, its wavelength is very long. A 100Hz tone, has a wavelength of 3.41m (134.4 inches). This number is so large in comparison to the ears separation that they both will receive approximately the same amplitude. In this situation, the source location is determined by the difference in the sounds arrival time. If the 100Hz source was directly opposite the left ear, the sound would arrive at the right one about 0.5 ms later.

In the upper frequency range, where the wavelengths are short, (1kHz.) the head acts as a shield. A sound originating from a line opposite one ear will be attenuated before it reaches the other one.

Ear Canal

To be heard, a sound must enter the ear canal (Figure 5). This opening is about 5mm wide and about 28mm long. The ear drum, or tympanic membrane, is located at the inner end of the canal. Due to this location, it acts like a pipe that has been sealed at one end. Maximum sound pressure will occur at the ear drum, when the wavelength of the sound is four times the pipe length. This is approximately 2847Hz., and both Figures 3 and 4 have a peak in this region.

In addition to terminating the ear canal, the ear drum is also part of an impedance matching device. On the side where the canal is located, the impedance of the air is very low. The inner ear, shown as the

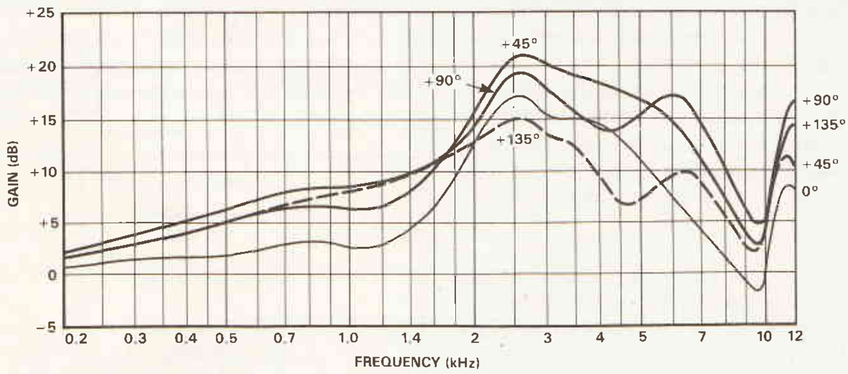

Fig. 4 Response showing gains for different angles

ır Image?

cochlea in Figure 5, contains a fluid having very high impedance. Maximum energy transfer occurs when the source and load have the same impedance. The ear drum and the middle ear must therefore act as an impedance converter. Without it, 99.9% of the acoustic energy that strikes the ear drum would be lost.

Middle Ear

Besides being a contributor in solving the impedance problem, the middle ear also changes acoustical energy into a mechanical force. This is accomplished in two ways. The ear drum is connected to three very small bones called the oscicles. The first two are fairly rigid. As the ear drum moves, they transfer the corresponding motion to an inner bone called the stapes. It, in turn, is connected another membrane called the oval window. As shown in Figure 5, this element separates the middle from the inner ear.

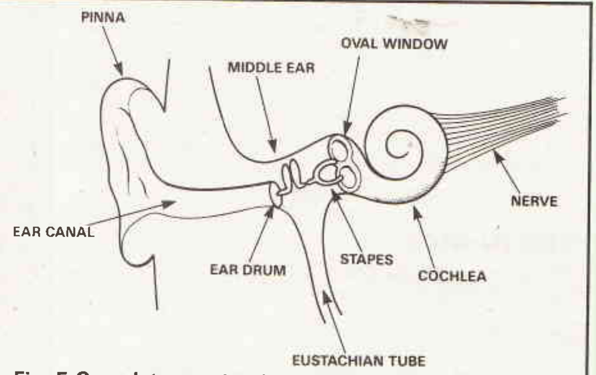

Fig. 5 Complete ear structure

Both the ear drum and oval window perform a similar function. When a sound strikes the ear drum, it produces a force that is equal to the pressure multiplied by the area of the ear drum. This energy is transferred by the oscicles to the oval window. Due to the size difference, the force at the oval window is increased by 17.5. See Figure 6a.

In addition to the increased pressure, the bones which link the oval window to the ear drum create an additional force. As indicated in Figure 6b, the three bones act as a fulcrum. The total force on the oval window is the product of 1.3 (produced by the fulcrum) and the 17.5 from the size difference. This increase is equal to 22.75 or 27dB.

The muscles of the middle ear also have an effect on what we hear. Very loud sounds below 1kHz are attenuated by approximately 12 to 14 db. This provides some protection against loud continuous sounds, but not those that are transient in nature.

Inner Ear

Like the middle ear, the inner ear performs several functions. Its main purpose, is to change the mechanical force that appears at the oval window to neurological impulses. As shown in Figure 5, its shape is similar to that of a snail. For this reason it is called cochlea, being Latin for snail.

The cochlea contains tiny hair cells immersed in a fluid. When the stapes pushes against the oval window it creates a motion in this fluid causing the tiny hair cells to vibrate, each one responing to a different frequency. The overall effect is similar to a third octave filter, and this is one reason why this type of analysis is an important acoustic measurement.

Nerve endings (part of the acoustic nerve) carry the motion of the hair cells to the brain as neurological impulses. Here they are combined, and the encoded information identifies the type and source of the sound.

In essence a sound wave that started as a variation in atmospheric pressure is directed towards the ear canal, increases in value through the middle ear, changed to a mechanical force and passed on to the inner ear. Hair cells encode the resulting force producing a neurological pulse in the brain. The outcome is then identified as being the music of a symphony, the sounds of a baby crying or some other pleasurable or raucous noise that has become part of our every day lives.

Hearing Problems

The preceding explanation has indicated how a normal hearing system functions. When the auditory mechanism has a defect, the result is divided into two categories. Hearing loss before the cochlea is a conductive loss and produces a frequency dependent attenuation. This can quite often be cured by either a hearing aid, antibiotics or surgery.

A hearing loss occurs in the cochlea or auditory nerve is sensorineural and usually develops with advancing age. It, as yet cannot be cured (see Figure 7).

Auditory Images

In a visual system, the three dimensional effect was obtained because each eye received a slightly different view of the same object.

As stated, auditory imaging is related to the difference in a sounds amplitude and arrival time at each ear. The Haas effect, published in 1951[3], verified this concept. In his experiment, Haas used two sources. Each one could be independently controlled in both its amplitude and acoustic delay. After trying several locations, the two sources were positioned at an angle of 45° with respect to the listeners position. As shown in Figure 4 this arrangement produces the greatest ear sensitivity.

When two sound sources are arranged so their outputs have equal amplitudes and arrival times, the brain must determine if they are located in front or behind the listener. The solution to this problem is determined by the ridges and valleys of our ears. Those sounds which occur in front of a person will

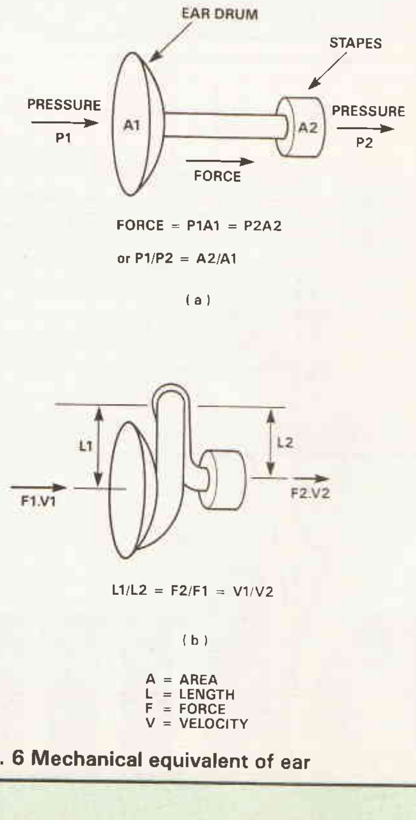

Fig. 6 Mechanical equivalent of ear

have a different neurological pattern from those that originate behind us.

Of course, not all sounds arrive at our ears concurrently. When one ear is stimulated before the other it can be the result of several possible conditions. If the acoustic delay is between zero and approximately one millisecond the brain will conclude that the sound is coming from the side that received the first stimulation. In this time range, the difference in the arrival time also produces an apparent increase in the perceived loudness. In affect it modifies the sound source and this enhances the stereo image.

As the delay between each ear increases toward 10ms, the localization process becomes less apparent. Although both sources may still produce the same acoustic level, our perception of the second source becomes less apparent. Haas concluded that our hearing process locks on to the sound that arrives first. It then ignores those that arrive in the range of 10-30ms (Figure 8). This phenomena was also reported by James Moir[4].

During this time, the amplitude of the delayed sound does not alter the imaging process. If it is 10dB louder then the sound that arrives first still does not contribute to the imaging effect. It is perceived as another sound source.

When the delayed sound exceeds 30ms, it is heard as an echo. To the average listener this time is of little interest. Most home listening environments cannot produce a delay of this length.

Besides the Haas publication, a similar experiment was described by Wallach[5]. His effect was called precedence. The most interesting aspect of these two experimental procedures is the conclusion. Although each scientist used a different technique, they both arrived at the same result.

The Listening Environment

When a stereoscope is used to view photographs that create a stereo image, the relationship between the pictures, the lens and the eyes are well controlled. Each picture has a separate lens to focus the image on the appropriate eye. Additionally the lenses are aligned so the images are shifted toward each other. This process blends them together, and the viewer obtains the best stereo effect.

Good audible imaging relies on similar techniques. In this situation, the sound is comparable to the pictures of the stereoscope. The speakers function as the lens, and the eyes are replaced by the ears. The major difference between these two methods is the dimensions.

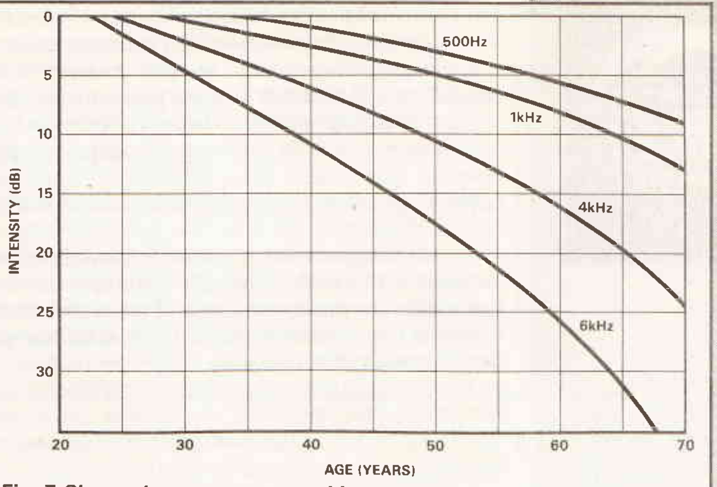

Fig. 7 Change in ears response with age

In a stereoscope, the components are only a few inches apart. Except for some extreme conditions, the result is not usually influenced by the environment. When sounds are produced by a loudspeaker, the dimensions between the different components is in the order of metres or feet. The imaging is now affected by both the characteristics of the speakers and those of the surrounding environment.

The Source

The purpose of a loudspeaker is to change electrical into acoustical energy. In performing this task, there are many factors which contribute to its effectiveness, one being efficiency. This parameter determines the input power required to produce an acceptable listening level.

Another factor is the amount of distortion the speaker produces. If it is too high, the result is a muddy sound that interferes with the imagine effect. A third speaker characteristic is its frequency response. In the previously described Haas and Wallach hearing tests, the positions of the sound source was easily identified. This was due to the transient nature of the test signals. With a continuous sound such as a steady tone, the hearing mechanism has a lot of difficulty in locating the source. A speaker system that does not have an adequate frequency response will not only have poor transient response, but also poor imaging.

Figure 9 indicates how a speakers acoustic output varies as a function of the radiated frequency. Over the 'C' region the cone of the loudspeaker acts as a piston, and the frequency response is flat. For

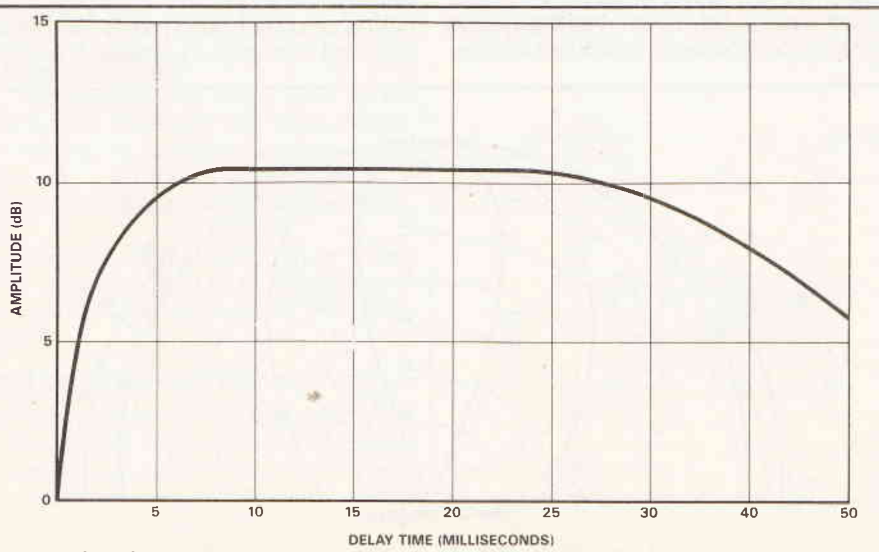

Fig. 8 Ear perception plot

monophonic listening, where the listener is situated on the speakers axis, this is an adequate presentation.

Unfortunately, many people position their speakers so the principle listening position is located off axis. The graph of Figure 9 does not provide any indication of how the acoustic output varies for these listening conditions. This information must be obtained from a graph similar to the one shown in Figure 10.

In this diagram, the zero line corresponds to the speakers axis, and the adjacent numbers indicate a loss in dB. The horizontal line, and those projecting outwards from its intersection with the axial line are the off axis angles in degrees.

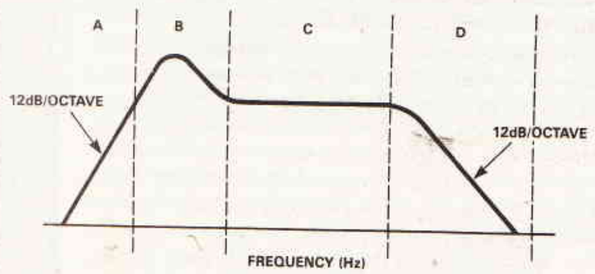

Fig. 9 Speaker frequency response

The 'a' designation of the ka parameter, is the speakers radius in metres. The 'k' in this sequence is a wave number. Its value is equal to (6.28 x frequency)/343. In all speakers, these two factors interact to control the radiation pattern.

If ka is equal to or less than one, the acoustic pattern is hemispherical. As the frequency is increased, and ka becomes greater than one, the cone no longer acts as a piston. When ka equals two, the radiated pattern has decreased in width. Because of this, the acoustic output (60° off the speakers axis) will have a 3dB loss in amplitude. A further increase in the frequency will cause the width of the curves to get even smaller, and the 3dB points will move closer to the speakers main axis. The sound will now be concentrated along this line, and the effect is known as beaming. Table 1 indicates the frequency as a function of the speakers size. (ka = 1). This point could be called the speakers critical frequency.

Environment

To determine how this information is related to stereo imaging, consider the diagram shown in Figure 11. As indicated, the two speakers have been placed against a wall, 8 feet or 2.4m apart. The listeners are seated in the middle of the room, six feet or 1.8m from a line that is parallel to the front surface of the speakers. Position 'B' is centered between the two speakers, and it is located 34° off of each speakers axis.

This off axis location is approximately the same as the 60° line in Figure 10, and it will have similar characteristics. If the speaker system contained a single eight inch radiator, there would be a 3 dB loss in amplitude at 1000Hz. (ka = 2). When ka equals five, (2690 Hz) the loss will increase to 17 dB. With the width of the radiation pattern decreasing (ka > 3) the off axis listener may not hear the speakers direct sound. Instead, the source maybe produced by a reflection from a nearby object or an adjacent wall. This will alter the overall imaging effect.

While some speaker manufacturers have used the reflection principle to increase the width of the sound stage, both speakers must be placed in specific location. The main requirement is to have equal reflection paths.

If the reflection paths are not equal, the sound from one speaker will arrive at the listening position before the other. The brain, must then decide how the two sounds are related. It is unlikely, in the average listening environment, that the delay will be long enough for the brain to conclude there is no relationship. Any delay, will produce a change in the acoustic image.

In Figure 11, listening positions 'A' and 'C' have a different problem. The listener at each of these locations is approximately 0.6m or 2 feet closer to the axis of the nearest speaker. Not only is the sound from the farthest speaker delayed, but the increased distance will also reduce its amplitude. These two factors, decreased sound pressure and increased time delay will combine, so positions 'A' and 'C' will have

TABLE 1
Critical Frequency vs Speaker Size

Speaker Diameter (inches)	Radius (meters)	Critical Frequency (Hz)
15	0.1905	287
12	0.1524	358
10	0.1270	430
8	0.1016	538
6	0.0762	717
4	0.0508	1075
2	0.0254	2150
1	0.0127	4300

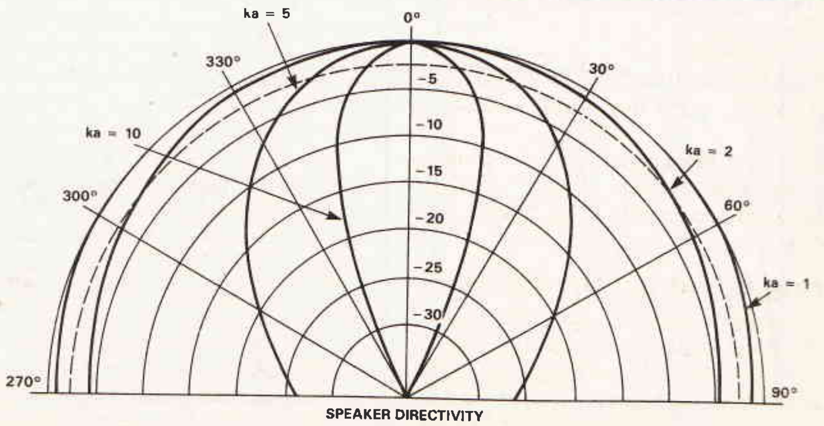

Fig. 10 Speaker radiation pattern

very poor imaging. In fact, for most of the time a listener at either of these two locations will only be aware of the closest speaker.

To overcome some of these problems, the listening position could be moved forward, so position 'B' is at a 45° angle. Another alternative is to move the speakers farther apart. In either case, each speaker should be rotated so that position 'B' is on each of their axis (See Figure 12). In this way the acoustic images are shifted toward each other, and the sound at position 'B' will arrive at an angle of 45°. This ensures that this listener will obtain maximum auditory sensitivity, and will hear the direct sound before any reflections.

Positions 'A' and 'C' will also benefit from the new speaker placement. Each position will now be two feet off the speakers central axis. This provides a listening angle of approximately 19°. Both positions are within the sphere of maximum ear sensitivity.

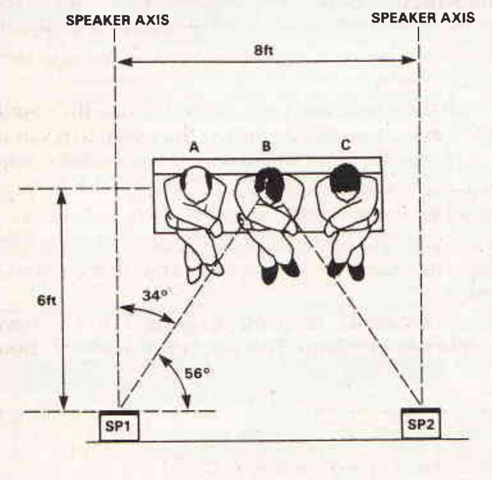

Fig. 11 Typical speaker arrangement

Although 'A' and 'C' will still have a -3dB point, they do not occur until ka = 5. Since this is not the top of the audible range, the frequency response is usually extended by using a crossover network and a smaller speaker. If a one inch speaker is used as a tweeter, the -3db point for positions 'A' and 'C' will not occur until the radiated frequency is almost 20kHz.

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Estimating Speaker Directivity

The most accurate method for determining the directivity of a speaker is by measuring its acoustic output on each side of its central axis. Not only does this take time, but it also requires some equipment that is usually not available to the audiophile or serious listener. It is, possible to estimate the radiation pattern by doing some simple calculations.

Although the result of these calculations can produce a graph like the one shown in Figure 10, this amount of detail is not necessary. If the 3dB points are known, the speakers can be placed for the best stereo imaging and the widest sound stage.

The Ka Factor

The principle factors that determine the directivity of a speaker are its size and the wavelength of the radiated sound. The following example will show how to calculate the 3dB points for an eight inch speaker in an infinite baffle. Because speakers are mounted in a cabinet, this latter parameter is not usually a limitation. Above the point where ka is equal to one, the wavelength of the sound is usually smaller than the baffles dimensions. Therefore, the speaker will appear to be in an infinite baffle.

A speakers off-axis acoustic output will be 3dB down when the value of the following equation is approximately equal to 1.6125.

$X = ka \times \sin(S)$

Where $X = 1.6125$ by definition

k = a wave number

a = the speakers radius in metres

S = the off axis angle

Suppose, the off axis location is 45° and the speaker has an eight inch diameter. The radius in metres is 0.1016, and 'S' is 45°. Inserting these numbers into the previous equation and solving for k gives:

$k = 1.6125/[(0.1016) \times \sin(45)]$

$= 1.6125/[(0.1016) \times (0.707)])$

$= 22.45$

The associated frequency can be obtained from another equation for k. That is:

$$k = (6.28 \times f)/343$$

re-arranging and solving for f provides:

$f = (22.45) \times 343/6.28$

$= 1.23$kHz.

The physical position, on either side of the speakers axis that corresponds to the 3dB points can be determined from the listening position. If, as part of this example, this distance was six feet (1.8m), then:

$\tan(S) = y/d$

Where S = the off axis angle

d = the listening distance

y = the off axis position

Based on the previous assumption, the 3dB points should be located at:

$y = 6 \times \tan(45)$

$= 6$ feet

Therefore, for an eight inch speaker and a listening distance of six feet, the acoustic output will be 3dB down at 1.23 kHz. The two locations will be six feet on either side of the speakers axis.

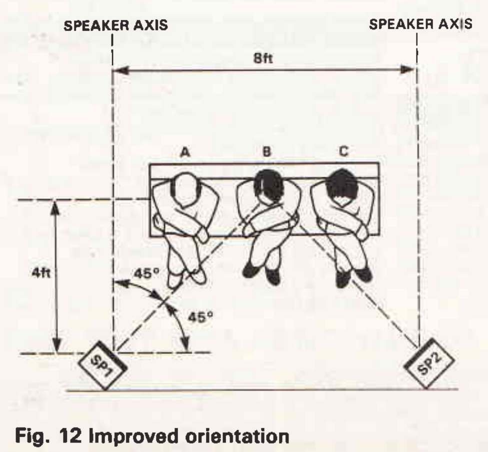

Fig. 12 Improved orientation

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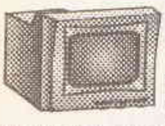

There has never been a deal like this one! **Brand spanking new & boxed** monitors from NEC, normally selling at about £140! These are over-engineered for ultra reliability. 9" green screen composite input with etched non-glare screen plus switchable high/low impedance input and output for daisy-chaining. 3 front controls and 6 at rear. Standard BNC sockets. Beautiful high contrast screen and attractive case with carrying ledge. Perfect as a main or backup monitor and for quantity users! **£39.95 each** (D) **or 5 for £185**(G)

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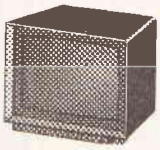
20"....£135 22"....£155 26"....£185 (F)

HI-DEFINITION COLOUR MONITORS



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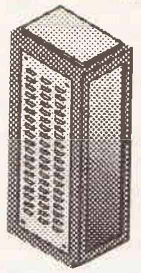

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PCBs for the remaining projects are available from the companies listed in Buylines.

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.

Price code	Price (inc. VAT)
C	£1.80
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E9011-5 Four-track cassette recorder (Bias/erase oscillator board .... K
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E9101-3 Remote Control Timeswitch — Transmit board E
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E9101-5 SBC Practice Interface Board .... F
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E9102-1 Remote Control Timeswitch — receiver board F
E9102-2 Anti Theft Alarm (2 bds) .... H
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E9103-2 64K EPROM Emulator .... N
E9103-3 SSB Radio Receiver .... G
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E9104-2 Active Direct Injection Box .... F
E9104-3 EPROM Eraser .... F
E9104-4 Digital Tachometer .... F
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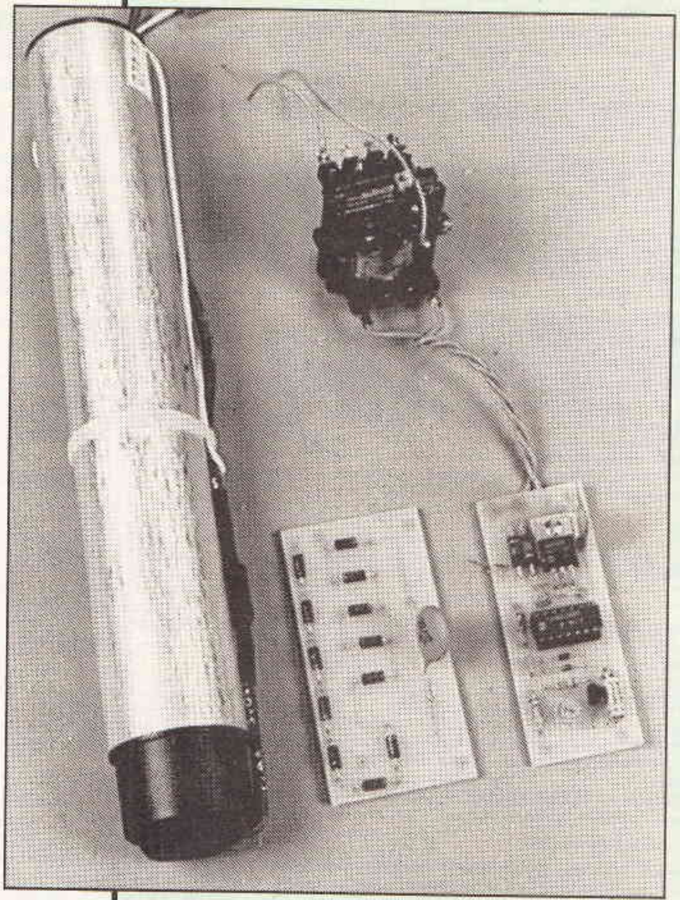


This project follows on from last month's article which described how a laser works. Sadly for those of you who want to incinerate the neighbours' cat we will not be describing how to build a 2 kW CO_2 laser but something a little less awesome and with a lot more practical applications.

This laser is a Helium Neon Laser (HeNe for short), it has a power output of about 2mW, which as it requires about 1.500 volts at 5mA to operate gives an overall efficiency of about the same as a pork pie salesman in a kibbutz.

Table 1 gives the details of the laser tube we are using for this project.

Table 1

Number	Phillips LHN-VLP/04
Striking Volts	between 6 and 8 KV
Running Volts	1.2 to 1.5 KV
Running Current	5mA
Output Power	2mW
Wave Length	630nm (strongest) plus others
Beam Diameter	750um
Divergence	1.43 RAD (note 1)
Visible Distance	2 Miles (suppliers data)

Note 1: I am a little sceptical about this figure which came from the suppliers data as this works out at nearly 82 degrees! Supplier J&N Bull Electrical, 250 Portland Road, Hove, Brighton, BN3 5QT Telephone 0273 203500/734648.

The Price is £40.00 plus £3.00 for insured delivery.

Kevin Kirk now turns to the practical aspect of modulating a Laser.

2 Lasers

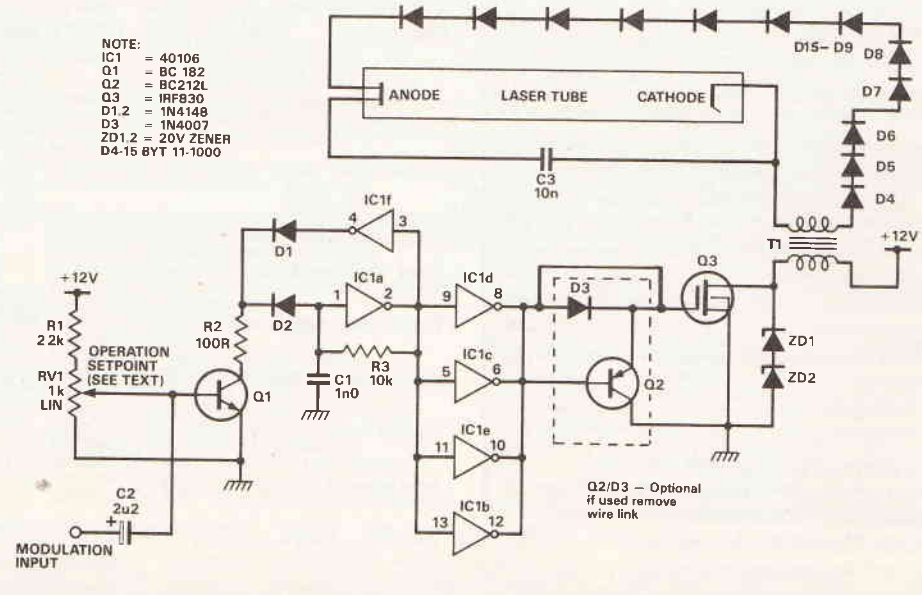


Fig. 1 Circuit diagram of AM Laser

LASER

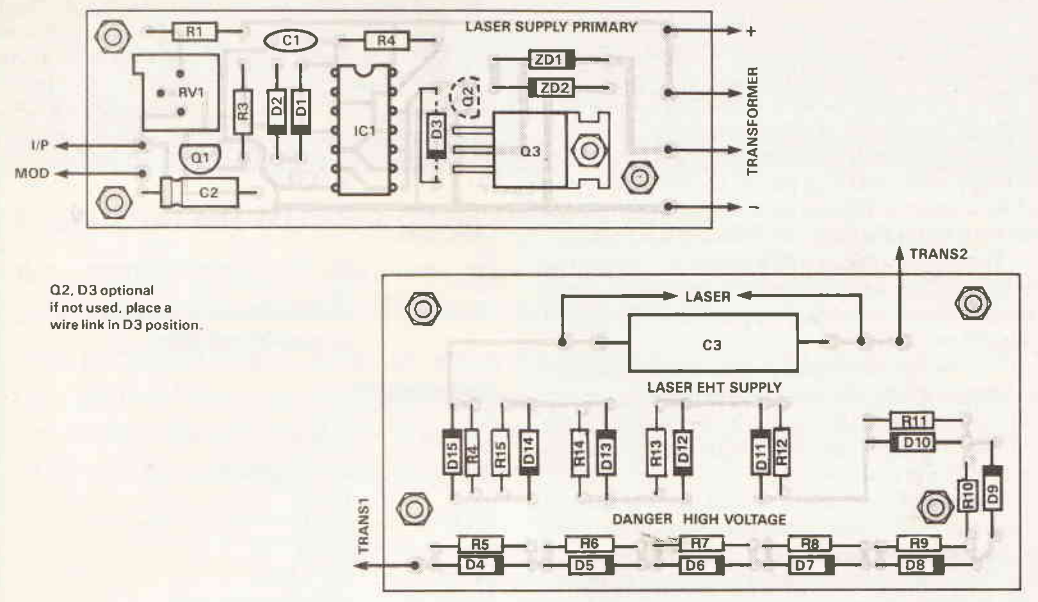


Fig. 2 Component overlay for high and low voltage sections of AM Laser

This particular laser was chosen as it gives a reasonable output level, at a useful wavelength it is also readily available and reasonably priced.

The problem with a laser of this type is the striking and running voltages need to be fairly high. Graph 1 shows the typical current to voltage curve. At first the laser tube is off so it draws no current, the voltage across the tube may be increased until it reaches the 'striking voltage' at which point the gas ionises and the lasing action begins.

If the current is increased (by increasing the voltage across the tube) there reaches a point when the laser no longer lases and if this point is further exceeded then the tube will actually arc inside. This could damage the tube, distort or discolour the mirrors and so it is best avoided.

For this reason the design of the power supply is very important. Initially I was going to use a standard linear transformer and cockcroft-walton multiplier chain (as per the ETI laser in September 1973) which would have fulfilled most of the tasks wanted it to but suffered, in my view, from the following drawbacks:

a) It was difficult to modulate.

b) It was bulky and heavy.

c) It couldn't be operated from a 12V battery so it could not be used for field use.

This cut down the options to a switch mode power supply or a 7500V battery with current limiting. The battery option was ruled out on the basis that I couldn't find a suitable source of battery clips, so it had to be the switch mode supply.

Usually when you mention switch mode supplies then people tend to turn off, true they do have their annoying little traits like the suicidal transistors which give up their lives to save the fuse and their tendency to have CATASTROPHIC failures (everything dies all at once), but they do have redeeming features like their lightness, their ability to run from 12 volts and the fact that you can modulate them.

In fact the supply used here is not what you are used to, unless you are heavily into television where it used to supply the EHT amongst other things, it is called a flyback circuit. It works on the following basis (see Figure 1).

The flyback switch mode supply works by alternatively storing energy in a magnetic field then dumping this stored energy to the load. Therefore by varying the amount of energy stored and dumped per cycle the output power can be controlled. This may be achieved by varying the power supply voltage or current limiting the power supply (which amounts to the same thing) but a more elegant way is to vary the mark/space ratio of the oscillator so the switch (transistor) is on for longer for more power out and for less time for less power out.

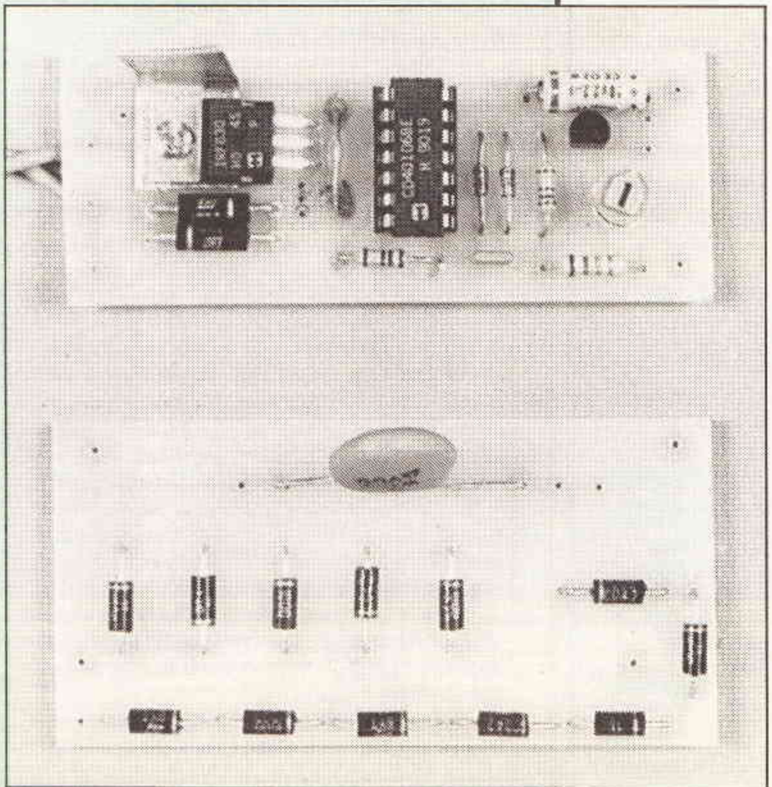
This is referred to as a version of pulse width modulation. Now the neat trick is that this directly amplitude modulates the laser beam, so an audio signal in can be decoded at a distant station as an audio signal out by using a simple (!) opto amplifier, such as that described next month.

Construction

There is two very important safety tips to this project:

a) Never look directly into the laser beam, it can blind you.

b) Take great care with the power supply, it can very easily kill you. Even the primary voltage



is nasty.

The transformer is wound on a DT2723 bobbin which fits a FX3720 Ferroxcube 'E' core, this set is designed specifically for this job.

The secondary is wound first, 320 turns in 8 layers of 40 turns of 0.2mm diameter wire. Each layer should be separated by paper (not sellotape), the prototype used computer paper. On the prototype a further 2 layers of 30 turns were wound on to provide increased output voltage for different laser tubes.

The primary consists of 4 pieces of 0.4mm wire twisted together and wound 10 turns followed by a further 2 turns to provide a tapping for lower output voltage if required.

The transformer should then be soaked in a good insulating varnish, failing that a polyurethane varnish (with no additives). This should be allowed to dry for 24 hours prior to use. The PCB should also be varnished to prevent arcing.

The rest of the circuit presents no problems as long as the PCB is used, note the leads on the laser are connected to the right positions on the board the white lead goes to the negative (−ve) and the black to the positive (+ve).

Prior to starting, check and recheck and preferably get someone else to check all of the connections. Switch mode supplies, even fairly tame ones like this, tend to be a bit unforgiving especially if the oscillator is not running. If you have access to a 'scope then don't connect the transformer and check that Q3 is getting pulses of around 50% mark/space ratio, if not adjust RV1.

If this is OK, then try turning RV1 up this should alter the mark space ratio. The final setting of RV1 will be determined by the use the laser is put to so an initial setting of 50% mark/space is a good start.

Now connect the transformer and laser tube, the laser should give a red beam shortly after switch on. If not switch off and check all connections.

If it works then directing the beam onto a sheet of paper you should see a red dot. Alternatively blowing smoke across the beam will show it up.

When running the supply don't use it without either the laser tube or some other load connected. If not, the power will be either dissipated in the zeners or the secondaries inside the transformer may arc over.

If the laser is to be run from a power supply which may run other devices then it is recommended that a 100μ Electrolytic (at >12VDC) and a 100n disc ceramic are put in parallel on the power supply, a couple of ferrite beads on the power leads will reduce any RFI.

It is strongly recommended the supply and laser be built into some form of plastic case before use, but the exact type is left to the constructor but note the laser is longer than 10 inches.

Finally take care with the laser tube, it is packaged inside an aluminium tube, but remember it is glass inside and is fragile.

Try not to drop the tube, because even if the glass envelope survives you may knock the mirrors out of true, which will ruin the final output mode.

PARTS LIST

RESISTORS	
R1	22k
R2	100R
R3	10k
R4-15	1M (optional – see text)
RV1	1k lin preset
CAPACITORS	
C1	1n
C2	2μ2
C3	10n/10kV (May have to be made in a series/parallel combination)
SEMICONDUCTORS	
IC1	40106
Q1	BC182L
Q2	BC212L (optional)
Q3	IRF830
ZD1,2	1N5388
D1,2	1N4148
D4-15	BYT 11-1000
D3	1N4148 (optional)
MISCELLANEOUS	
T1	Ferroxcube 'E' core FX 3720 on DT2723 bobbin

Laser Tube – HeNe 2mW
Copper Wire – 0.2mm and 0.4mm dia
PCB – ETI PCB Service.

BUYLINES

The Laser tube comes from J&N Bull (see text) and ZD1,2 and D4-15 from Farnell Electronic Components. You'll need to shop around for C3 the high voltage capacitor.

HOW IT WORKS

IC1a is a configured as a standard oscillator together with R4/C1. This output at about 70kHz is fed through IC1b-e which act as invertor/drivers for the MOS switching transistor Q3. They will not be able to turn off this transistor quickly enough to give a sharp edge so Q2 is used to achieve this. However, the gates used in the prototype could fire Q3 directly and so Q2/D3 were omitted. The voltage on the primary of T1 will rise rapidly when Q3 switches off and to avoid exceeding the Vds of the transistor Z1 and Z2 (1N5388) will clamp this voltage to 400 Volts. The transformer has a ratio of 32:1 so the output voltage is about 6.4kV which peaks around 9kV so the tube will quickly strike. This supply is designed for use with other laser tubes other than the one specified so they may need up to 9kV to strike. Our tube should be limited to 8kV so there are various tappings to achieve this.

When the tube strikes it will start to draw current which will reduce the voltage on the output of the supply, but to ensure that no diode in the chain (D4-15) hogs more than its fair share, the resistor chain, R4-15 may be inserted.

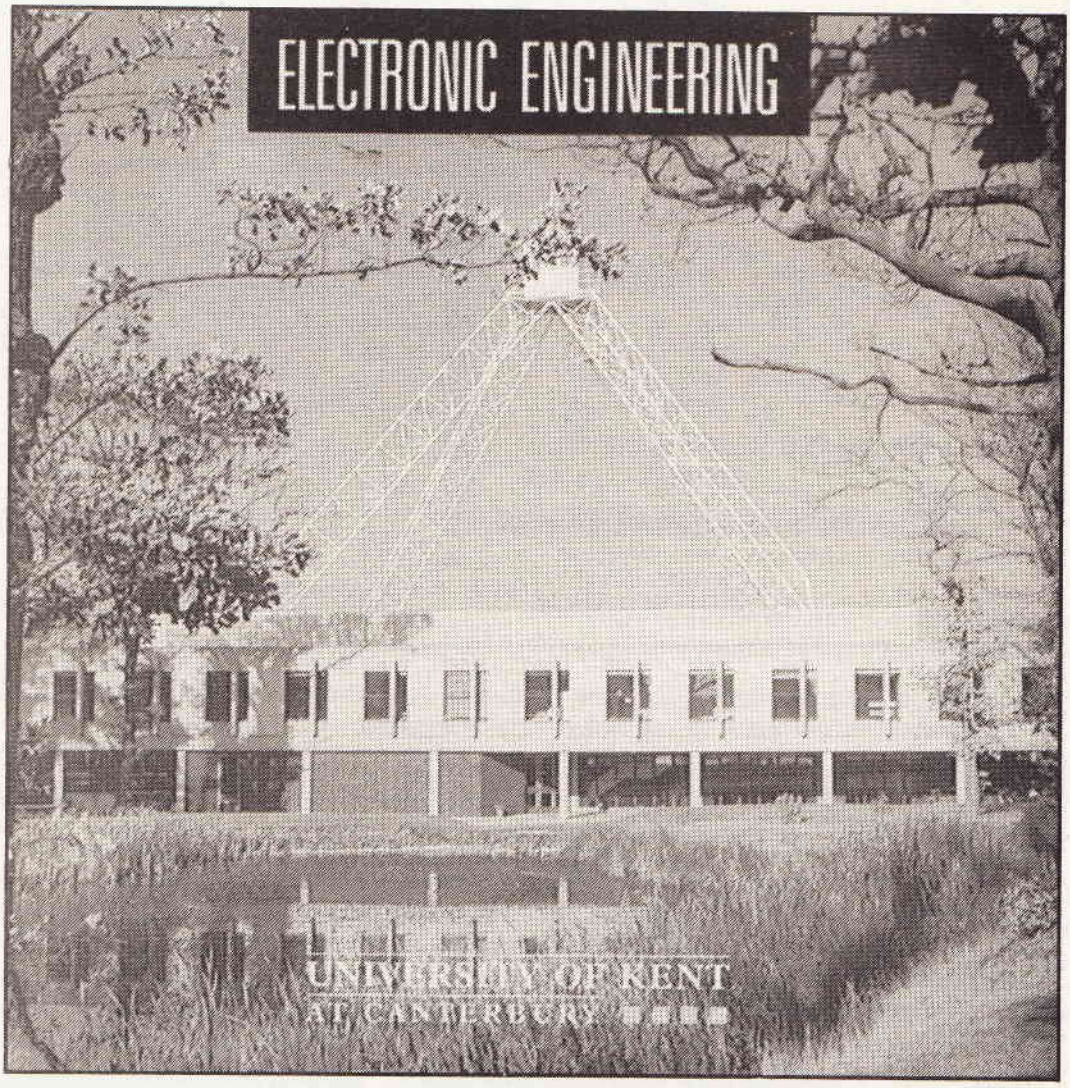
The modulation is carried out by Q1 which will, when turned on, draw current from C1 which will tend to discharge it faster which will reduce the time that Q3 is turned on for thus reducing the energy transferred to the transformer T1. To ensure that this discharge current is only drawn during the Q3 on time, IC1f/D1 will reverse bias D2 ensuring that C1 charge time is not affected by the modulation on Q1.

The actual operating point of the laser may be set with RV1, it may be changed if the laser is drawing too much current, or too little. It also provides a control so that Q1 can be biased into it's linear region for analogue/audio modulation and biased non-linearly for digital on/off modulation.

Note that at no point should the laser be turned completely off, it does take a little time to stabilise so turning it on and off quickly is not advisable. So the type of modulation recommended is between two laser brightness levels. This may be readily detected using a straight-forward opto amplifier and the beam being on all the time gives scope for a carrier present signal generation (for communications systems) and laser sighting.

There is one further point to note. The modulation should be limited to less than 20kHz, preferably a lot lower as the oscillator frequency is only 70kHz and the modulation may not be as effective at higher frequencies.

Electronics At The Leading Edge



Dr. Ken Smith discusses a new Four-year Degree Course at the University of Kent.

Probably many readers of ETI wonder about how the professional edge of Electronics leaps forward. The news-stand magazines do a very fine job showing some of this — I make the point later that they perform a very low cost educational job, which deserves more recognition. I wonder if the same readers ever give thought to possibilities of studying for an Honours Degree in the subject?

The traditional way into such advanced work involved getting sufficient grades at GCE 'A' Level in science and maths (ugh!) subjects, and this route naturally still applies. But consider all the people who often say (at least to themselves . . .) "If only I'd had the chance — I really would love to go to University." Said not only to themselves, because I have heard many say as much to me at various times.

I said 'ugh!' after mentioning Mathematics just now. You might have nodded agreement at this point. Perhaps you have been to a party or meeting, and overheard someone boasting that they are 'pretty thick' at Maths, but it has not held them back! (Yet have you come across anyone boasting, "I can't read or write."? No-one admits that, — there's shame in being illiterate, but why not an equal shame at being innumerate . . .?)

The way Maths has often been portrayed in school becomes so impossible because of bad teaching, that young people turn away pretty quickly. Even in our technical hobby magazines, we end up 'apologising' if a formula slips through. Yet many popular authors in magazines like ETI have done wonders with beginners' articles. So have the Radio Amateurs' Exam Courses. You will find these often introduce ways to simple design calculations which are fun, together with the electronics. The Government should be very grateful for this rather widespread area of costless (to them . . .) 'self-help' educational activity in the voluntary sector.

Returning to the arena of public investment, money has become available to some extent (from the Government) to enable many more people to gain access to higher studies in engineering. One or two Universities have begun to develop access type Courses, which should enable more mature, and experienced people to return to studies. Also, (and with apologies to the implicit criticism about teaching at school level earlier) younger people (17 yr olds) than those traditionally entering University can seize the chance to get out of school ,if they have found school intolerable for one reason or another and do the Foundation studies in a stimulating one year Course at University.

A Four Year Course

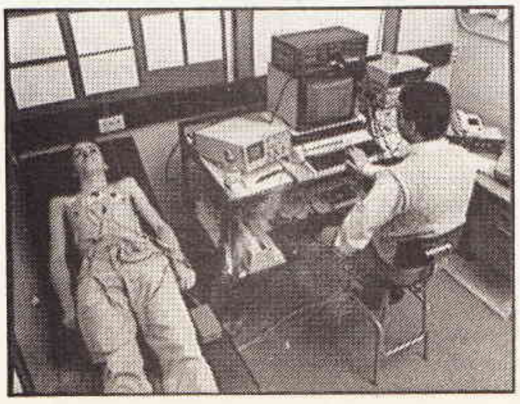
With a course such as this at Kent you would come up to the University for a First year course which lays the foundations in a challenging and stimulating way. You will find these developed in programmes offering Maths, Physics, Electronics and Language Skills, thus enabling you to enter the three year Honours Course for B. Eng Degrees with full Professional credit and qualifications at the end of it.

The First Year I talked about above, has grant assisted status. The Course has plenty of Laboratory practical work on the basics. You would find experiments and measurement techniques, some Electronics projects, even simple Surface Mounting skills and practice. The Course also contains a stimulating Tutor-guided study of the interesting Maths. background required, (here is your chance to start, say, that study of Calculus you've always wanted to do. . .) together with Physical and Electronics Theory, as I indicated.

You might ask, is a such a non-traditional entry to an advanced study likely to succeed? Once in the stuffy old past, the answer would have been "No, because only a few 'special' people possess such ability", (Usually the Middle Class prodigy who went to Public Schools . . .). The Open University has convincingly shown this is a most false assumption — itself no doubt founded on Britain's rather Class conscious Society of some time ago.

Opportunities For The Future

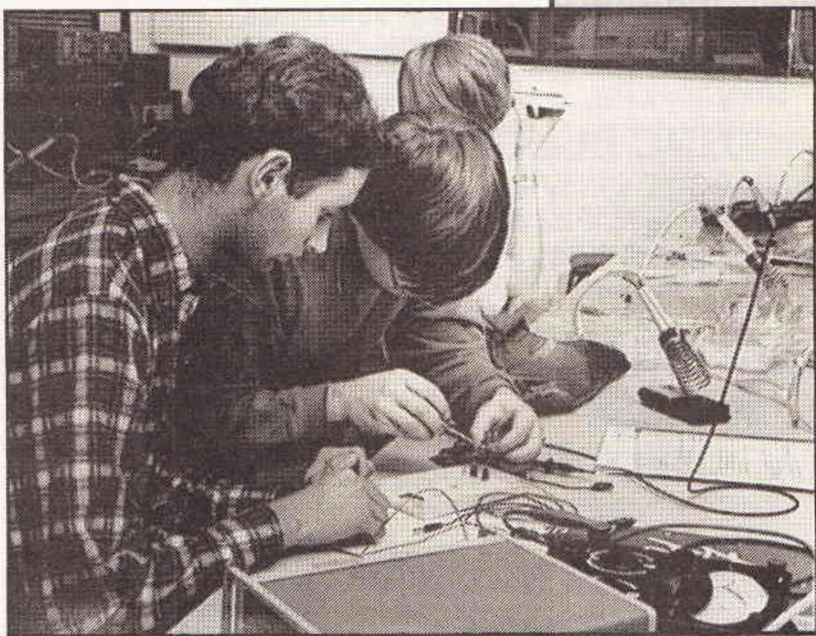
It doesn't need me to state how Electronics has and is revolutionising ways of life. It permeates virtually everything now. Art, including its visual and musical aspects makes mighty use of Electronic techniques, and it has permeated virtually every home and workplace. A glance along the magazines rack in any Bookshop shows many Electronics and Computing hobby magazines on offer. But if you stop to think, it is a most unusual phenomenon — amateurs and hobbyists can vie with professionals, using exactly the same components/techniques as they do — and make important contributions. The pastime side of the subject is not a 'toy' version as in many other fields.



We are likely to find such applications of advanced techniques, and the research, design and development for the future, continually expanding. More people with skills at all levels will be needed.

What's Next?

Because contemplating a return to full time study may seem perhaps somewhat daunting, or you may know some young person who is unsure about his or her ability and asking you for advice, we have put together a package which explains more detail to help you see what is involved. A second stage when you have read the material in the package, could very well be to take up our offer of help in assessing yourself to see if you would fit in with the scheme on offer. If after that you think you really would profit greatly, and you 'take the plunge', then in a few years time you might be working in projects involving Fourier Methods of Signal Analysis, Cellular and Spread Spectrum Radio Systems, the digital telephone networks and other remarkable developments in Digital Comms. techniques. You name it, you could be doing it. Of course, all the other benefits of University life would widen



your views. Joining the Clubs and Societies, debating all manner of philosophy and argument — all forms the unique part of the best education we offer — the University.

Do we have a vested interest in the success of this new scheme of study? Well of course we do. As professionals with a commitment in the (Electronic) future of Britain and Europe, we know many keen bright people slip through the educational net year after year. In particular, we wish to show excellent results and success by means of this Course, so that the Government will maintain funding, expand the method to many other Institutions, and generally work to improve our Education system and standards.

If you feel moved with enthusiasm by this possibility, then write to me for more details. And I am sure, the Editor would like to hear from you regarding your views.

Dr K L Smith,
Electronics Engineering Laboratories,
The University,
Canterbury,
Kent CT2 7NT.

A VLF & ELF Earth Loop Antenna 2

George Pickworth continues to probe the Earth in search of those mystery signals.

For most observations, the author uses the permanent 35m base extending along the garden boundary, but when required, a temporary 135m base is extended into the adjoining farmland where it can be swung over an 180 degree arc. Coaxial cable is used to bring the leads from the earth bases into the garden chalet used as study/laboratory. Almost directly above the 35m earth base is an elevated antenna about 7.0m high and 35m long (Figure 1).

To reduce contact resistance between the earth rods or plates and the soil, they should be as large as practicable, and it was found that 3.0mm mild steel plate to be very suitable; also only a very low level of Galvanic current was produced. For the permanent base, a pair of plates about 300mm wide and 1.5m long, obtained from the local scrap yard, were laid lengthwise in the soil. This gives a DC resistance of about 120R. For the temporary base, a pair of polished spades was an excellent alternative. As far as minimising Galvanic currents is concerned, the ideal earth is a carbon rod of the kind used in search lights, surrounded by crushed charcoal.

Conversion

Antennae convert electromagnetic waves into alternating electric currents which can then be converted into an audible sound, or the waveform displayed by an oscilloscope. Depending upon their design, antennae respond to either the 'total' Hertzian wave, or only its magnetic or electric field. But first let us look at tuners which respond to the electric currents produced by the antenna.

Receivers

Receivers used by the author were generally described in part 1, but now let us look at heart of the receivers — their tuning coils. Tuning 'A' (Figure 2) has an inductor consisting of 500 turns of 0.9mm enamelled copper wire wound on a 15mm diameter ferrite rod 180mm long to give an inductance of approximately 20mH. The coupling coil, located at the end of the tuning coil, has 300 turns tapped at every 50 turns. Tuning as explained in part 1 is by means of a capacity box to give continuous coverage from less than 1.0kHz to more than 15kHz.

'B' also has its coils wound on a ferrite rod, but is 10mm diameter and 180mm long. The tuning inductor is divided into two sections; the original rod with a 'long wave' winding, is retained as one section and the other consists of 250 turns of 0.19mm diam enamelled wire. The original section has inductance of about 4mH but with both sections in series, the total inductance is about 15mH. The coupling coil is located between the two sections and has 500 turns 0.19mm wire tapped every 100 turns. Tuning is by a double gang 500p tuning capacitor (both gangs in parallel). For frequencies between 150-90kHz the original winding is used alone, but for frequencies between 90kHz-40kHz, both sections are connected in series (Figure 3) Tuner 'C' is identical to 'B' except that it has no coupling coil.

The narrow bandwidth of the tuning coil limits frequency response, so when we look at a modulated signal, we see selectivity is reduced by the 500k variable resistor connected across the tuning coil.

Impedance

As already explained, with tuners 'A' and 'B' the tuning

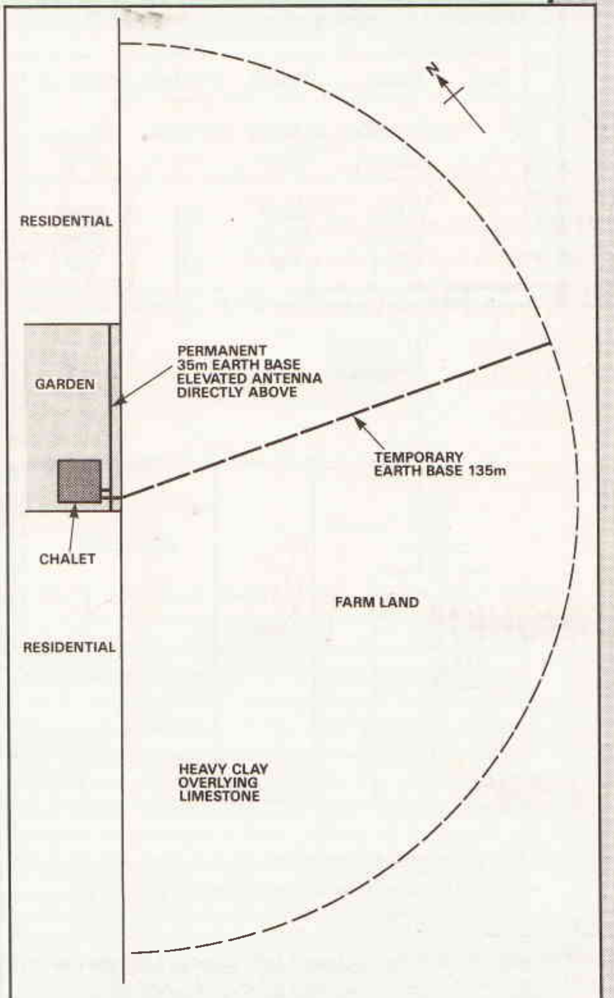


Fig. 1 Sketch plan of author's site

coil is matched to the impedance of the earth loop by means of a tapped coupling coil. With the coupling coil of 'A' tapped to give best signal strength, (DC resistance between 1.0 and 3.0R) the input impedance at frequencies between 1.0-6.0kHz is below 20R. This increases slightly when the tuning coil is brought into resonance with the incoming signal. At about 10kHz, input impedance rises to about 50R with little change when the tuning coil resonates or not. At 16kHz impedance increases to several thousand ohms, but then drops sharply to less than 50R at resonance. The impedance of the coupling coil of 'B', tapped for best signal strength is about 50R at resonance, but rises to a very high impedance when 'off' resonance.

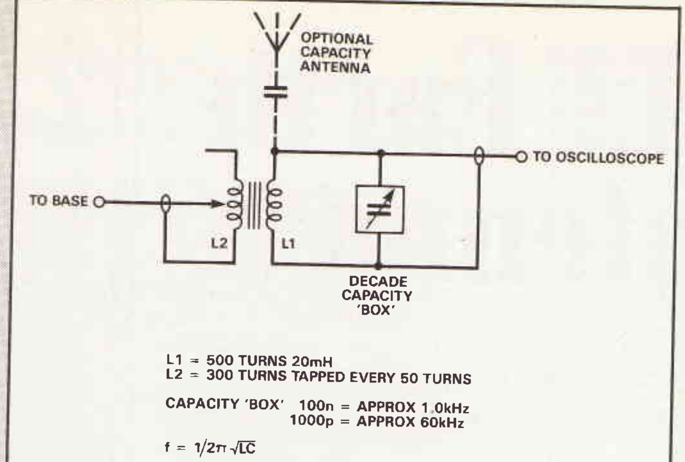


Fig. 2 Schematic of Tuner 'A'

Signal Strength

Signal strength measured across the 2M0 input terminal of the oscilloscope is shown in Table 1 below.

Tuner	Station	35m base	135m base	capacity ant.
'A'	3300Hz-250Hz 16kHz	10-500mV 400mV	100-700mV 1.7V	No signal 120mV
'B'	60kHz 80kHz 198kHz	800mV 475mV 2.0V	2.8V 1.5V 6.3V	230mV 110mV 0.5V

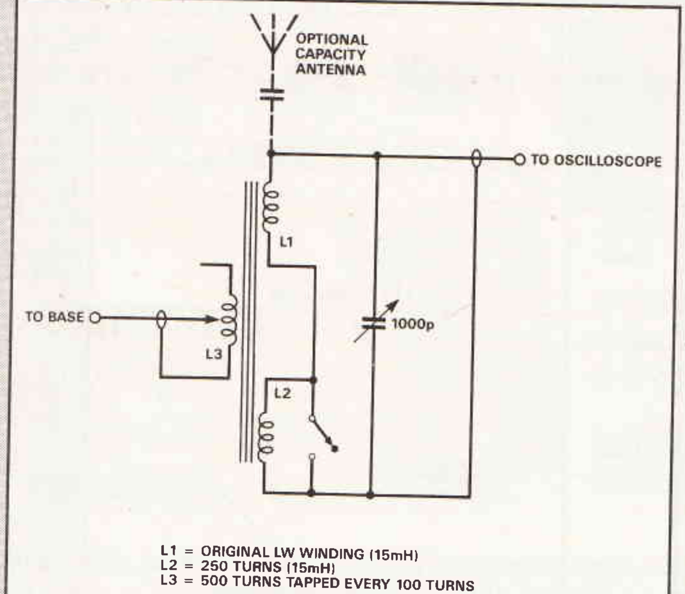


Fig. 3 Schematic of Tuner 'B'

All measurements were made shortly after the top soil became moist following a long dry period but while underlying limestone was still dry. Signal strength dropped by about 15% when the limestone became moist. The DC resistance of the 35m base was 160R, and the 135m temporary base, 210R.

The relative signal strength with a ferrite rod tuner/antenna employed alone and when coupled to the 35m elevated 'capacity' type antenna is shown in Table 2 below:

Station	Ferrite rod alone *	plus 35m capacity ant.
60kHz 80kHz 198kHz	8.0mV 7.5mV 35.0mV	225 150 0.5V

* in open farmland.

Linear Or A Loop

Disconnecting the lead at the distant earth pin and leaving the lead lying on, but insulated from the ground, caused signal strength with all stations to fall virtually to zero. Shorting the two earth pins with an additional lead, so to stimulate the current flowing directly from pin to pin, also gave no signal. However, extending the shorting lead to form a loop 150m in diameter, on the ground, so as to stimulate an earth loop, produced weak signals. The fact that the simulated earth loop gave a signal, albeit weak, and the direct return did not, and also the orientation of the earth base made no significant difference to signal strength, supports the earth loop theory, as a horizontal loop has no lateral orientation.

To gain some insight as to whether a closed loop antenna responds to a 'total' electromagnetic wave or simply its magnetic field, let us first look at a 'linear' resonant Hertzian type antenna, where a current is induced by a wave flowing linearly along the conductor. Being 'open ended' a 'linear' antenna does not significantly respond to a magnetic field. At first sight, therefore, a 'linear' resonant Hertzian antenna may seem to have little in common with an earth loop, but Hertzian antennas can also be in the form of a horizontal closed loop with a circumference equal to a complete wavelength or multiples of a wavelength. The 'Sky loop' is an example of an horizontal loop (Figure 4a and b).

However, the position of the nodes around a resonant horizontal loop antenna is determined by the position of feed point and the direction of the incoming wave, nonetheless the antenna is generally non-directional and its impedance is between 100-200R. Unlike a linear antenna, a loop also resonates when exited by magnetic field.

By inserting a resistor with a value more or less that of the loop's impedance, directly opposite the feed point, to form a so called 'terminated' loop, the loop becomes virtually non-resonant but more significantly, become directive and most responsive to waves flowing either way along an imaginary line connecting the feed point with the resistor. In this mode, one must assume that it now responds to the 'total' wave.

Antennas less than half a wavelength long cannot accommodate a standing wave, so cannot resonate; they intercept the wave's electric field and are known as capacity antennas; typical examples include AM car windscreen antennas where the conductor may also act as a defroster, and short rod type antennas used with earlier medium and low frequency car radios. Capacity type antennas exhibit a high impedance, which imposes minimal damping and are often connected directly to the tuning coil. As resonant long wire antennas are generally impractical at VLF so capacity type antennas are often used instead.

With the authors 35m capacity antenna coupled to tuner 'B' set to receive Radio 4, which has a wavelength of about 1500m. the antenna is only about 1/43rd of a wavelength long. At frequencies around 16kHz where the wavelength is about 19km, the 35m antenna is then only about 1/540th of a wavelength long, a ratio comparable to a typical rod type car antenna connected to a receiver tuned to medium wave station.

Now, as a capacity type antenna is relatively insensitive to a magnetic field, it is reasoned that if a signal was received by both an earth loop and a capacity antenna it most likely arrived as an electromagnetic wave. On the other hand, if no electric field was detected, it could be possible that the signal arrived as an earth current or as a magnetic field. So when required, the capacity antenna was coupled directly to the 'top end' of the tuner windings of 'B' and 'C' by means of 500p variable capacitor.

Hypothetical Case

Let us, consider the hypothetical case of earth current communication over a range of 10km. WW1 earth current communication had a norm of 5.0km, and 10km is well within the range author's equipment, where the current would theoretically follow a loop having a circumference of about 32km. This is more or less equivalent to one wavelength at 9.0kHz. This assumes that a wave travels at the same speed in the earth as in air. By the same token, for a loop to resonate at 16kHz its circumference need be only about 19km, about 5.0km at 60kHz and only 1.5km at 198kHz. However at 2.2kHz the loops would have to be 136km long! (Figure 5).

Unfortunately, the earth loop theory is complicated by the fact that there is not one single earth loop on either side of the base line, but an infinite number of loops in parallel, each increasing in diameter, and each carrying proportionally less current and therefore the resistance of the soil increases. A resonant earth loop must therefore be compared with a multi-band or broad band antenna and these factors have frustrated the author's attempts to set up standing waves in an earth loop and prove that resonant earth loops can exist.

A study of earth loops is further complicated by the nature of the underlying earth. With overlying limestone, as on the author's site, the stream-lines are confined close to the surface and under these conditions earth current signalling has the greatest range. However, current flow lines are not confined to land; they also develop in water, and as saltwater is a better conductor than earth, stream-lines do not extend as far as on land. In deep water, as Preece demonstrated, stream-lines form a hemispheroid; indeed, the same would theoretically occur on land, but the various strata flatten or distort the hemispheroid.

Nonetheless, as Preece had also shown, the basic principles that govern earth loops on land also apply to water and in 1913, an American named Greenleaf Whittier Pickard patented a system based on current stream-lines for communication between submerged submarines. A magnetic field will extend through water, whereas an electromagnetic wave is highly attenuated, is it therefore, the magnetic field component of the 16kHz VLF Hertzian wave that allows communication with a submerged submarine?

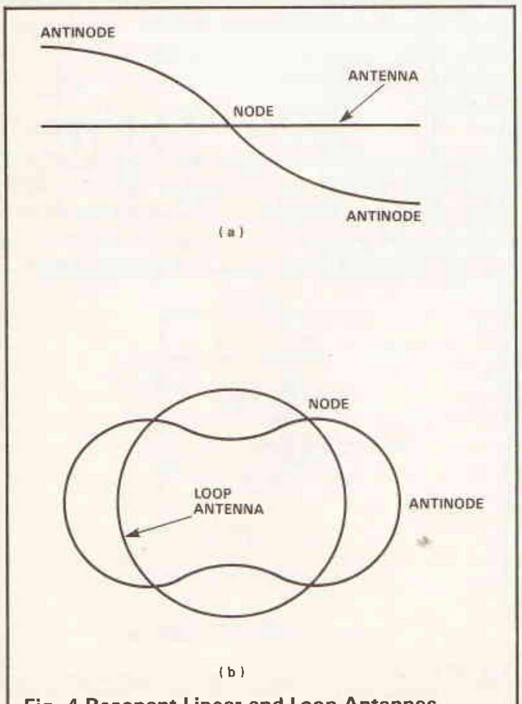


Fig. 4 Resonant Linear and Loop Antennas

Conclusion

These experiments show that under the author's conditions, a pair of earth rods form an efficient ELF, VLF and LF antenna, so earth loops presumably occur, but is open minded on whether the loops are resonant, or whether they respond to the 'total' Hertzian wave, or just its magnetic field. As an earth base can theoretically form loops of infinite circumference, resonant earth loops may well exist.

With regard to the origin of ELF signals below 3.3kHz, for which no organisation has admitted responsibility, the author can only speculate. As no complemetary electric field has been detected, could these ELF signals originate from latter day replicas of Preece's magnetic communication system, but with infinitely more powerful magnetic pulse transmitters? Could they, even result from the resuscitation of Tesla's 'earth standing wave' system? (Figure 5). Indeed the damped waveform of the 2.2kHz signals bears a striking resemblance to what we would expect from Tesla's 'magnifying' transmitters. Or, could they be transmitted as earth currents and, obeying Stanley's theory, travel through the surface of the earth via inductively coupled earth loops?

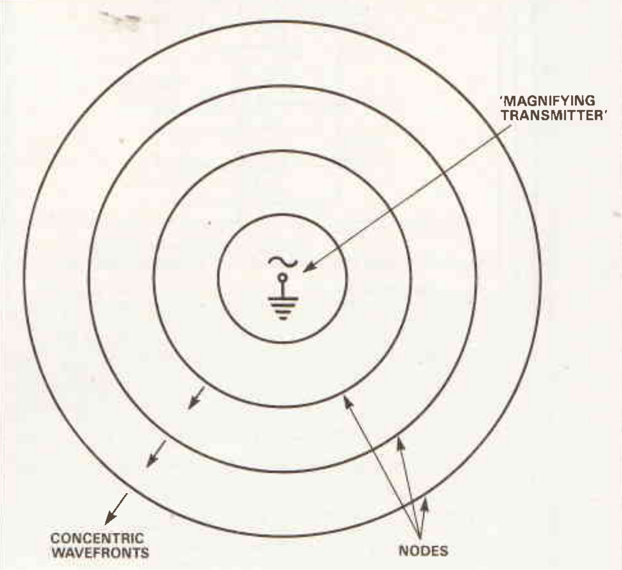


Fig. 5 Concentric Earth Standing Waves (After Tesla)

However, it would seem more likely that the 35m elevated capacity antenna working with an oscilloscope does not have sufficient amplification to detect ELF Hertzian waves, but that they may become apparent with greater gain. Having said that, greater amplifier gain, introduces its own problem.

No matter how the ELF signals arrive, the value of an earth loop antenna for their reception seems beyond doubt, and allows amateur scientists to study these man-made experimental, and naturally generated signals which might otherwise be impossible. Moreover, the cost of an earth loop antenna is minimal and as it can be made invisible, it is environmentally acceptable and does not attract attention.

References:

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Laughter Victor	Wireless Telegraphy Hand-Book	1909
Signals Service	Technical Instructions (France)	1915-1917
Stanley Rupert	Text Book on Wireless Telegraphy	1919
	Amateur Radio Handbook	1990

Constant Current Generator Circuits

Ray Marston takes an in-depth look at constant current generator principles, applications, and circuits.

Constant current generators (CCGs) are, as the name implies, circuits that generate a constant load current irrespective of wide variations in load resistance or voltage. Figure 1 shows a simple example of such a circuit. Here, Q1, is used in the common emitter mode; it has a stable 2.7V set on its base via R1 — ZD1, and thus generates an emitter current of about 1mA via R2; consequently, since the collector and emitter currents of a high gain transistor are almost identical, the collector (load) current remains virtually constant at 1mA in spite of load resistance variations between zero ohms and 12k (at which value the transistor is close to saturation).

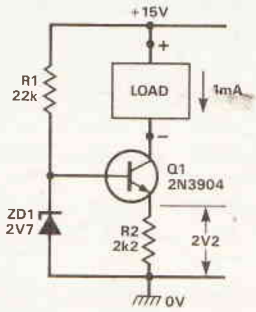


Fig. 1. Simple transistor 1mA constant current generator.

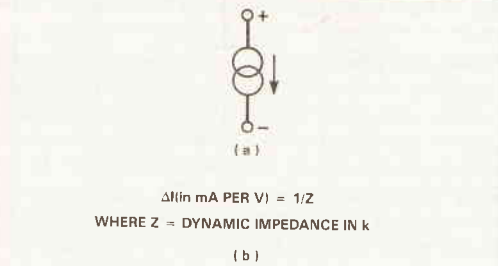


Fig. 2. Circuit symbol (a) and current regulation formula (b) of the constant current generator.

Figure 2a shows the standard symbol used to represent a constant current generator (i.e. the collector-to-ground path of Figure 1); note that the symbol does not indicate the nature of the CCG's circuitry. The most important parameters of a practical CCG are its nominal operating current value and its dynamic impedance (Z). This last parameter represents the current regulation accuracy, as shown by the formula of Figure 2b; thus, if the Figure 1 circuit has a Z value of 1M, its current varies by 1μA per volt change on Q1's collector.

Generator Applications

Constant current generator circuits are sometimes used purely as current generators, as in the four applications shown in Figure 3, and at other times simply as high dynamic impedances, as in the three examples shown in Figure 4.

Figure 3a is the basic circuit of a linear-scale ohmmeter in which the Rx value is read off on a simple voltmeter; if the CCG's 'I' value is 1mA the output voltage is 1mV per ohm of Rx value, and if 'I' is 10μA the output is 10mV per kΩ, and so on.

In Figure 3b the generator is used to provide

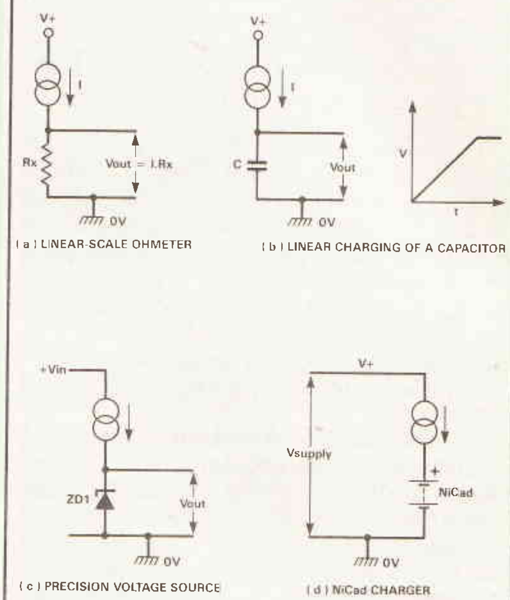


Fig. 3. Typical CCG 'constant current generator' applications.

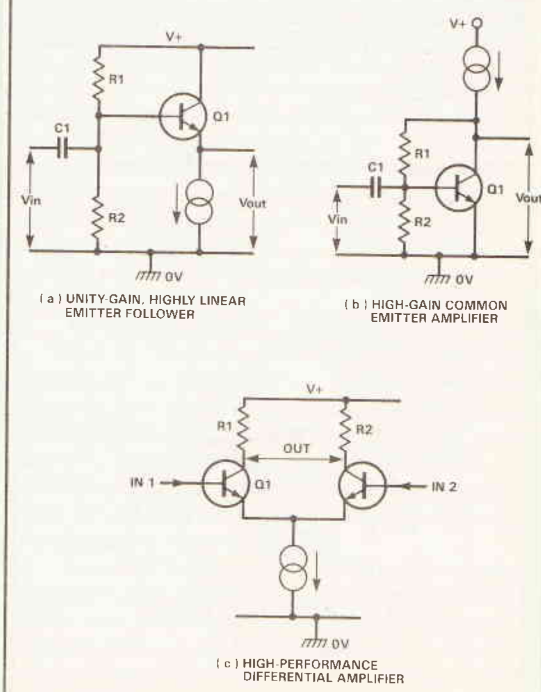


Fig. 4. Typical CCG 'high dynamic impedance' applications.

CIRCUITS

linear charging of a capacitor; this circuit is useful in linear timebase generators and the like.

Figure 3c shows a typical power supply application in which the CCG applies a fixed bias current to the zener diode, irrespective of wide variations of input voltage, and thus enables the zener to generate a very stable output reference voltage.

Figure 3d shows how the generator can be used as a Ni-Cad charger in which the charge current is constant irrespective of the number of cells that are used in the Ni-Cad stack.

Figure 4a shows a CCG used as the emitter load of an emitter follower, where the high dynamic impedance of the generator gives the follower excellent linearity and near-unity gain.

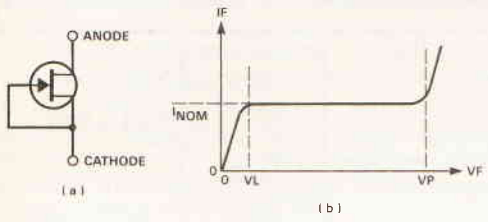


Fig. 5. Actual circuit (a) and characteristics (b) of the JFET 'constant current diode'.

In Figure 4b the CCG is used as the collector load of a common emitter amplifier, where its high dynamic impedance causes the amplifier to operate with very high voltage gain (typically about 70dB).

Finally, Figure 4c shows the CCG used as the emitter load (tail) of a differential amplifier, where its high dynamic impedance causes the amplifier to operate with high gain, excellent linearity, and a high CMR ratio.

Constant Current Diodes

Practical CCGs can be built using a variety of discrete or integrated component, or can be obtained in fully integrated form. The simplest of all CCG devices is the so-called 'constant current diode' which, as shown in Figure 5, is actually an n-channel depletion-mode JFET with its gate and source terminals shorted together so that, when driven by a suitable voltage (typically variable from about 3V to 50V), it passes a constant current with a value pre-set (with a typical tolerance of ±20%) during manufacture. These devices are available in a limited range, with typical I/Z values between 0.5mA/3MΩ and 5mA/0.3MΩ.

Transistor CCG Circuits

Bipolar transistors can easily be configured to act as efficient CCGs, as already shown in Figure 1. This basic circuit can readily be altered in a variety of ways to give different characteristics. Figure 6, for example, shows how it can be 'inverted' to give a ground-referenced constant current output that is variable from about 1 — 10mA via RV1.

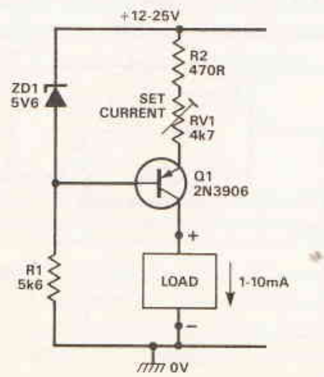


Fig. 6. Simple variable (1mA to 10mA) ground-referenced constant current generator.

In most practical CCG applications the precise magnitude of the constant current is not of great importance, and in such cases the basic circuits of Figures 1 and 6 will satisfy most needs. If greater precision is needed, the characteristics of the reference voltages of these circuits must be improved, to eliminate the effects of supply line and temperature variations. One simple modification is to replace R1 with a CCG, as shown in Figure 7, so that the zener current (and thus the zener voltage) is independent of variations in supply line voltage.

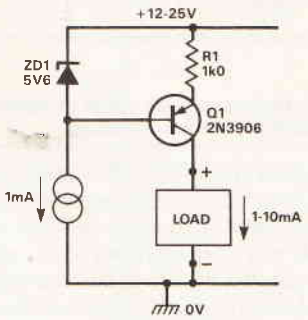


Fig. 7. Precision constant current generator with stable voltage reference.

If high precision is needed the zener reference should have a temperature coefficient of −2mV/°C, to match the V_{BE} coefficient of Q1. An easy way round this problem is to use a forward biased red LED in place of the zener, as shown in Figure 8; the LED voltage is roughly 2V, so only about 1.4V appears across 270R emitter resistor R1, which sets the constant current output level at about 5mA.

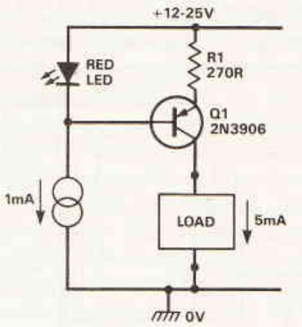


Fig. 8. Thermally stable CCG, using a LED as a voltage reference.

Note that all the transistor CCG circuits shown so far are '3−terminal' designs that need both supply and output connections. Figure 9 shows an example of a 2-terminal CCG that generates a fixed 2mA and

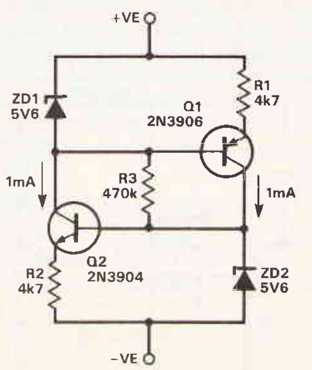


Fig. 9. 2-terminal 2mA constant current generator.

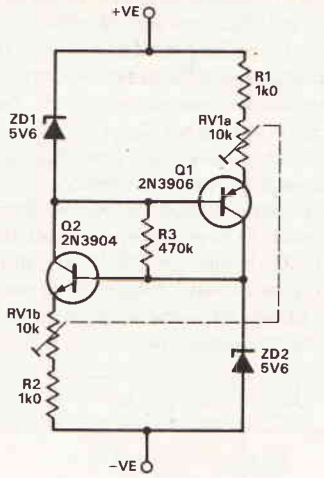


Fig. 10. 2-terminal variable (1mA to 10mA) constant current generator.

can use supplies in the 15V to 40V range. Here, ZD1 develops a fixed 5.6V on the base of Q1, which (via R1) thus generates a constant collector current of about 1mA; this current drives ZD2, which thus develops a very stable 5.6V on the base of Q2, which in turn generates a constant collector current of about 1mA, which drives ZD1. The circuit thus acts as a closed-loop current regulator that generates a total constant current equal to the sum of the two collector currents. R3 acts as a start-up resistor that provides the transistors with initial base current.

Figure 10 shows a variable version of the above 2-terminal CCG; its operating current is variable over the approximate range 1mA to 10mA via RV1. Note that these two circuits need a minimum operating voltage, between their two terminals, of about 12V, but can operate with maximum ones of 40V.

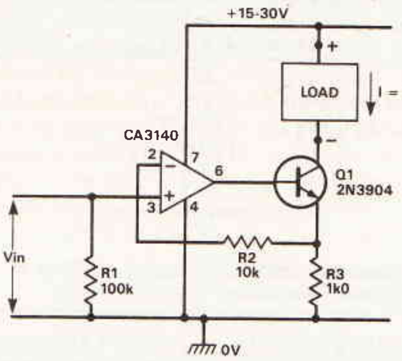


Fig. 11. Precision voltage-to-current converter.

Op-amp CCG Circuits

High-performance constant current generators can easily be built using standard op-amps, either on their own or in conjunction with an external transistor. Figure 11, for example, shows how a precision voltage-to-current converter can be made by wiring a 3140 op-amp and a transistor as a unity-gain voltage follower and taking the output (load) current from Q1's collector; the V-to-I conversion factor is controlled via R1, and is 1mA/V at 1k0.

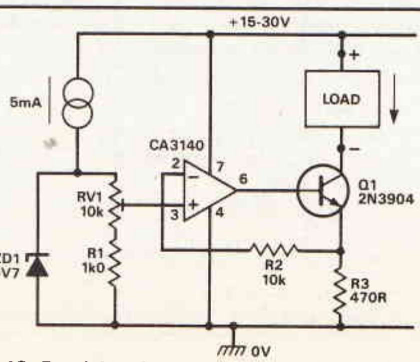


Fig. 12. Precision 1mA to 10mA constant current generator.

Figure 12 shows how the above circuit can be converted into a precision 1-10mA CCG by supplying the current-setting input voltage via a stable 4.7V zener source and RV1; note that the 4.7V zener has a near-zero temperature coefficient.

All the CCG circuits shown so far are unidirectional current generators, in which the load current can flow in only one direction. A very different type of CCG is the voltage – controlled bilateral circuit, which can be used to convert an AC input voltage into an AC load current that is virtually independent of the value of load resistance. Figure 13 shows a simple example of such a circuit. The op-amp is wired as an inverter, but uses the 'load' as its feedback resistor; the

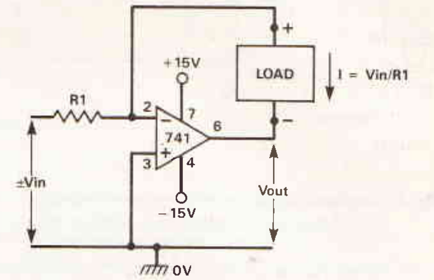


Fig. 13. Bilateral CCG with floating load.

inherent circuit action is such that the feedback (load) current self-adjusts to equal $V_{IN}/R1$, irrespective of the load resistance, so bilateral constant current generation is automatically obtained. Note that the output voltage is directly proportional to the load impedance.

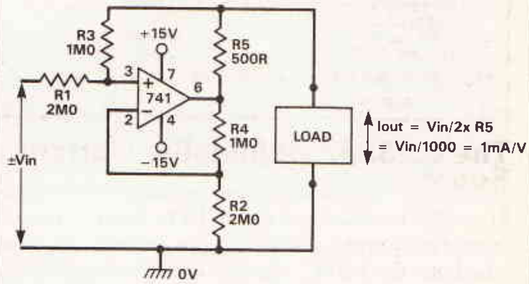


Fig. 14. Bilateral CCG with grounded load.

The above bilateral circuit is useful in applications where the load is fully floating. If the load is not floating but has one end tied to ground the alternative circuit of Figure 14 can be used as a bilateral CCG. Here, when R1 to R4 have the values shown the circuit feedback causes the output load current to be determined entirely by the values of R5 and V_{IN}, irrespective of the value of load impedance. With the R5 value shown the load current equals 1mA/V. Note

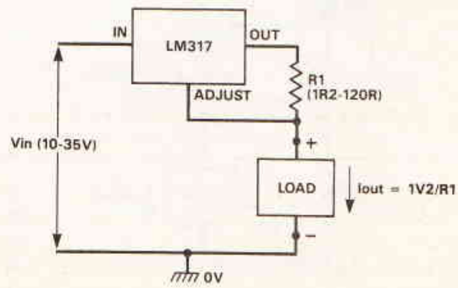
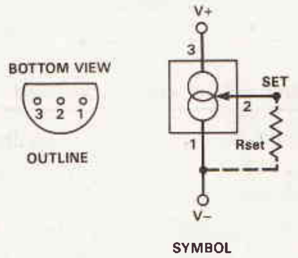


Fig. 15. Precision high-value (10mA to 1 Amp) CCG.

that the circuit's output voltage is directly proportional to the load impedance, and the circuit can thus readily be adapted for use as an impedance-measuring piece of test gear.

A High-current Generator

Most practical CCG circuits are designed to give fairly low outputs currents (usually only a few mA). There are occasions, however (such as when charging Ni-Cads), when fairly large output currents are needed, and one easy way to obtain these is to use an LM317 3-terminal voltage regulator IC in the configuration shown in Figure 15. The basic action of this IC is such that its OUT terminal automatically adjusts to a value 1.2V greater than that set on the ADJUST pin. In the diagram the IC's output current flows to ground via 'sensor' resistor R1, which has its low end taken to the ADJUST pin. Consequently, the output current automatically self-adjusts to a value of 1.2V/R1, almost irrespective of the load impedance, and the circuit thus acts as a constant current generator. When R1 has a value of 1R2 the circuit acts as a 1 amp generator, and when it has a value of 120R it acts as a 10mA generator. The circuit can be used with any input (supply) voltage in the range 19 — 35V.



BASIC SPECIFICATION

OPERATING VOLTAGE RANGE	= +1-30V
OPERATING CURRENT RANGE	= 1uA-10mA
CURRENT REGULATION ACCURACY	= 0.02%/V (TYPICAL)
CURRENT SENSITIVITY	= 0.68V/Rset
TEMP COEFFICIENT	= +0.33%/°C
Rset VALUE (AT 25°C)	= 68,000/I(uA)

Fig. 16. Basic details of the LM334Z adjustable current source.

The LM334Z Adjustable Current Source

The LM334Z IC is a high-performance 2-terminal constant-current generator that can be used with supplies in the 1-30V range and can have its operating current set to any value between 1A and 10 mA via a single external resistor (R_{SET}). Figure 16 shows basic details of the device, which is housed in a 3-pin package.

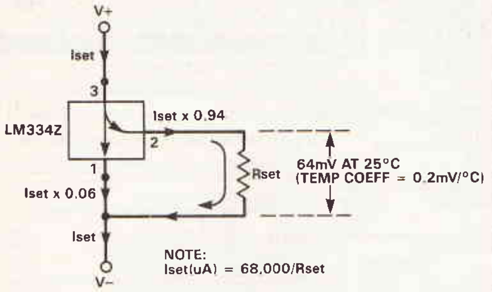


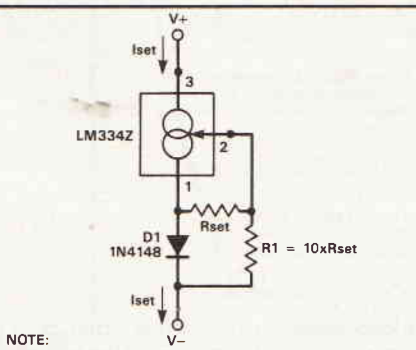
Fig. 17. Practical representation of the LM334Z, showing its current distribution.

Note that the LM334Z symbol of Figure 16 may give a deceptive impression of the device's operation; a more accurate representation of the device action is shown in Figure 17, where the following points should be noted. The I_{SET} current flowing into the LM334Z via pin 3 splits within the device, with only 6% of it flowing to the negative rail via pin 1, and with the other 94% flowing to the negative rail via pin 2 and R_{SET}: at 25°C a voltage of 64mV is developed across R_{SET} (between pins 2 and 1), and this voltage has a temperature coefficient of +0,2mV/°C. Thus, I_{SET} is temperature-sensitive, and at 25°C has a value (in μA) of 68,000/R_{SET}.

Figure 18 shows the basic way of using the LM334Z as a 2-terminal current source, and Figure 19 shows how the circuit can be modified, with the aid of R1 and D1 (which must share the thermal environment of the LM334Z), to eliminate the temperature sensitivity of the current source.

The operating current of the LM3334Z is inherently temperature sensitive, and is given by the formula:

$$I_{SET} = (227\mu V \times {}^{\circ}K)/R_{SET}.$$



NOTE:

SELECT R1/Rset RATIO (NOMINALLY 10:1) FOR ZERO DRIFT

Iset(uA) = 136,000/Rset

e.g. FOR 1mA OPERATION, Rset = 136R, R1 = 1k36

Fig. 19. Zero temperature coefficient current source.

Consequently, although the IC is not specifically designed for this purpose, the LM334Z can be used as a fairly accurate °K temperature-to-voltage converter. Figure 20 shows a version of such a circuit with an output sensitivity of 10mV/°K. Here, R_{SET} is chosen to give an I_{SET} current of (ideally) 293μA at 20°C (= 2.93°K), so that an output of 2.93 volts is generated under this condition. In practice, the basic circuit (when using 1% resistors) may give an initial error as high as 5% (= 150mV), which translates into a reading error of 15°C; if such an error is important, it can be eliminated by trimming the value of R_{SET} to give an output of precisely 2.93V at 20°C.

The Current Mirror

Before closing this look at constant current generator circuits, mention must be made of one of the most important elements used in modern linear IC design, the so-called 'current mirror', which takes the basic form shown in Figure 21. Here, Q1 and Q2 are a matched pair of transistors (usually integrated) and share a common thermal environment. When an input current (I_{IN}) is fed into diode-connected Q1, it makes Q1 generate a proportionate forward base-emitter junction of Q2 and, since the transistors are closely matched, causes it to sink an almost identical ('mirror') value of collector current (I_{SINK}). Q2 thus acts as a constant current source that is controlled via I_{IN}, but has the outstanding advantage of acting as such even at collector voltages of only a few hundrred millivolts.

In practice the I_{SINK} current is (when perfectly matched transistors are used) always 1% to 2% less than I_{IN}, since some of I_{IN} is absorbed as base-drive current. Note that the circuit will still work quite well as a current-controlled constant current generator even if Q1 and Q2 have badly matched characteristics, but in this case may not act as a true current mirror, since its I_{SINK} and I_{IN} values may be very different.

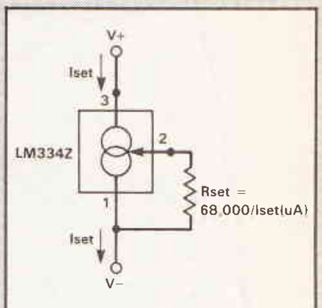


Fig. 18. Basic 2-terminal current source.

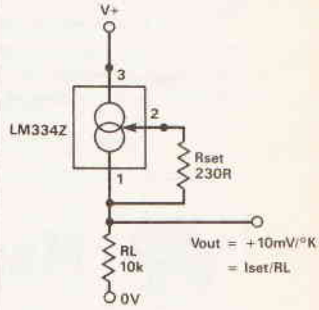


Fig. 20. Degrees Kelvin temperature-to-voltage converter.

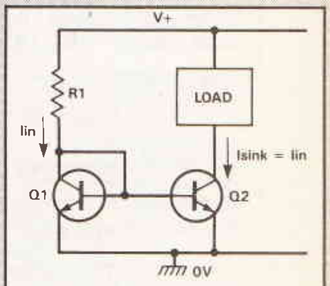


Fig. 21. Basic Current Mirror Circuit

Thyristor Tester

A large number of modern components, such as resistors, capacitors, rectifier diodes, may often be conveniently checked for operation using a conventional multimeter set to its ohm range. When it comes to testing three terminal devices things become a bit more complicated and dedicated test equipment, such as transistor testers are often employed. The thyristor, in common with the transistor, is a three terminal device and as such requires more than a simple test on the ohms range of a multimeter in order to evaluate its capacity to in fulfil particular application.

The Thyristor Tester described in this article is designed to test thyristors for the correct operation and also to indicate the gate current and gate voltage requirements for the device to reliable trigger. It is capable of testing a wide range of these devices, from small T092 encapsulated units to large stud mounting types capable of handling load currents of several hundred amperes!

The Thyristor

The thyristor may be considered as a development of the transistor in which a second emitter layer is added on the collector side. One effect of this is that the device is able to sustain alternative stable states, on and off. It also enables the device to operate in a triggering mode, whereby a small gate current may control the switching of the much larger load current. An indirect effect of the addition of this fourth layer is to enable the device to withstand high reverse voltages (In some devices an excess of 1KV!) and hence function as a rectifier.

With reference to Figure 1 it will be seen that the device has three terminals labled here as A(anode) C(cathode) and G(gate). If the gate is made sufficiently positive with respect to the cathode a current will flow into the gate and trigger the device into conduction, enabling the load current to flow between the anode and the cathode. Once a sufficiently large anode current is established the gate may be disconnected and, providing that the anode current remains sufficiently high, the device will remain conducting indefinitely.

It may be concluded from the above that some form of variable power supply and current/voltage measurement circuit is required for testing thyristors. The unit, which is the subject of this article provides these functions automaticaly.

Circuit Description

The full circuit diagram for the thyristor tester is provided in Figure 2. Power for the thyristor tester is provided by a PP3 9V battery, B1 via switch SW3, a push to make-release to break switch. Capacitor C2 is a supply decoupling capacitor and is included to prevent the possibility of any voltage spikes reaching

PROJECT

Another invaluable test item for the workbench by Mark Daniels.

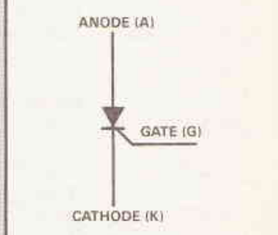


Fig.1 Symbol for thyristor

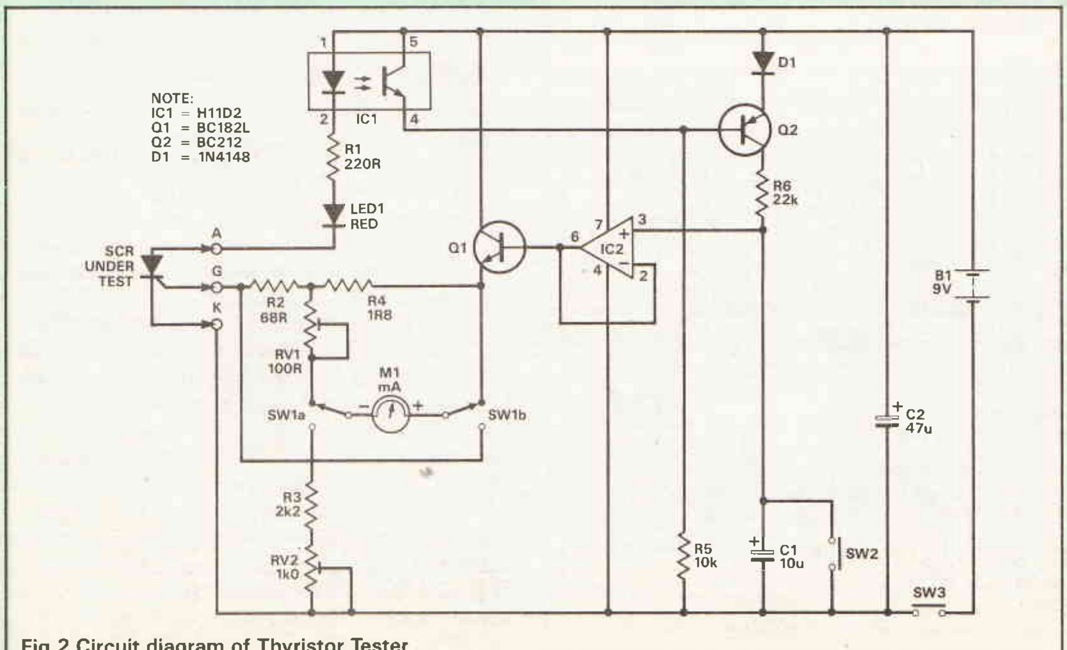


Fig.2 Circuit diagram of Thyristor Tester

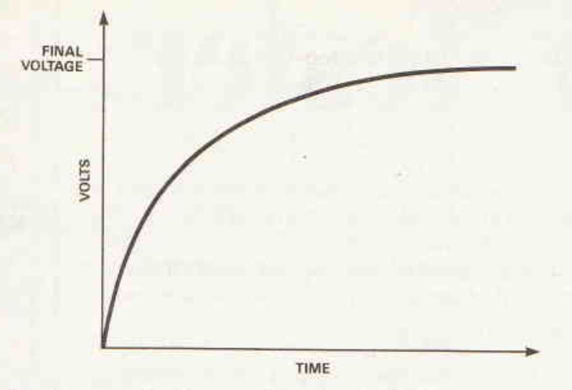


Fig.3 Graph of voltage against time for R-C Network

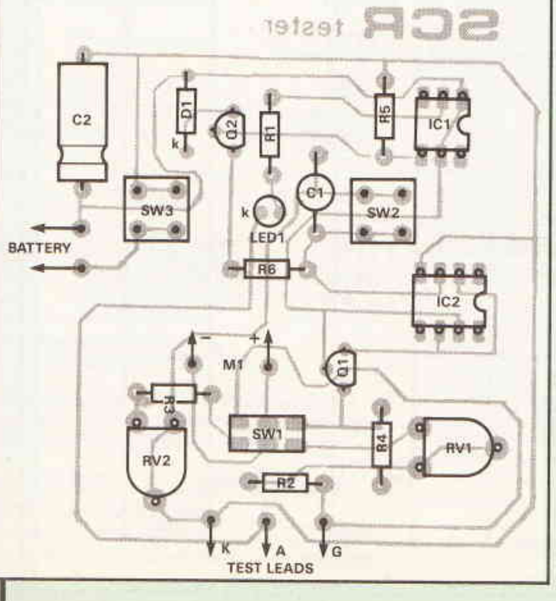
ICl, which could affect this device and cause incorrect readings on the meter, ME1.

When a thyristor is first connected to the tester and switch SW3 is closed, transistor Q2, a PNP device, is forced to conduct by the negative voltage on its base, provided by resistor R5. A small current flows through diode D2, the emitter and collector of Q2 and resistor R6 to charge capacitor C1. The voltage across C1 is initialy zero, but as it charges the voltage across this capacitor rises exponentialy, as shown in the graph of Figure 3.

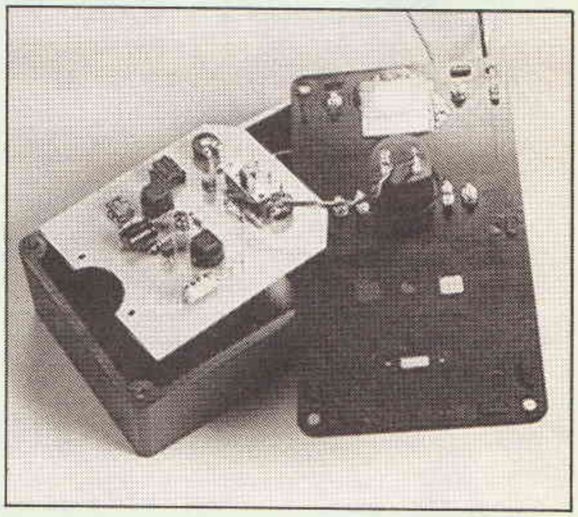
The operational amplifier IC2 is connected as a super emitter follower in this application. This provides unity voltage gain but phenomenal current gain. The CA3140E specified for IC2 is slightly unusual in having a CMOS input stage and a bi-polar output stage. This provides it with the extremely predictable performance required in a piece of test equipment, by virtue of its extremely high input impendance (about 1M4) and a very low output impedance (negligable in this application). The output from IC2 is buffered by transistor Q1 which is connected as an emitter follower stage to provide the relatively heavy gate currents required by some thyristors under test.

Ignoring the meter circuitry for the present, Q1 emitter provides gate current to the thyristor via resistors R2 and R4. R2 is included to limit this current to a safe maximum under fault conditions. As capacitor C1 charges the voltage on the thyristor gate will rise, as will

Fig.4 Component Overlay for Thyristor tester.



the gate current, until a point is reached where the thyristor is conducting between its anode and cathode. A current may now flow through the device from the battery via LED1, resistor R1 and the led across pins 1 and of the opto-isolator ICl. LED1 will light up showing the operator that the thyristor has started to conduct, while the light from the LED in the opto-isolator falls onto the base of the photo-transistor which now conducts. The emitter of this NPN transistor is connected to the base of Q2 and causes Q2 base voltage to fall towards the positive supply rail, switching the transistor off. Diode D2 is included in Q2 emitter circuit to ensure that Q2 base can be made sufiiciently positive to guarantee effective turn off of the device. When Q2 is turned off capacitor C1 stops charging and the input voltage to the operational amplifier IC1



remains fixed at the voltage of C1 positive plate, and hence the thyristor gate current and voltage are stabilised.

The meter ME1, with switch SW1 in the position shown in Figure 2 will read thyristor gate current. Resistor R4 is a current shunt for the meter to enable it to read up to 60mA. Preset RV1 adjusts the current range of the meter. Resistor R3 and preset RV2 set the voltage range of ME1 to 3V, when SW1 is changed over to volts range.

Switch SW2 is included so that capacitor may be discharged completely prior to testing the thyristor. It may also be used to remove the gate signal to the thyristor while it is under test to check that the device remains conducting.

Construction

The majority of the components are mounted on a single sided glass fibre PCB, the foil pattern and component overlay are shown in Figure 4.

The following order of assembly is recomended: fit all resistors, the socket for IC2, then the two presets followed by the capacitors and two push switches. If the recomended switches are used it will be seen that they have a flat on one side. The switches should be mounted with the flat side towards the LED. Switch SW1 may need the holes in the PCB. opening into slots before it will fit. It is suggested that double sided terminal pins be used for all external connections to the PCB as some wires need connecting to the underside of the board. The two transistors need to be fitted close to the board in order to clear the case lid. The LED is also fitted close to the board, but should be slightly higher than the transistors in order to protrude slightly through a suitable hole in the case lid. IC1 is soldered directly to the board without the use of a socket. The two meter leads are connected via the top side of the PCB. The rest of the leads are

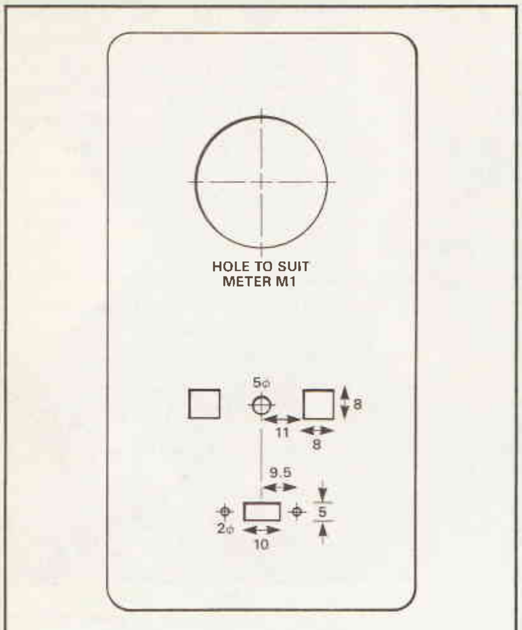


Fig.5 Positioning of holes in case lid

connected to the underside. The op-amp IC2 should be handled with great care while inserting it into its socket: since its CMOS inputs are unprotected and very susceptable to damage from static electricity. All its pins should be kept shorted together until it is inserted into its socket.

The holes should be made in the case lid as in Figure 5 for the three switches and LED. A hole must also be made to suit any meter used for ME1. This is not shown in the figure as it will very much depend on the meter used. Two holes should be drilled and countersunk to accept M3 x 20mm screws such that the meter will cover the screw heads when fitted. Spaces may then be fitted to these screws to support the top end of the PCB. When it is finaly installed the bottom end is held in position by SW1 mounting screws. The test leads are passed through suitable holes in the base of the case before the test clips are fitted. The battery should be fixed securely in place by some means, such that it cannot move around and cause damage to the PCB or wiring. Figure 6 shows a suitable case layout and front panel for the thyristor tester.

Setting Up And Testing

Connect a PP3 battery to the battery clip and set the meter switch to volts. Press the test button and check that the meter deflects beyond the end of the scale. The LED should not light. Now connect the anode and the cathode test leads together and again press the test button, checking that the LED illuminates this time. If it does not, check that it is connected with the correct polarity. Next switch to milliamps and with the cathode and gate leads shorted together, press the test button. The meter should once again show deflection greater than full scale, but the LED will not illuminate at all this time.

If all the above tests can be performed satisfactorily by the thyristor tester, the unit may now be calibrated and used to test a thyristor.

Select a thyristor which requires a gate current of 10mA or more using Table 1 or other data as available and connect it correctly to the test leads, refering to Figure 7 if necessary for layout details. Connect a multimeter, set to a low DC voltage range, across the cathode and gate connections (negative to cathode, positive to gate.) and press the test button, with the gate switch set to volts. Adjust preset RV2 such that ME1 reads the same voltage as the multimeter.

Disconnect the multimeter and insert it between the gate lead and the thyristor gate to measure the gate current. Switch the gate switch to 'mA' and the multimeter to a suitable milliamp range for the thyristor under test. Press the reset button before testing. Preset RV1 should be adjusted to obtain a reading on the milliamp scale of ME1 which matches the current measured by the multimeter. The gate current measured will not necessarily be as high as that shown in Figure 1, since this figure is the minimum current guaranteed by the manufacturer to trigger all devices of that type number and most will trigger at much lower currents.

New scales may be applied to the meter, if required, by removing the front glass and using rub down lettering to mark the new numbers on. Typists correction fluid may be used if necessary to cover the original markings.

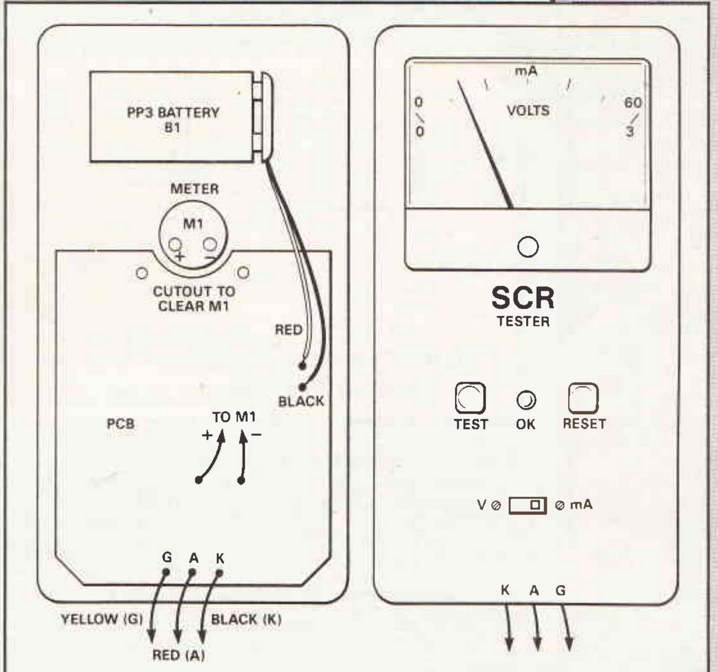


Fig.6 Front panel and Internal layout

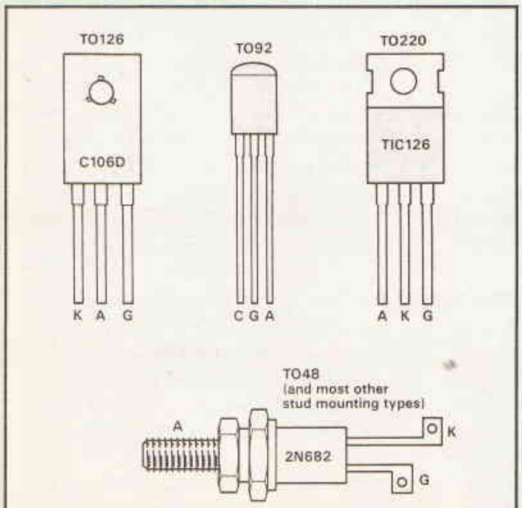
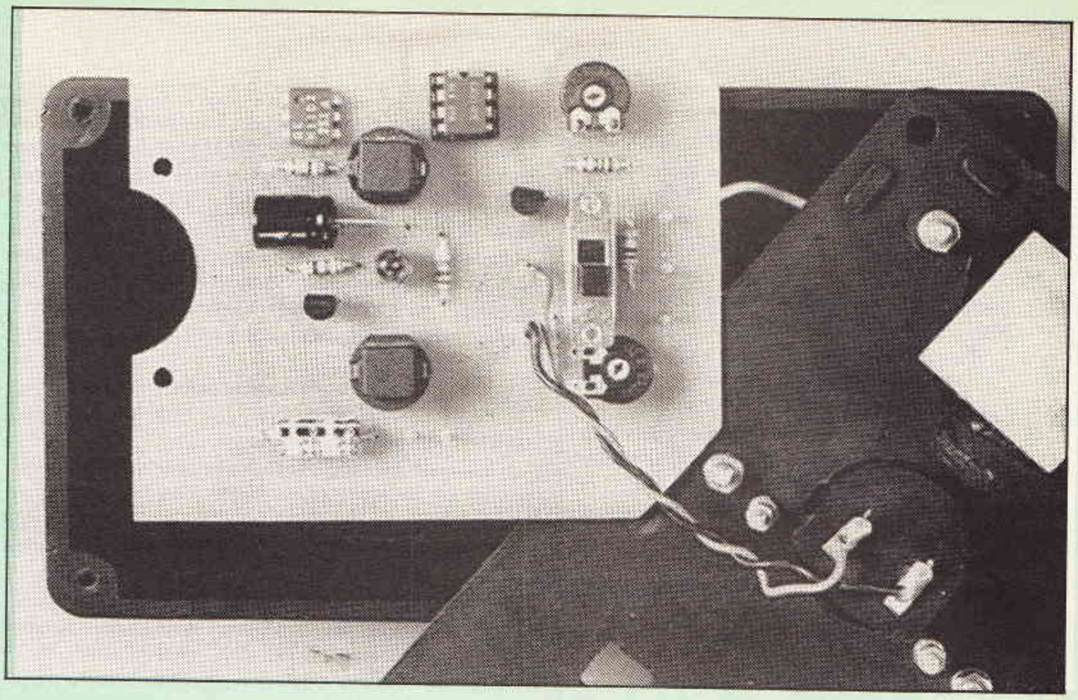


Fig.7 Package outlines

In Use

The unit should now be fully functional and tested. Its primary design function is testing thyristors, which



may be tested as follows,

Connect the three test leads correctly to the thyristor which has to be tested and press the reset button to discharge the ramp capacitor C1. Press the test button and check that the LED lights. If it does not make sure that the thyristor is correctly connected (thyristors requiring a large gate current may require a moment for C1 to charge before the LED lights). Set the gate switch to volts and read the gate voltage off the meter volt scale whilst holding the test button depressed. The gate current may be checked in a similar manner with the gate switch set to milliamps. In this case with a very sensitive thyristor with a gate current of less than about 0.5 mA the meter may not register.

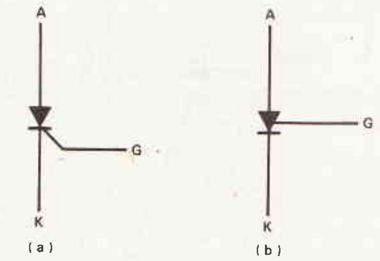


Fig.8 a) Cathode fired resistor
b) anode fired resistor

SPECIFICATIONS	
Max gate voltage	3V
Max gate current	60mA
Max anode current under test	20mA

DEVICE CODE	VGATE (V)	IGATE (mA)	VMAX (V)	IMAX (A)	In (mA)
2N5062	1.2	0.35	100	0.8	5.0
C106D	1.0	0.5	400	2.5	1.7
T1C116D	1.5	20.0	400	8.0	----
T1C126D	1.5	20.0	400	12.0	40.0
2N682	0.75	2.0	75	25.0	15.0
C35D	3.0	40.0	400	35.0	40.0
S8613D	1.5	35.0	400	75.0	----
T70012 3503	1.1	50.0	1200	350.0	250.0

A final test may be made on the latching action of a thyristor by depressing the reset button while holding down the test button. This immediatly disconnects the gate of the device, which should remain conducting. Some large devices may appear to fail this test since the anode current provided by the thyristor tester will not be sufficient to latch them even though they may be perfectly sound. See column in table 1. It should be noted that this unit will only test the more common 'cathode fired' thyristors and it is therfore not useable with the rarer 'anode fired' types, usual denoted by the symbol shown in Figure 8b.

Triacs may be part tested with the thyristor tester by connecting the two main terminals to the cathode and anode leads of the tester, and the gate leads to the devices gate. The device will only give a result with its main terminal connected one way around and not the other, so cannot be fully tested.

PARTS LIST

RESISTORS (all ¼W 5%)

R1	220
R2	68
R3	2k2
R4	1R8
R5	10k
R6	22k
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RV2	1k sub-min horizontal preset

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C1	10μ 35V axial electrolytic
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IC1	H11D2
D1	5mm Red led
D2	1N4148

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High Definition Television

MITVV-RC

James Archer continues his look at the American alternatives for better TV pictures.

This is a more conventional ATV system, which operates in a single 6MHz channel, and which provides improved picture quality for viewers with ATV receivers, whilst enabling viewers with NTSC receivers to obtain relatively normal quality pictures, except for the appearance of a black bar at the top and bottom of the picture when displaying picture signals transmitted from an ATV source.

No video information is carried on the top and bottom 12.5% of the picture, which means that the remaining 75% of the normal 480 active lines are displayed in the form of a picture with a 16:9 aspect ratio. The extended vertical blanking interval, seen as black bars that appear above and below the picture on a standard NTSC receiver, is used to carry luminance enhancement information which can be used to improve the quality of the picture available to the viewer with an ATV receiver. The transmitted luminance resolution is 3MHz over the NTSC area of the picture and 4.2MHz over the enhancement area. Extra chrominance resolution on static portions of the picture is obtained by reducing the chrominance frame rate to half of the normal, (15 fps), at the expense of some reduction in resolution during moving parts of the picture. The transmitted chrominance bandwidth is 0.6MHz, whereas the displayed bandwidth on an ATV receiver is 1.2MHz.

The system described is one of the simplest methods of providing ATV in a compatible manner. On transmission the signal behaves just like NTSC, and it is compatible with all NTSC receivers and video recorders, and can be recorded and played back as usual.

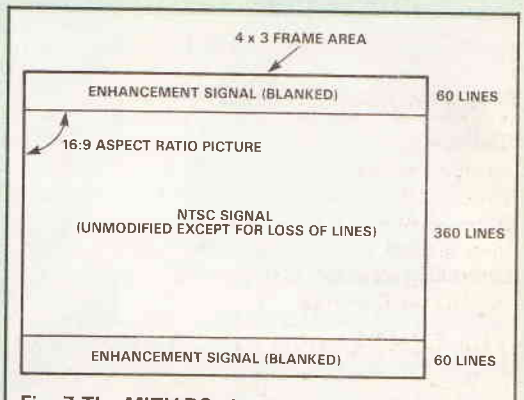


Fig. 7 The MITV-RC picture as seen by an NTSC receiver

The MITV-CC system is in essence simple, in that it makes use of the space freed by reducing the picture height, which provides a great deal of capacity for future improvements.

The MITV-CC system was designed on the assumption that viewers would eventually use 'smart' television receivers, sometimes called 'open architecture' receivers, which allow for a great deal of flexibility and programmability; in essence they can be adapted by using different software to cope with a wide range of ATV systems, and any evolutionary changes which may come about.

One scenario for the introduction of the MITV systems that is being considered is for the receiver-compatible MITV-RC to be introduced first; this would allow viewers with NTSC receivers to continue to use their existing receivers, but manufacturers hope

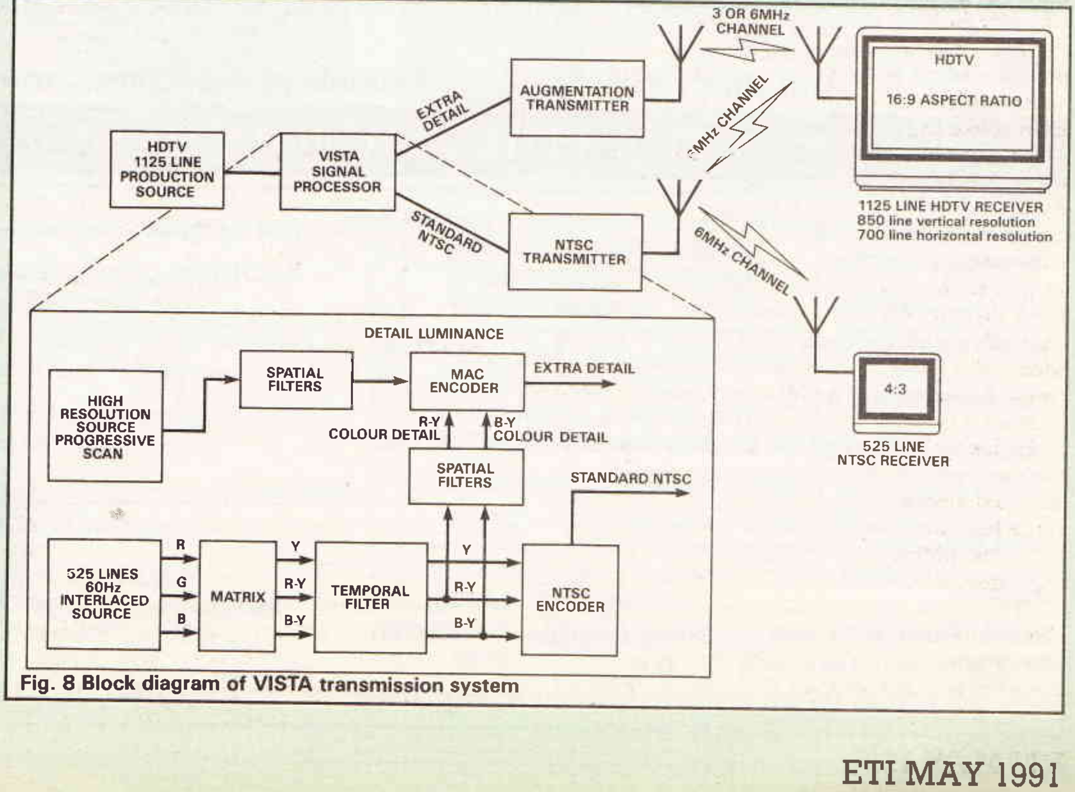


Fig. 8 Block diagram of VISTA transmission system

HDTV

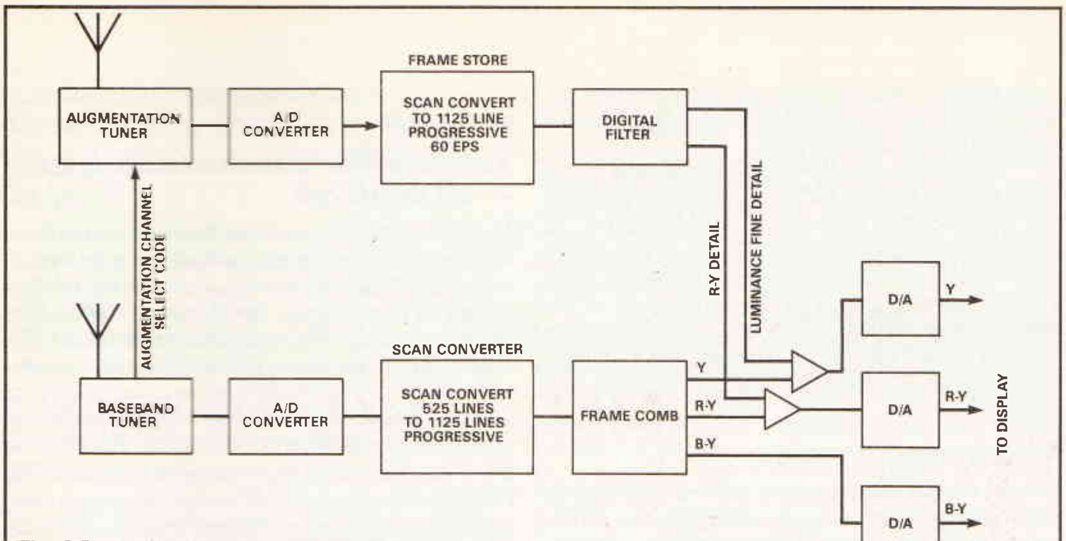


Fig. 9 Block diagram of a VISTA receiver

that many people would then be persuaded to buy an open architecture receiver to provide the wide-screen EDTV quality pictures that MITV-RC makes possible. At a later stage these same receivers could then be used, perhaps with some modification to the controlling software, to display HDTV pictures from the MITV-CC signals.

The VISTA system

Dr William Glen of The New York Institute of Technology NYIT has proposed and demonstrated in the laboratory a system known as VISTA, an acronym obtained from VIsual System Transmission Algorithm. VISTA is a two-channel system, where the first channel carries an NTSC signal and the second channel an augmentation signal. Some of the techniques used are common to other schemes that we have discussed, and it is understood that other systems actually make use of NYIT patents.

VISTA separates the information in the source pictures into components, one set having low spatial resolution and high temporal resolution, corresponding to a standard NTSC signal, and the other having components with high spatial resolution and low temporal resolution, these forming the augmentation signal.

The input signal of the VISTA system is from an 1125 line 16:9 aspect ratio progressively scanned source, chosen because there is already an 1125/525 convertor available from Japan, and the basic NTSC signal for the VISTA system is therefore obtained from the 1125/525 conversion equipment, but very much improved by the application of temporal filtering at the source and corresponding comb filters in the receiver; cross-colour and cross-luminance are much reduced. The information to be transmitted over the augmentation channel consists of the high frequency luminance detail from the source picture and the colour detail, in the form of the higher frequency R-Y information, but this information is sent less frequently i.e. at lower frame rates than the basic picture information. As both 3MHz and 6MHz wide augmentation channels are allowed by the FCC rules, alternative specifications have been provided for the two different cases. Assuming that a 6MHz wide augmentation channel is available, the channel carries information at 15 frames per second, with a maximum video bandwidth of 5.3MHz, and this is carried on a single-sideband suppressed carrier system. Tests have been carried out to confirm that this information can fit into a standard 6MHz wide NTSC channel without causing undue interference, and it has been found that the VISTA augmentation signal produces less adjacent channel interference than NTSC, and can tolerate more interference. If only a 3MHz channel were to be available, perhaps because of problems with 'taboo' channels, then their augmentation information would be sent at the reduced rate of 7.5 frames per second, with a maximum video bandwidth of 2.7MHz, and code 19 signals in the vertical blanking interval would indicate to the receiver which type of augmentation signal was being used.

Since suppressed carrier modulation is used for the augmentation channel there is no main carrier, no colour subcarrier, and no sound carrier, and its power can be much less than that of the main signal carrier.

When receiving a main signal and an augmentation signal care has to be taken to see that the two signals are received at the same time, or else path length variations due to reflections, perhaps from moving aircraft, could cause problems. The augmentation signal therefore has a 3.58MHz burst at the end of each line to phase lock the augmentation signal so that it can be accurately loaded into the frame store

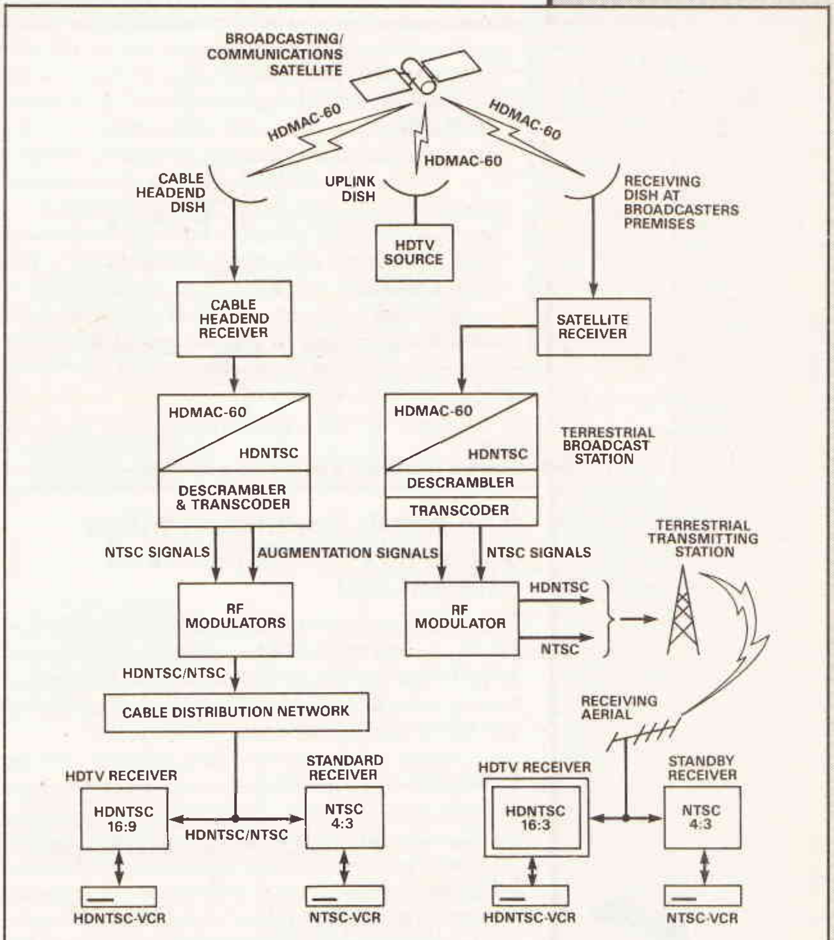


Fig. 10 Overall concept of N.A. Philips HDMAC-60 / HDNTSC system

in the receiver. One line of the vertical blanking interval is also used to carry low level digital code signals which identify the individual frames.

Whenever a two channel system is used, some method must be found of telling the receiver where the augmentation information is to be found. To ensure that the receiver always tunes to the correct augmentation channel a digital code is inserted in the vertical blanking period of the NTSC part of the transmission, and this code is used to automatically tune the second tuner in the receiver to the augmentation channel. Figure 9 shows a block diagram of a VISTA receiver.

Wider aspect ratio

In order to obtain pictures with a 16:9 aspect ratio, only 443 of the 448 active lines available in the NTSC system are used in the HDTV receiver; the horizontal blanking interval of the NTSC signal is also reduced by 4µs to help to increase the aspect ratio further. In the receiver the 443 active lines are scan converted to produce 1024 active lines (1125 lines total) for display. The NTSC viewer would see the full 4:3 image, whereas the VISTA viewer would see a vertically cropped image.

The VISTA system can provide an evolutionary path to HDTV which provides existing viewers with NTSC receivers with excellent pictures. VISTA signals are suitable for distribution over cable systems, and could be carried over satellites if two channels were made available.

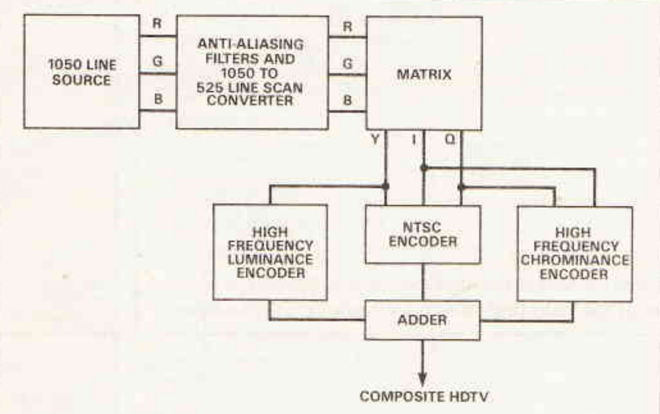


Fig. 11 Block diagram of the BELL HDTV encoding system

The North American Philips proposals – HDNTSC and HDMAC-60

The North American Philips company (NAP) has taken a comprehensive approach to the introduction of HDTV to the United States, and has put forward what is called a 'hierarchical ATV emission system with full NTSC compatibility and HDTV quality'.

This is effectively a system concept offering several options, but essentially containing two related formats for ATV systems, one particularly suited to satellite transmission, the other intended for terrestrial and cable transmission. The signal to be used for satellite transmissions is a widescreen multiplexed analogue components (MAC) signal, whereas the terrestrial version, which can simply be derived from the satellite version, is a two channel system. One of the two channels carries a standard NTSC picture whilst the second channel carries augmentation information which includes side panel information for wide aspect ratio operation, higher resolution detail information about the pictures, and digital audio. One idea put forward by NAP is that the MAC signal could be distributed via satellite, and that these signals could be converted to the terrestrial signal format for distribution by cable or for onward transmission by broadcasters.

The satellite transmission system – HDMAC-60

The basic pictures required by the NAP system are in 525 line, 59.94 frame rate, progressive scan format, with a 16:9 aspect ratio and an active line time of 26µs but, as we have seen previously, these could be derived from an 1125/59.94 studio source if desired. The choice of a 59.94 frame rate simplifies later conversion to NTSC. HDMAC-60 has been carefully designed to provide a balance between spatial and temporal components of the picture signals that matches the characteristics of the human visual system. The HDMAC-60 system uses different compression ratios on different lines, so that different lines are effectively transmitted with different bandwidths. This technique allows high spatial and temporal resolutions to be achieved in vertical and horizontal directions, with low temporal resolution in diagonal directions, a situation that the human visual system is quite content with. Alternate lines are sent as line 22 difference signals at a lower resolution, using a 2:1 time compression ratio; these transmit the vertical/temporal high frequency detail of the luminance component of the signal. One out of every two of the remaining lines, i.e. one line of every four of the picture, is expanded in time by a factor of 16/9 so that it can carry a full resolution signal. The other one of the two remaining lines, again one line in four of the picture, is neither compressed nor expanded, and carries information with medium resolution. The B-Y and R-Y colour difference signals are transmitted on alternate lines, with each signal alternating between 2:1 compression and 4:1 compression. The total bandwidth of the baseband signal, which includes four digital audio channels, is 9.5 MHz, and is suitable for direct transmission over satellite channels.

The terrestrial system – HDNTSC

The HDNTSC system has been designed to carry the same information that is carried in the HDMAC-60 system, whilst remaining fully compatible with NTSC. It provides a standard NTSC signal using a 6MHz channel, whilst the augmentation information needed to provide the extra information for HDTV is carried in a separate radio frequency channel. Although the aim of NAP is to squeeze the augmentation signals into a 3MHz wide channel, at the present time at least 4.6MHz is required. HDNTSC is based upon a 525/59.94/16:9 continuously scanned source, identical to that used for HDMAC-60, and the system has been arranged so that transcoding from HDMAC-60 to HDNTSC can be carried out simply and without introducing any undesirable artifacts, so that it would be practicable for terrestrial HDNTSC transmitters to use HDMAC60 signals from satellites as the source of their programmes.

The information in the baseband HDNTSC signal is separated into two signals, the NTSC signal package, a conventional 525/59.94/2:¼:3 NTSC signal, and the augmentation signal package (ASP). The NTSC signal to be carried on the first channel is obtained by taking a portion appropriate to a 4:3 aspect ratio of every alternate line of the progressively scanned picture.The portion of the original 16:9 aspect ratio picture which is used to provide a 4:3 aspect ratio picture for the NTSC signal is variable, so that the director of the programme can arrange for the picture to be panned and scanned to provide the most appropriate 4:3 picture. The remaining parts of the 5:3 picture will be in the form of side panels, not necessarily of equal size, and the information representing these is carried in the augmentation channel. The augmentation channel is thus used to carry the higher resolution horizontal and vertical detail of the image.

Options

The North American Philips company stresses that the basic ideas used in their system could be modified in various ways to provide the 'optimum' NTSC compatible HDTV system, and the company has suggested a number of different options, including the possibility of utilising a digital augmentation signal.

The Bell Laboratories Proposal – The SLSC (Split Luminance/Split Chrominance) system

Bell Laboratories have proposed an HDTV system which requires two 6MHz channels to provide an NTSC compatible system. Figure 11 shows how it works.

The source is a high definition 1050 line picture, which is vertically filtered and then scan converted to provide a 525 line signal which has the same horizontal resolution as a normal NTSC picture. The first radio frequency channel carries this picture signal, which provides standard pictures on standard NTSC receivers. The remainder of the original 1050 line HDTV picture, the higher frequency parts of the luminance and the colour difference signals, are separately encoded and transmitted over the second radio frequency channel. This system is sometimes called the Split Luminance/Split chrominance (SLSC) system, since both luminance and chrominance signals are separated into low and high frequency areas. Figure 12 shows the baseband radio frequency spectrum arrangements used in the Bell system, and although it indicates that adjacent channels are used for the two signals there could be benefits in using quite separate channels.

An HDTV receiver would make use of both the NTSC information coming from the first channel and the augmentation information coming from the second channel. Using the same type of techniques we have seen for other systems, frame stores in the HDTV receiver would be able to provide a 1050 line HDTV picture. Bell claim that the horizontal resolution of their HDTV pictures will be twice that of NTSC, and that there is sufficient capacity available in the second radio frequency channel to carry digital sound as well as augmentation information. Wide aspect ratio pictures could be obtained by using one of the methods utilised by other systems, such as carrying side panel information in the augmentation channel by using suppressed carrier amplitude modulation, but no firm proposal had been made at the time of writing.

HDB-MAC – The Scientific Atlanta HDTV proposal

Scientific Atlanta have demonstrated a working widescreen HDTV system based on their B-MAC transmission system. This allows for the transmission of widescreen HDTV pictures with up to six high quality audio channels as well as teletext and computer data, and the first major public demonstration in December 1989 showed pictures from a world boxing championship on nine-foot high HDTV projection screens. The source signal can be a 1050 line interlaced-scan HDTV picture or a 525 line progressively scanned picture, but the former must be converted to the latter before the actual signal processing takes place. HDB-MAC is backwards compatible with B-MAC, so that broadcasters using B-MAC could eventually upgrade to HDB-MAC. Although a description of the HDB-MAC system is included in this section about the American approach to HDTV, this is more for the sake of completeness than because of a belief that it will be chosen. HDB-MAC is not generally considered to be a contender for the American ATV crown, because of its basic incompatibility with NTSC receivers; only by using a set-top HDB-MAC/NTSC convertor could an NTSC receiver make use of the signals. The basic principles behind the encoding process are shown in Figure 13.

The 525-line picture with 750 samples per line is diagonally filtered, and the resulting signal is then quincunxially sampled, using a similar method to that used by the European HD-MAC system, and this means that we are effectively discarding every alternate sample. The resulting samples from each of the even lines are then moved upwards in the picture to the line above, so that samples from alternate lines are placed side by side, and alternate lines contain no samples at all. The lines without samples are of no use and may therefore be discarded, which effectively produces a 525 line interlaced picture, which can be transmitted via a standard satellite channel.

A standard B-MAC receiver would then display the received signal as a normal 525 line interlaced picture, but an HDB-MAC receiver containing a number of line stores could rebuild a progressive scan picture by looking at the incoming samples and processing them so that missing samples could be interpolated from the surrounding samples, and hence the missing lines could be synthesised.

In next months article we shall look at our fourth batch of ATV proposals, and try to reach some conclusions as to which systems have a realistic chance of coming to fruition, and which are likely to remain pie in the sky.

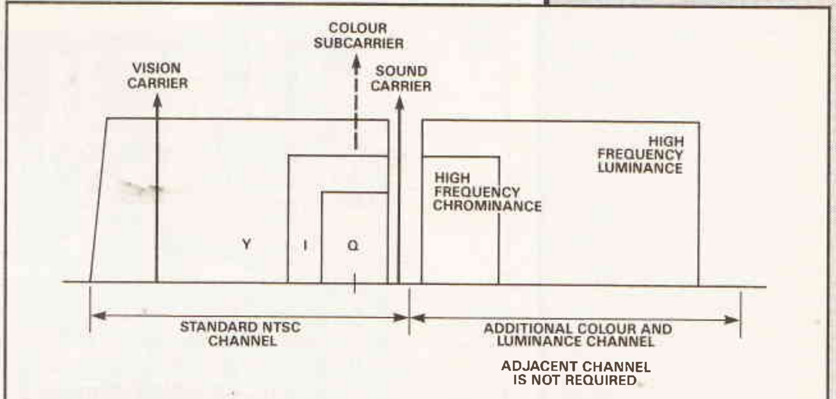


Fig. 12 The spectrum utilisation of the Bell Laboratories HDTV system

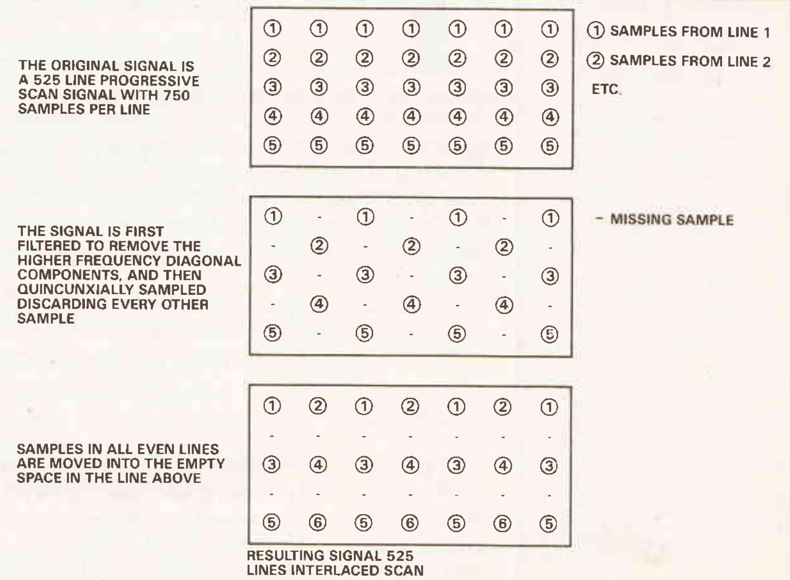


Fig. 13 HDB-MAC coding arrangements

Remote Controlled Timeswitch

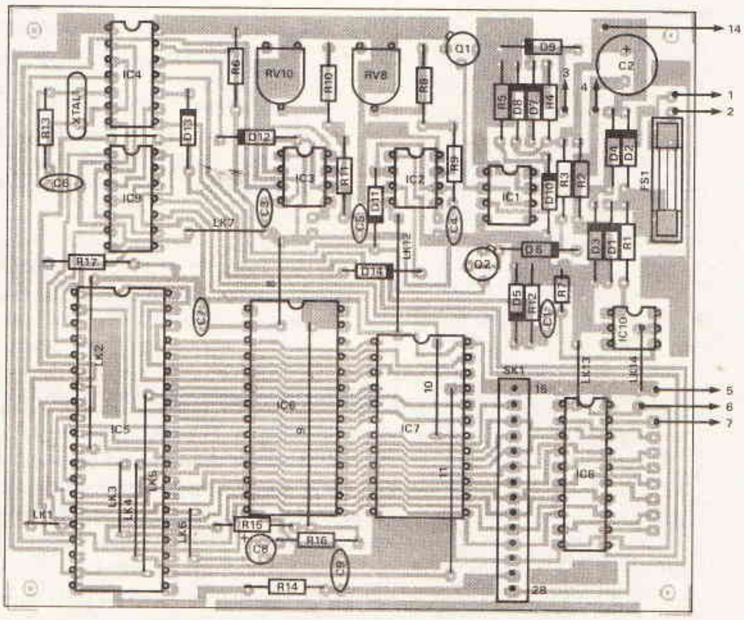


Fig. 13 Update of Main Control Board.

A Constructors View by Jon Herd

Tackling such a large project can be fun if you know what you are doing and the Remote Controlled Timeswitch by Kevin Browne in ETI Dec, Jan, Feb 91 is no exception. Getting a project of this magnitude going is best tackled by testing out the smaller sections with a 'scope as you go. However,a number of problems arose through designer and typographical error and indeed is a problem when a prototype goes through so many hands in getting the information to you the reader. These have been ammended and so far things are functioning as they should.

I have set out in table form the adjustments I had to make to the Main Control Unit

Dec 90 Page 29 Fig.4	
R12 27k Fix a 10k preset Symptom — Clock too fast — Cannot Adjust to zero	This value may not work. I had a lot of trouble trying to adjust to zero. In my circuit with this value the duration of 50Hz pulse was 195μs. This is seen by the CPU as at least 3 times the interrupt pulse and the symptom is the clock runs at 3 times the speed! Eventually, I used a 10k preset in place of R12 and using a 'scope, I adjusted it until a 50Hz pulse of 70μs duration was received. This is about the best value and gives reliable clock timings. The resistance value of the pre-set was 9.72k for 70us.
IC1/Q1 Fix-replace with 7805 +5V Regulator Symptom — No key entry possible	This regulator set-up in my opinion is not very satisfactory. On my project the symptom was that none of the keys would accept an input. Scoping the voltage rail, it was sitting at 5.23V and had a lot of harminics on it. I replaced with a 7805 regulator and it works OK. To install this, remove IC1 and Q1 Solder regulator into Q1 position and add a link from what was Q1 to the IC2 pin 4 rail.
Opto-isolator	No type or value given in text. I used the cheapest one from Maplin and it worked fine.
Figure 5 Page 29	
R8 220k Fix-replace with 330k	I found that it was not possible to adjust the 50Hz pulses for the correct frequency. They should appear at every 20ms. Replace R8 with 330k. This

Symptom — Clock does not keep correct time in Battery mode and Adjustment is not possible when D11, C1 removed (see set-up in Jan 91)	allows the adjustment to work OK.
R10 22k Replace with 10k	Similar to above. Cannot adjust the pulses to 3.125kHz. Also adjust is not possible in setting up.
December 90	
Fig.6 Main CPU	
R15/16	R15/16 are shown transposed. These need to be changed over.
January 91	
Fig.13 Page 38 Printing errors	D9 has no polarity shown. Positive, striped end should go to the left (R5/D8 junction) D11 is shown reversed. R13 is shown twice. The one below IC1 should be D6 (Zener) and the positive strip should go to the right (R3 junction) R7 is shown going to the positive rail above IC8. It should go to the negative rail where LK13 is. R18 below IC9 should be R17 and the right hand end should go to the positive rail not the negative rail. The overlay presented on the other page shows the correction.
Page 38	Section-Calibrating the timing Circuits: The end to the paragraph mentions RV3. This should read RV8.
Page 40	Parts List R2,11,17 shown as 1k — should be 10k

Main CPU Board Problems

You should inspect the copperside of the PCB closely for any solder bridges. These can occur between the tracks of IC5/6/7 as the tracks are very close together. When I first powered up the project, the display gave a series of blocks. This proved to be shorted tracks on the data address bus lines. I used a 2.5mm soldering iron and 22swg solder and still managed to bridge a few tracks. No damage was done to the display. Check thoroughly your solder work before powering up. I suggest the IC sockets are mounted and soldered first and then before any components are added, use a meter to check all address and data lines for shorts. This avoids problems later.

Frequency Plotter

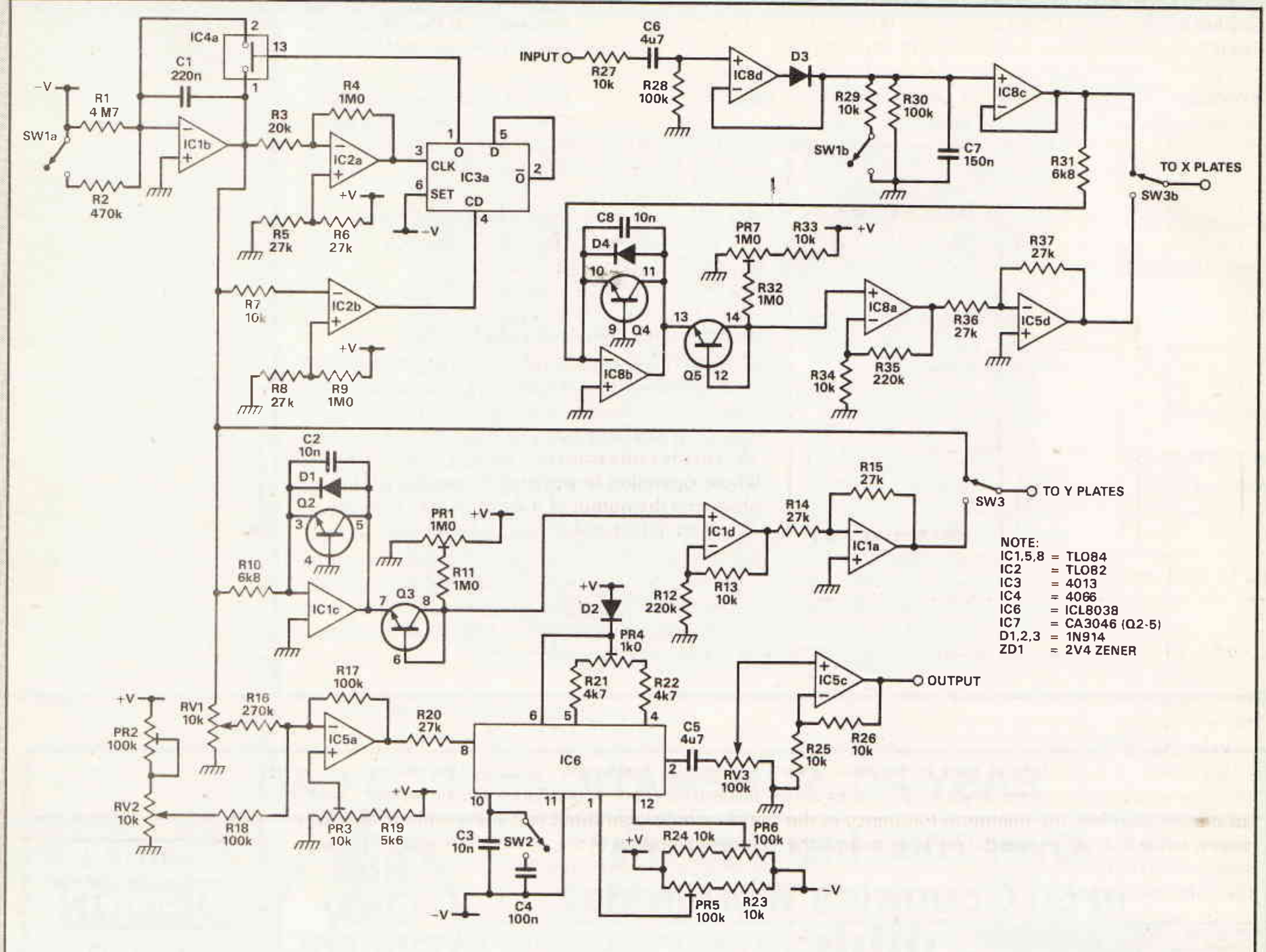


Fig.1 Circuit diagram of Frequency Plotter

Edward Barrow constructs this handy piece of test equipment to use with your oscilloscope.

If you're not confident with the design aspects of passive or active filters or being an audio buff, you want to test the response of your speakers, amplifier or whole system, this project could be for you. You do need an oscilloscope however, to plot the frequency response, of your questionable circuit. By frequency response, we mean the amplitude response (y-axis) versus frequency (x-axis). The usefulness of this project is limited by your own ingenuity.

The unit generates both voltages to drive the x and y plates of the oscilloscope and you have the option of having either logarithmic or linear plots for both amplitude and frequency response — what more could one ask?

Theory

The basic operation can be condensed into a paragraph with the help of a schematic diagram (Figure 1), but to understand its full operation this needs to be expanded.

This project can be broken down into two sections, the first generates a pure audio tone,(a sine wave), which sweeps up the spectrum and so provides a test signal. After this signal is processed by the circuit under observation it is returned to the second section of the circuit. This signal gives a direct indication of the frequency response but needs the second section to turn this signal into a form palatable to oscilloscopes.

Now we've dispensed with the simplified form lets take a closer look at the workings. The heart of the circuit is the sine wave generator built around IC6. To sweep this, a ramp generator has been built around the integrator IC1 b. By an integrator we mean a circuit which performs the mathematical function of integration. This is done with respect to time and so the result of putting in a DC constant is a linear time function, ie a straight line of increasing voltage. Two comparitors and a D-type flip/flop provide the necessary logic to control this integrator To understand this, its best to do so in conjunction with a timing diagram, Figure 2. When the circuit is first switched on the output of the integrator, originally at zero, starts ramping upwards, when it reaches +V/2 the output of comparitor 1 (IC2a) changes state to a high one. A slight amount of positive feedback has been added to make this transition a smooth one. This has a knock-on effect as its connected to the clock of the flip/flop which is configured as a divide by 2. The net result is that the flip/flop's output goes high turning on the bilateral switch thus resetting the integrating capacitor so causing the integrator's output to drop like a lead weight towards zero volts.

If you were to wait for it to reach zero you would be there a long time, because of the exponential nature of the decay it only approaches zero. So we compromise and say when it reaches +V/50 then we start the ramping process again. Comparitor 2 (IC2b) makes this decision. When this voltage is reached it sends a positive pulse to the flip/flop resetting its output low, turning off the bilateral switch and so stopping the reset cycle. Notice that no positive

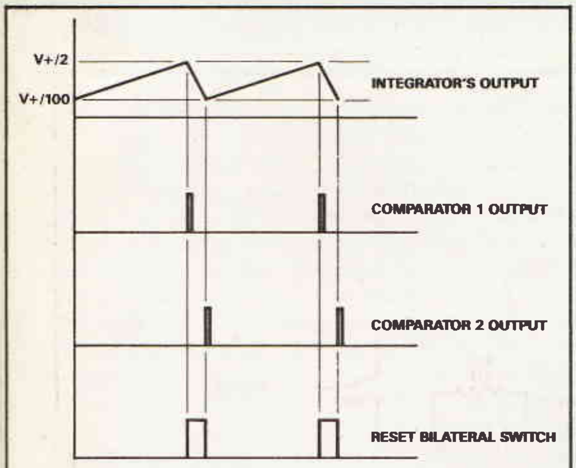


Fig.2 Timing Diagram

feedback has been included as a clean transition is less critical, once the flip/flop has been reset. The result of all this is a linear ramp which we use to sweep both the oscilloscope and the oscillator. To allow the user to tailor the range of sweep and the offset frequency of the oscillator two pots have been included to alter the characteristics of the ramp wave. RV2 provides an offset which sets the minimum frequency of the sweep, while RV1 attenuates the ramp so controls the sweep range. Before the oscillator can be driven the above two quantities have to be summed and inverted as the oscillator has a negative voltage frequency slope, (higher voltages result in lower output frequency).

As mentioned in the introduction, the bottom frequency axis can be made logarithmic as well as linear. An alternative method from the obvious one that is to change the ramp wave sweeping the oscillator from a linear one to a logarithmic one), is used. Instead we change the oscilloscope's sweep voltage from a linear one to a logarithmic one. The bit that does this is, a logarithmic converter. More about its workings in the 'How it works' section.

The returned signal is buffered and simultaneously actively rectified. The DC signal that results has a direct correlation to the attenuation experienced by the generated sine wave. In other words this DC signal represents the frequency response at that particular frequency. So a plot of this would be a plot of amplitude response vs. frequency, exactly the thing we are after.

Again a log converter similar to the previous one allows logarithmic amplitude response to be plotted.

Testing And Setting Up

Since the only people who will build this circuit have access to an oscilloscope this section has been easy to write. The first task is to turn on the power and check that power is flowing in the right quantity and direction to the right parts of the circuit, namely the supply pins of the IC's. Do this before inserting the IC's in their sockets. Working your way around the circuit with a probe the logical place to start is at the output of the integrator. Check that it is producing a smooth ramp and that by flicking the switch its frequency rises from 2Hz to about 20Hz. If this is not the case then check the states of the comparitors and the flip/flop, Figure 2 will give you some help with what to look for. Next check the output of the logarithmic converter and make sure it looks something like the one shown, flat tops and steep sides. To set PR1 use your oscilloscope to adjust it so the output cycle starts at zero volts.

Next on the agenda is the oscillator. Set RV1 and RV2 to zero and adjust PR3 so that the output of IC5a is the same as pin 6 on IC6. This should ensure oscillation at the output (pin 2). Now comes the part where a good eye is required to adjust the symmetry and the distortion. The idea is to monitor pin 2 while firstly adjusting PR4 so that it looks symmetrical, some might find it easier to monitor the triangle or square wave output, pin 3 and 9 respectfully to obtain a 50% duty cycle. After you are satisfied with this then adjust PR5 and PR6 so that the sine wave looks best. Its worth mentioning that the former adjusts the roundness of the top of the wave while the latter adjusts the bottom. If you have access to a distortion meter then life is made more exact and simpler. Lastly check the whole operation is working by turning RV1 while observing the output of IC5c. It should look like the depiction in Figure 4 but more importantly its amplitude should be constant throughout a full sweep. Flipping SW2 will raise the frequency to the next range.

There only remains the rectifier part to check and calibrate. This requires the connection of the unit to both the x and y plates as it would be when in every day use (see In Use section). With no input, the linear and logarithmic outputs should be at zero but logarithmic will require the adjustment of PR7. To test that all is well connect the test output directly to the test input. The result, if all is correct, is a straight line plot above the zero axis on both logarithmic and linear settings. Just to be sure of workings of this project I suggest you test the responses of some simple high and lowpass RC filters. This should yield the well known logarithmic plot of 3db per octave.

In Use

Connecting this project is a pretty straight forward exercise. Before connecting up though, override your oscilloscope's own ramp generator, there is usually a switch to do this marked 'external'. The two sets of plates can now be connected to their respective outputs on the unit.

The sweep frequency has to be selected. Some tips on this: firstly when examining responses in the bottom of the audio range, below 100Hz, it is advisable to use the 2Hz setting to allow the oscillator and the rectifier time to settle. The high range has no such restraint. When setting up the unit for your particular needs set RV1 to zero and adjust RV2 so that the frequency of the oscillator is the minimum test frequency you require. Next adjust RV1 so the range of the sweep is adequate for your needs. The other pot, RV3, has been included so that the unit can be used on test circuits which have amplification or can only handle small input signals. So when testing equipment like amplifiers, start with this pot in the zero position and slowly increase it (emphasis on slowly) till you get a reasonable returned signal.

By connecting the unit to your stereo (see above warning) and using a microphone to pick up the returned signal you can test the frequency response of

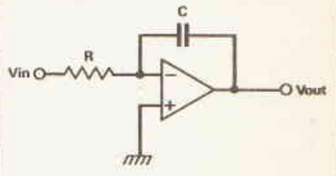


Fig.3 The Active Integrator Circuit

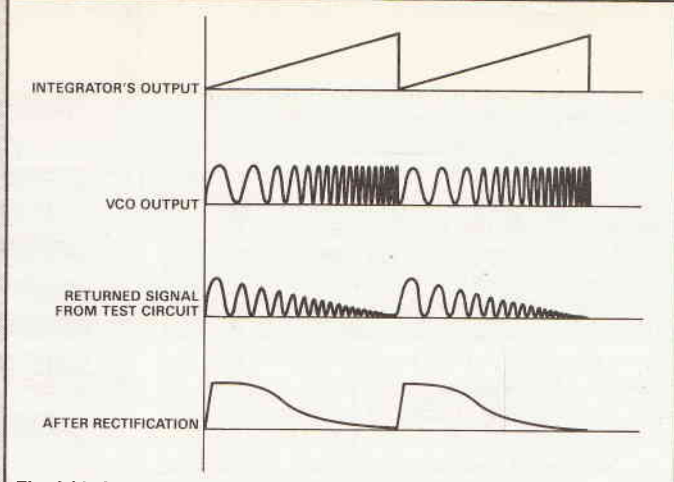


Fig.4 Various output waveforms

your system. Some amplification and buffering may be needed if high impedance microphones are being used. It is possible also to test the frequency response of cassette record/playback mechanisms with different tapes, but the workings has been left to you to figure out, answers on the back of a postcard (only kidding).

Construction

Board construction follows the usual logical pattern, link wires and small components like diodes and resistors first. Secondly IC sockets, presets, and finally the capacitors, regulators and bridge rectifier. Then connect the pots and switches and proceed to test the circuit. After that ordeal, finally solder the connectors in place and fully adjust the presets.

I used a simple U shaped two part aluminium box

HOW IT WORKS

The active integrator is configured in inverting mode so the – input is a virtual ground so for Figure 3 we can postulate

Vin/R = -C(dVout/dt)

or Vout = (-1/RC) int (Vin)dt

By making Vin = -V supply and choosing values of R and C we can get our desired rate of ramping.

One hurdle in any circuit of this type is the problem of choosing a sweep frequency that will give adequate settling time for the oscillator. It would be ludicrous to sweep an oscillator with a range from 20Hz to 20kHz with a 40Hz ramp as the oscillator will have little or no time to actually generate any audio signals at the lower end of the range. So to get around this hurdle two switchable frequencies are possible, 2Hz and 20Hz. The former frequency obviously will not give a stable trace only a moving dot, but the latter will due to persistence of vision.

Both logarithmic converters are of the same design. The op-amps exploit the logarithmic relationship between the base-emitter voltage and the collector current of a transistor to produce an output proportional to the logarithm of the positive input voltage. the input resistor is necessary to turn this input voltage into a suitable current for the transistors to process. The other transistor is necessary for temperature compensation. The zeroing presets generate a small offset current to set what input voltage gives zero output. The capacitor placed across the transistor is there to stabilise the feedback loop while the diode provides an insurance policy to the transistor if by some fluke the input voltage goes negative. If this is allowed to occur then base emitter breakdown would occur and a bill for a new transistor will follow. The non inverting amplifier provides the gain to bring the output level from hundredths of a volt to volts and a inverting amplifier returns it above the zero volts axis. Before finishing with logarithmic converters it should be noted that its best to use op amps with low offset currents like FET input ones and in the area of transistor selection a monolithic set is preferable as this gives good temperature matching. Here a package of six transistors, LM3046, and common TL084 FET input op-amps are used.

Turning to the oscillator a differential amplifier, IC5a, acts as a both a summer for the DC bias and the attenuated ramp and as an inverter. preset (PR3) sets the level about which the inversion takes place and so sets the minimum possible frequency.

The ICL8038 (IC6) is configured as a voltage controlled oscillator with a 40:1 range. A voltage from about +V supply to +V supply/2 will cover this range. To get around the problem that op amp outputs can only rise to 2V below its positive supply we drop the oscillators positive supply by 2.4V using a zener diode, thus giving some headroom to the op-amps. The timing symmetry of the sine wave can be adjusted by PR4 and the distortion levels of the sine wave can be similarly tweaked by the two presets PR5 and PR6. This chip also produces square and triangle waveforms but these are of no use in this circuit its only the sine wave output that we are interested in. It is not the best of sine waves as it is made from a triangle one by clipping it with a diode ring, but even so distortions of less than 1 are possible. Again two ranges are catered for by switching timing capacitors these are 20Hz-800Hz and 500-20kHz. Amplitude adjustment is made by RV3 before buffering with a little gain by IC5c.

The returned signal is decoupled before being actively rectified, this is done to remove any stray DC components that might have been added by the test circuit. The design of the low pass filter that proceeds the diode (D5) is critical as this determines the speed at which the output can decay and so dictates the steepest measurable falling amplitude response. A balance must be struck between the speed of decay, a high one is preferable, and its other action to smooth the bumps caused by the sine wave, a low one preferred. There is no such problem with the attack time as the diode has negligible resistance when conducting and so the only limiting factor is the output resistance of the op amp IC8d. Two choices of low pass action are available and correspond to the two ranges available on the oscillator. On the high range it is not necessary to have such a heavy low pass action as the minimum possible frequency is 500Hz so the lowpass action is lightened to allow steeper decays. The power supply for this circuit consists of a bridge rectifier generating a DC signal that is smoothed by two large electrolytic capacitors. Two 5V regulators, one positive and one negative, feeds off this and in turn supply the circuit board with power. The only external requirement is a transformer to provide the AC.

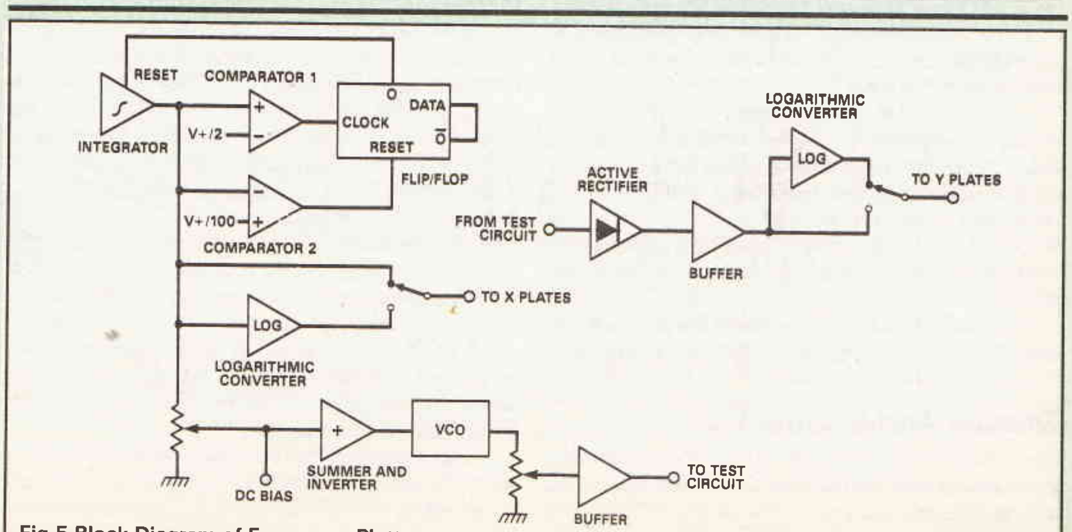


Fig.5 Block Diagram of Frequency Plotter

to mount the unit and power supply. To reduce pickup all high impedance connecting wires were screened. The connectors used on the prototype were 4mm plugs for connection to the test circuit and standard BNC ones for connection to the oscilloscope.

IC sockets were used on the prototype and are as always recommended to you. Take extra care with the ICL8038 as it has a very sensitive disposition to static so apply the usual CMOS precautions. The same is true of the two less expensive and less sensitive CMOS chips.

BUYLINES

No problems in any department as all components are widely available. Only getting hold of a 2.4V zener diode might present problems but a higher value like 2.8 can be substituted.

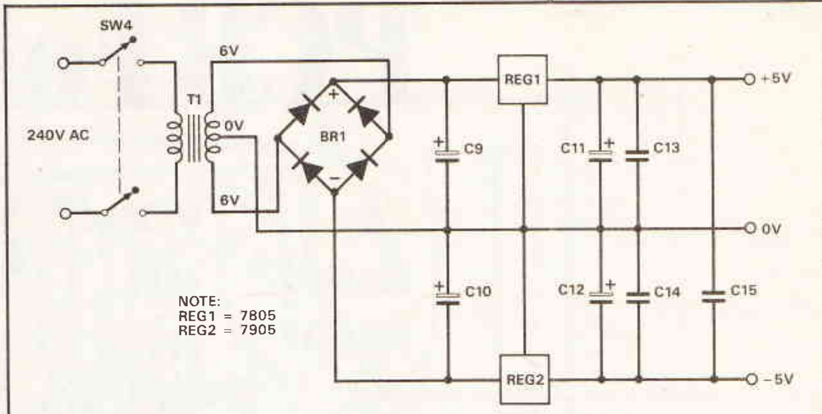


Fig.6 Power supply cicuitry

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	4M7
R2	470k
R3	20k
R4,9,11,32	1M
R5,6,8,14,15,20, 25,26,36,37	27k
R7,13,23,24,27, 29,33,34	10k
R10,31	6.8k
R12,35	220k
R16	270k
R17,18,28,30	100k
R19	5k6
R21,22	4k7
R38	1k2
RV1,2	10k
RV3	100k
PR1,7	1M
PR2,5,6	100k
PR3	10k
PR4	1k
CAPACITORS	
C1	220n poly
C2,3,8,15	10n Poly
C4,13,14	0.1µ Poly
C5,6	4.7µ Tant
C7	0.15µ Poly
C9,10	4700µ
C11,12	2200µ
SEMICONDUCTORS	
IC1,5,8	TL084
IC2	TL082
IC3	4013
IC4	4066
IC6	ICL8038
IC7	CA3046
REG1	7805 +12V 1A
REG2	7905 -12V 1A
D1,3,4	1N914
ZD1	2V4 Zener
LED1	5mm RED
MISCELLANEOUS	
SW1,4	SPDT Sub-min toggle
SW2	SPST Sub-min toggle
SW3	DPDT Sub-min toggle
4mm plugs	
6V-0-6V 500mA Transformer	
Case and power lead to suit	

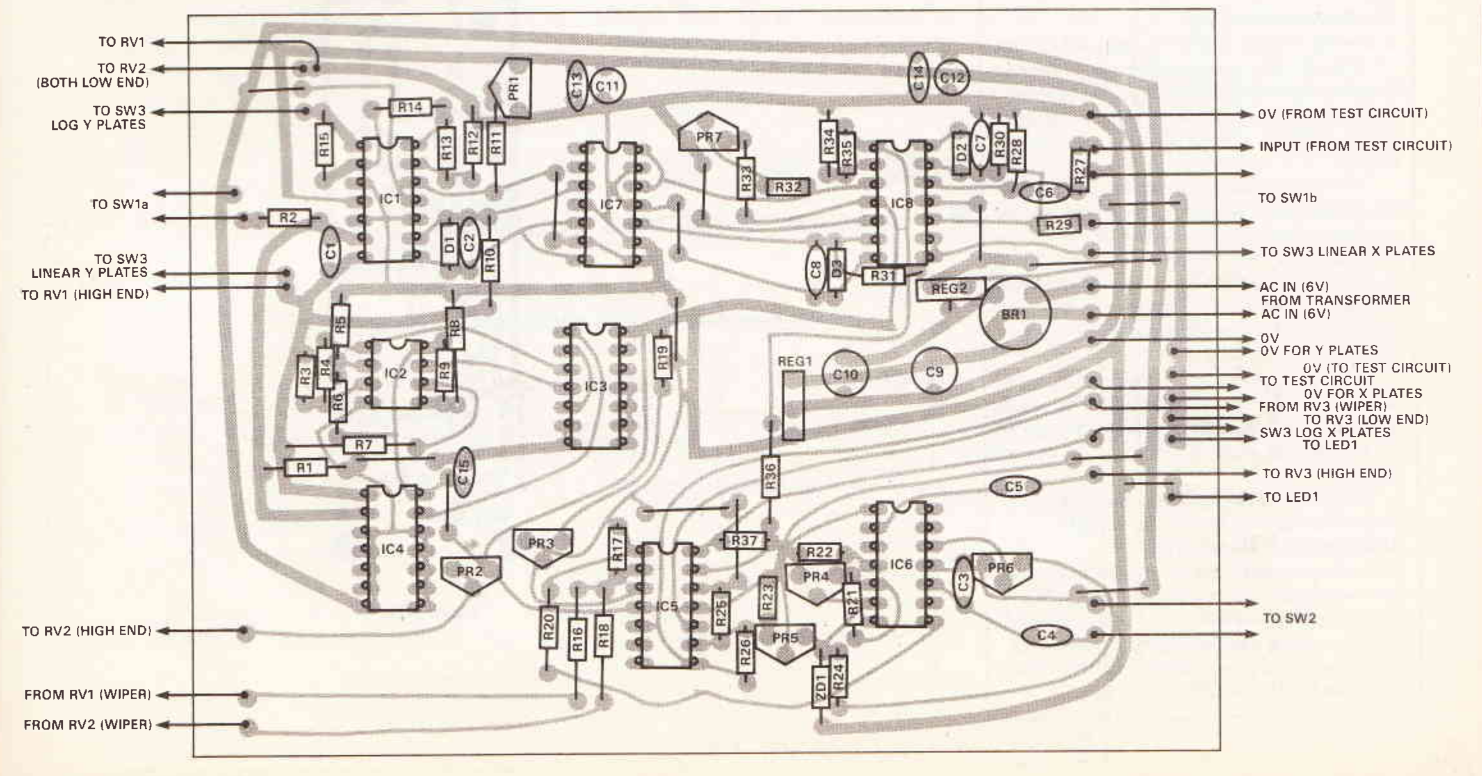
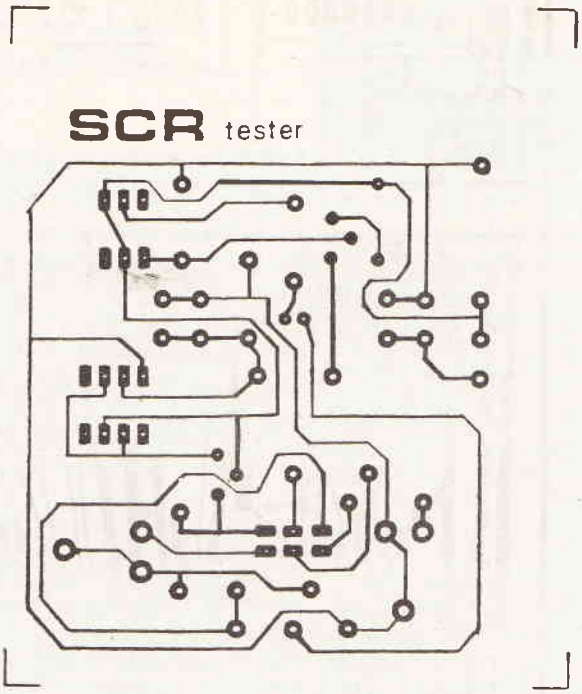
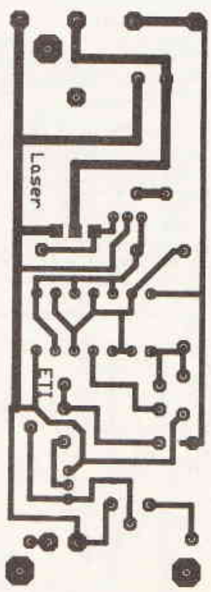


Fig.7 Component Overlay for the plotter

PCB Foils



Thyristor Tester Foil



Laser Foil

OOPS!

Remote Control Timeswitch Project (Dec, Jan, Feb 91)
The following paragraph is missing from the text.

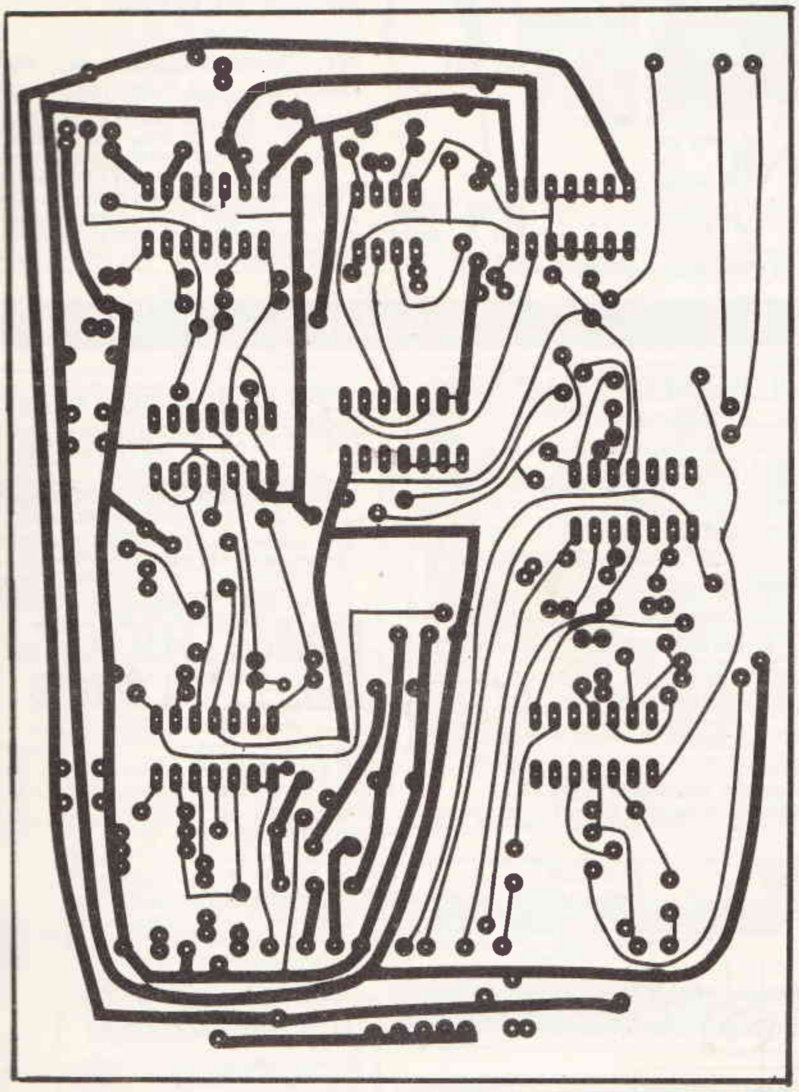
The Standby Battery
A standby battery should be selected for the control unit. The type must be able to supply 50mA whilst maintaining at least 7V. I used an 8.4V 'PP3' style Ni/Cd battery (Maplin HW31J) which gave a standby capacity of 2hours.

In ordeer to find the correct value of resistor R4 for the type of battery chosen, connect a 10k variable resistor and a meter in place of R4 on the board. Connect the power and adjust the variable resistor until the recommended trickle charging current flows. Replace the 10k pot with a standard resitor of approx the same value resistor.

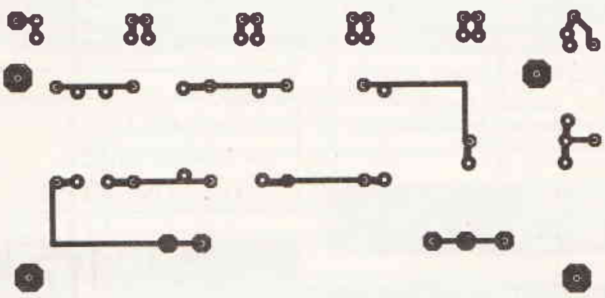
Any opto-isolator with correct pin layout is suitable for IC10 (Maplin WL35Q). The value of the crystal is 1.8432MHz. In Table 7a on page 32 of February. Note should read 1-link not fitted.

Further modifications to the timeswitch project can be seen in this issue of ETI.

SSB Receiver March 91
IC3 is shown present on the overlay but not in the cicuit diagram or component listing. IC3 is not required and should have been removed from the overlay after development of the cicuit. Q1 can be any of a vast selection of PNP transistors like BC557 or BC177 if to hand.



The Frequency Plotter Foil



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NEXT MONTH

Next month we continue our Laser series with a look at building a receiver for the modulated laser project this month and delve into the minefield of applications this creative little idea could be used for. Ray Marston looks at temperature sensor circuits and if precise control of temperature is a requirement of yours then look no further than the next issue with a project on this theme.

We also have a modification to the Four-track cassette recorder we featured in November.

The theory of the Piezo-electric effect is always in intriguing subject to look at and Back to Basics, our beginners series, examines inductance.

In response to our never ending stream of letters regarding the quality of audio components, John Linsley Hood presents an article on 'Supercomponents' to give hi-fi nuts something else to debate

All these to be consumed in the June edition of ETI, out on 3rd May.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

Projects which featured in the April issue of ETI were as follows:

Active Direct Injection Box.
A Digital Tachometer.
Designing an electronic testmeter.
A Radio Callibrator.
Nicam TV conversion.
An EPROM Eraser.

Features included: Lasers, Resistive networks, Mystery earth signals in VLF, Earth Loop Antennas, and Voltage Reference Generator Circuits. A limited back number of copies are available from Select Subscriptions (address on contents page).

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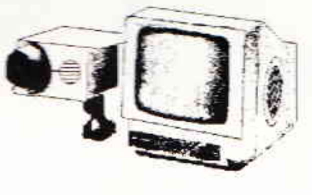

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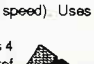

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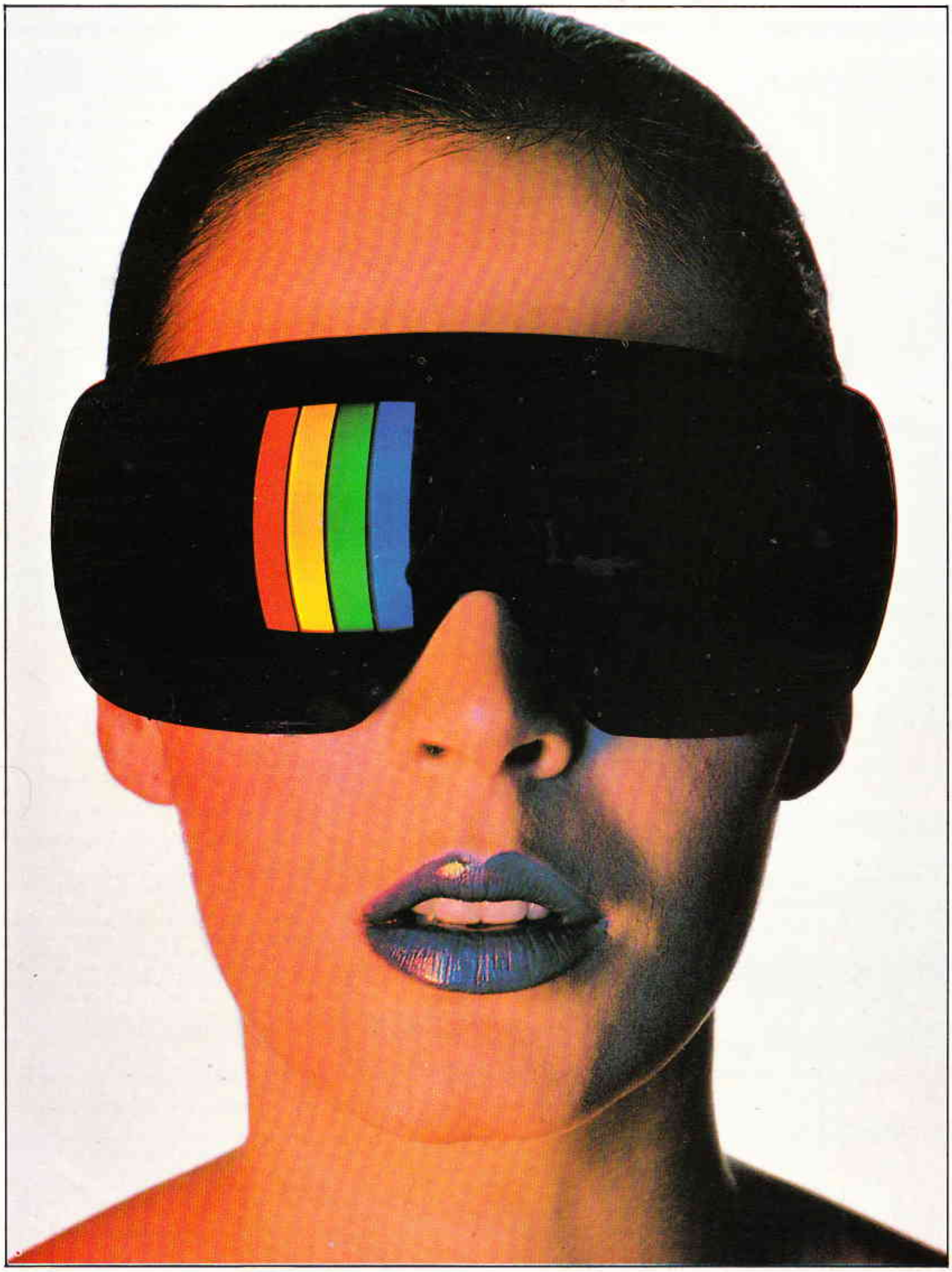

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