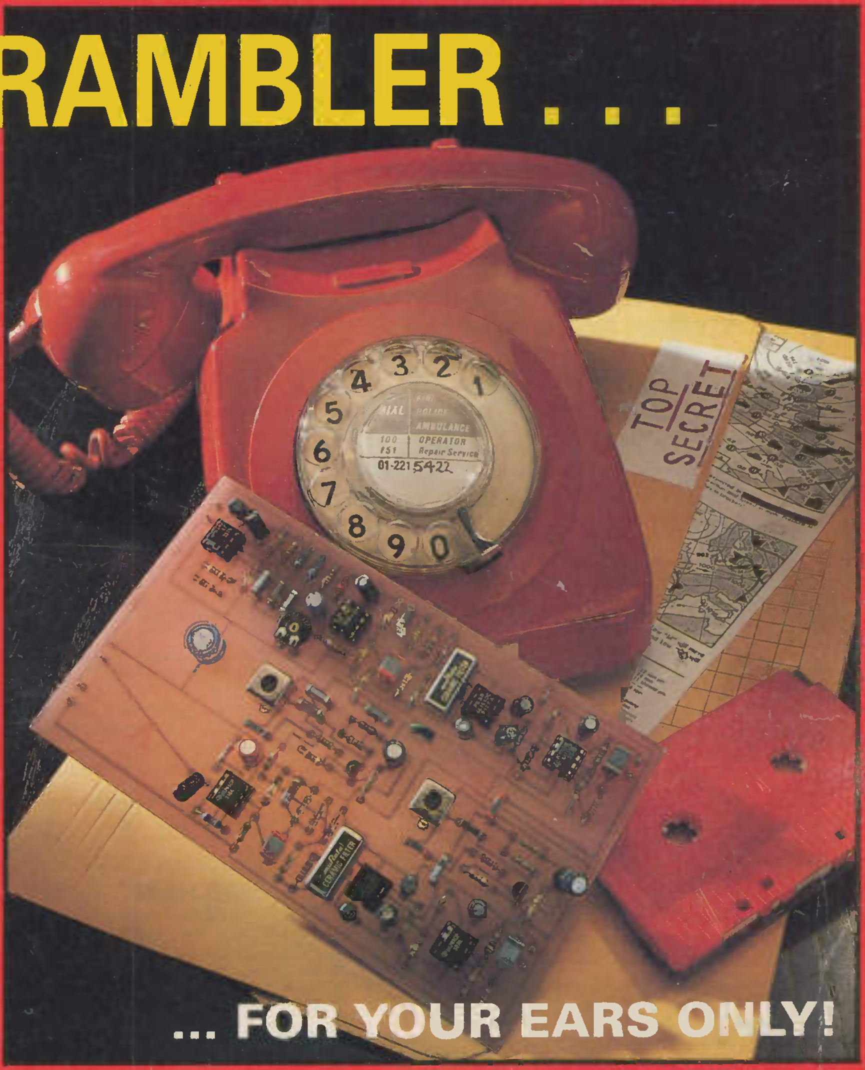
PRACTICAL ELECTRONICS
JANUARY 1987 · £1.25
SCIENCE & TECHNOLOGY

VOICE SCRAMBLER . . .



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EXPERIMENTATION — SCRAMBLING SIGNALS
THIS MONTH THE PROF LOOKS AT THE TECHNIQUES OF FREQUENCY INVERSION

PLUS:
- ★ SPACEWATCH
- ★ LEADING EDGE
- ★ INDUSTRY NEWS
- ★ CIRCUIT IDEAS

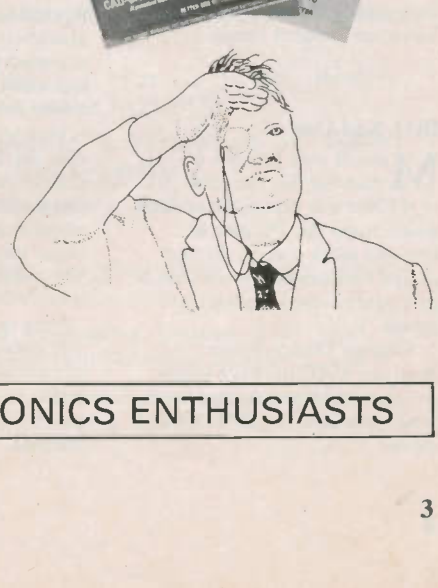
THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

PRACTICAL ELECTRONICS JANUARY 1987

CONSTRUCTIONAL PROJECTS

SPECIAL FEATURES

REGULAR FEATURES



THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

WHAT'S NEW . . .

WIRELESS BABY ALARM (NOV 1986)

As has been pointed out, modern house wiring may be wired with the neutral and earth linked at the consumer input as well as the sub-station. This could result in the alarm giving problems, especially if running on different circuits in a house. I would mention, however, that this is comparatively recent, and older homes should present no problem. However, if a constructer has problems due to this , the cure is fairly simple.

The mains live to neutral-earth is also fairly high impedance at 300kHz, therefore changing the live – neutral connections on both circuit boards over will effect a cure for this problem. The signal is then transmitted between live and earth. The isolation capacitor in the parts list is rated at 1kV, provided the correct part is fitted, no hazard will exist. As I mentioned in the article, it is important to cover the end section of the board when testing, this can prevent shocks.

Additionally, a friend of mine has been using a pair of these units for a time, and has discovered that when the washing machine is powered, the alarm output goes low level. This we believe to be due to the effect of the mains filter incorporated in the particular machine, and since these types of filters are symmetrical, altering the alarm such that signal is from earth to live will not cure the problem. I can suggest no cure for this except leaving the washing machine turned off at the mains when not in use.

Testing Times

In recent years the skills required by TV service engineers have changed due to the introduction of VCRs, video cameras, satellite equipment and new TV technologies. Consequently, a need for more and more advanced test gear is growing. Bal Components, who produce a range of such test gear, have introduced two new unity gain video display lines and a colour patch generator.

The delay lines are intended for use where the television systems exact video signal path timing requirement cannot be known in advance. The patch generator is designed as a quick aid to testing and adjusting TV cameras' colour production.

Test it Fast

A simple to operate fuse and socket tester (F.A.S.T.) is now available from Galatrek International. Announced a few weeks ago in order to catch the Christmas trade, Galatrek expect it to appeal to people of all ages and all walks of life 'from housewives to electricians and academics to businessmen'.

The F.A.S.T. will test for six different fault conditions on 13A socket outlets and has a simple to use and safe fuse receptacle for testing and standard plug fuse. It is available at a 13A price of £14.95 inc. VAT and p&p from Galatrek.

Spark of Life

For modellers and hobbyists, a small 12V operated hand tool is available from Sparklife. It is available to fulfill a variety of applications including cutting and cleaning.

The blade has a vertical motion making it suitable for abrasive or jigsaw attachments which are provided with the unit. Obviously this little machine will find most uses in auto-electrical equipment such as distributors and spark plugs.

Any Computer Monitor

Reflect have designed a number of interfaces which allows virtually any computer to be connected to the *Electrohome* Vari-scan monitor range.

IBM Add-Ons

Mullard now provide a package for the IBM-XT or ATPC (with FutureNet added) which turns the PC into a low-cost work station for the design and simulation of CMOS gate arrays and standard cel arrays.

Number One Systems Analyser CAC package which was featured in our August issue is now available for IBM PCs and clones.

Amstrad Interface

A new interfacing system from Electronic and Computer Workshop (ECW) is now available for the popular Amstrad CPC664 and 464 machines. The system is based on a four slot mother board which is plugged into the computer's disk drive port. So as not to restrict the computer in any way, the mother board has an additional drive connector to allow simultaneous use of the I/O system and external disk drive.

Plug in units come in ready assembled or kit form and peripherals include A/D and D/A ports, Centronics printer ports, real time clocks and general purpose logic level facilities.

CATALOGUE CASE BOOK

Over the last month we have received details of the following catalogues and brochures:

Please note: Some items listed here may only be available to trade customers.

Electrovalue October 1986 electronic components catalogue available from: Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB. Contents include: Thousands of items for home constructors, experimentors, manufacturers, laboratories and institutes. Electrovalue also have retail outlets in Egham and Manchester.

The Cirkit Electronic Constructors Catalogue, winter edition, available from Cirkit Holdings PLC, Park Lane, Broxbourne, Herts EN10 7NQ. Contents include 170 pages of electronic components, tools and computers. Cirkit also have several retail sales counters serving London and the South of England.

Quarndon Electronics (Semiconductors) Ltd. Advanced Micro Devices Catalogue available from Quarndon, Slack Lane, Derby DE3 3ED. Contents include a large range of microprocessors and support devices.

Five Star's Connector catalogue available from: Five Star Connectors, Edinburgh Way, Harlow, Essex CM20 2DF. Contents include a wide range of connectors, particularly STC devices.

New handbook on personal computer instrumentation available from: **Burr Brown International,** Cassiobury House, Station Road, Watford. (Order on business letterhead only.)

The latest **Tandy** catalogue outlining their massive range of computer and electronic products. Details and catalogues available from Tandy Stores thoughout the UK.

The latest catalogue from **TK Electronics** Autumn '86 edition with new updates 50p refundable on first order from TK Electronics, 13 Boston Road, London W7 3SJ

CHIP COUNT

This month we have received details of the following semiconductor devices:

Monolithic Memories (MM1) 672104 and 673103 1 Megabit DRAM controllers available from **Rapid Silicon.**

Range of SystemGate CMOS gate arrays from **Mullard.**

Gallium arsenide field effect transistors (microwave GaAsFETs), CFX1, CFX17 and CFX22 – low power; CFX30–CFX33 – medium power, from **Mullard.**

PLE6p16, programmable logic element (MMI) from **Rapid Silicon.** 6-input, 16-output device equivalent to 16 x 64 EPROM.

IMS A100 cascadable signal processor from **Inmos.**

VTB8511, 8512 and 8513 high quality silicon photo-diodes (EG & G Vactec) available from **Norbain Technology.**

DP8512 video clock generator from **National Semiconductor.**

Range of break over diodes (BODs) from **Mullard.** BR210-single diodes, BR220-dual diodes.

Same Size But Smaller

Casio, a well known name in calculators, have extended their range of hand-held programmables with integral screen by introducing a cheaper version of the popular FX7000G. The original FX7000G which retailed at around £70 had a display of 96 x 64 dots. Whilst the new 6000G has only a 96 x 32 dot screen, the display or more accurately 'the virtual display' is just as big. This is achieved by only showing the middle section of the full screen of 96 x 64 dots. The rest can be seen by either scrolling up or down. Using this approach, Casio have been able to reduce hardware costs and at the same time improve programming capability because the screen handler requires less memory.

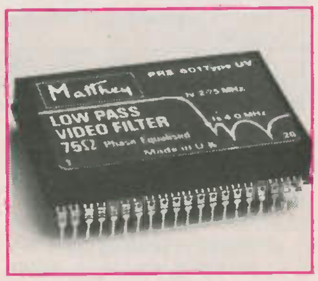
The FX6000G has 486 programming steps, 14 types of built in graph formats and 76 preprogrammed scientific functions. It retails at around £55.

Low Cost Storage

The new dual channel digital storage scope from Levell Electronics is said to be the lowest cost unit of its kind in the world – £498 plus VAT. The HM205 permits storage and display of events from 50 seconds to 0.1mS. Additionally it provides features expected of a 20mHz real time scope. It has a maximum sampling rate of 100KHz enabling it to register and display reasonable detail. Also with an optional add-on unit, the memory contents can be retrieved as hard copy using a chart or X-Y recorder. Other facilities include component tester and specially designed active video trigger input.

Dil Filters

With the trend towards higher packing densities in broadcast and video equipment there is much research and development time being devoted to d.i.l. filters. Mathey Electronics have produced a low profile d.i.l. low pass (LP) filter close to the specification outlined by the CCIR 601 recommendation for broadcast standards. They hope to have similar packages matching the complete spec sometime in the future.



Draught Board

A range of backlit draughting tables essential for complex p.c.b. work has been introduced by G.M. Technical Services Ltd. The working surface is plate glass allowing cutting and various sizes are available to accommodate artwork up to A0 size.

The lighting is provided by natural daylight colour corrected florescent tubes and to make viewing easier on the eyes, a pale green filter and dimmer control is provided.

SMD Development

SMD technology has gained widespread acceptance within the electronics industry but has created some problems for design and development engineers. Because of the nature of the technology it is difficult to prototype SMD p.c.b.s on a small scale. Surface mounted production systems provide a solution in the form of their HU1500 infra-red soldering unit. It allows a variety of soldering pastes, creams and adhesives to be used and tested for suitability in production and has three heating zones for boards up to 7 inches by 7 inches.

FIRM CONTACT

Further details of the products, services and companies mentioned in the News pages of Practical Electronics may be obtained from the following sources:

Casio Electronics Co. Ltd, Unit 6, 1000 North Circular Road, London NW2 7JD.

Matthey Electronics, Burslem, Stoke-on-Trent ST6 4AT.

Galatrek International Ltd, Scotland Street, Llanrwst, Gwynedd, LL26 OAL.

Sparklife, Unit 40B, Paddock Mount Offices, New Street, Dawley, Shropshire.

Levell Electronics Ltd, Moxon Street, Barnet, Herts EN5 5SD.

Bal Components Ltd, Bermuda Road, Nuneaton, Warwickshire CV10 7QF.

Electronic & Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY.

Reflex Ltd, Wellington Industrial Estate, Basingstoke Road, Spencers Wood, Reading RG7 1AW.

Number One Systems Ltd, 9A Crown Street, St. Ives, Huntingdon, Cambs. PE17 4EB.

Rapid Silicon Ltd, Rapid House, Denmark Street, High Wycombe, Buckinghamshire HP11 2ER.

Inmos International Plc, 1000 Aztec West, Almondsbury, Bristol BS12 4SQ.

Norbain Technology Ltd, Norbain House, Boulton Road, Reading, Berkshire RG2 OLT.

National Semiconductor, Industriestrasse 10, D-8080 Furstenfeldbruck, West Germany.

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

Tandy Corporation, Tameway Tower, Bridge Street, Walsall, West Midlands WS1 1LA.

Surface Mounted Production Systems Ltd, Unit 5, Sandbank Industrial Estate, Dunoon, Argyll PE23 8PW.

The Confederation of British Industry, Centre Point, 103 New Oxford Street, London WC1A 1DU.

WHAT'S HAPPENING

Technical education and the electronics industry

Industry in Education

There has been much said in recent times about the need for education at all levels to have a greater appreciation of the needs of industry in order to 'turn out' suitably qualified people for the future. Many would argue that education authorities and those responsible for arranging educational curriculums should not be influenced by external bodies but should concentrate on providing a well balanced education and not simply fodder for particular activities. On the other hand, high tech industries are crying out for suitably skilled or qualified personnel and claim that for various reasons not enough people are attracted to science subjects. Consequently, they say, we are lagging behind our overseas competitors in many areas of new technology.

It seems that both the government and the education authorities accept these views and are actively trying to introduce more science courses at all levels and at the same time encourage industry to support various education projects and ideas.

One of the major problems in secondary education was identified by Mr Ian Beer, Headmater of Harrow School, who said he was 'concerned that the majority of pupils leaving school were lacking confidence in the use of computers as a data base or word processor and without any practical experience in writing programs'.

Speaking at a recent meeting involving industrialists and representatives from the education sector, Mr Beer said that "Emphasis on A-level grades in specialist subjects for university or polytechnic entrance means that pupils are left with little or no incentive to acquire computer skills unless they play a part in their examination syllabus."

To solve this problem, a working party including representatives from the CBI, the City and Guilds and the DTI have come up with a course which will cause the minimum of interference to the sixth form curriculum. It is a modified C&G course which only requires a minimum of 20 hours of instruction for each student and can therefore be undertaken in conjunction with existing study.

A pilot scheme has been initiated with 40 schools and two Information Technology Centres taking part. It is sponsored by the DTI, ISTA, BAE and the CBI and successful candidates will receive certificates awarded jointly by City and Guilds and the CBI.

Sir Terence Beckett, Director General of the CBI, said that "All Britain's sixth formers could, in the future, have the opportunity of gaining a certificate of computer confidence, a skill which is today becoming almost as fundamental as reading and writing."

This sounds like a good idea but another problem which may prevent students from receiving the right sort of education is the lack of suitable teachers. A statement issued by the Engineering Council about teaching of mathematics and physics said that schools could be facing a crisis because of this problem. They offered various suggestions to overcome this including: different pay for maths and physics teachers; the use of industry and further/higher education as a source of teachers; encourage returners to teaching; encourage initial teacher training by paying more to mathematics and science trainee teachers.

"All Britain's sixth formers could, in the future, have the opportunity of gaining a certificate of computer competence, a skill which is today becoming almost as fundamental as reading and writing."

Further to the lack of suitably qualified teachers, a report by the Associated Examining Board (AEB) suggests that although employers are looking for school leavers with physics qualifications, these qualifications do not give any indication of specific experience or skills in electronics. As a result, the AEB and employers have got together to produce a specimen examination paper before offering the test to schools, colleges and companies in May this year.

The New Basic Test (Specialist) in electronics is supported by many large employers such as Westinghouse, Atomic Energy Research Establishment and Marconi.

At higher education level industry has, for many years, played an important role in the development of courses. However it is only in recent years that industry has begun to give real and direct financial backing. In the past industry has tended to 'use' educational establishments without really offering any support. Now, though, because of cut-backs in education budgets, universities and polytechnics have become far more commercially orientated and offer their research and development facilities at a price. They are also gearing up to produce commercially developed products rather than mere theoretical solutions and research.

Typical examples of this approach are those of the science parks such as Cambridge which are proving extremely popular. Whilst this may be the right path to follow under present financial constraints, many academics fear that we will lose sight of the fundamenal role of education establishments and important theoretical work which in the past has eventually proved extremely important will not be undertaken. True or not, it seems that at all levels of technical education there are problems and shortcomings.

COUNTDOWN

If you are organising any electrical, computing, electronic, radio or scientific event, big or small, drop us a line. We shall be glad to include it here. Address details to Countdown, Practical Electronics, 16 Garway Road, London W2 4NH.

NOTE: some exhibitions detailed here are trade only. Please check details and dates before setting out, as we cannot guarantee the accuracy of the information presented here.

Instrumentation 87, Feb 25–26, Harrogate Exhibition Centre.
Laboratory 87, April 8, 9, Manchester, (0799) 26699.
British Electronics Week 87, April 28–30, Olympia. All Electronics/ECIF: (0799) 26699, ATE: (0280) 815226.
British Manufacturing Technology Week 87, June 2–5, Olympia, 01-891 3426.
British Laboratory Week 87, October 13–15, Olympia, (0799) 26699.
International Test and Measurements 87, October 20–22, Business Design Centre, Islington, (0280) 815226.

CD-I – The Future

"a powerful new media standard that simultaneously integrates audio, visual and text/data functions in a real time, interactive format with software operating on essentially self contained players and/or systems"

Historically, the biggest problems faced by the media industry have been those of standards and compatibility. The media industry, loosely speaking, encompasses all communication mediums such as TV, radio, computing, printing, recording and filming, all of which have had serious setbacks due to an absence of agreement on standards or simply lack of communication or foresight. Typical examples include computer software which is able to run on one machine and not another, VCR versus BETA variations in world TV and radio transmission standards and the battle between LaserVision, CED and VHD. Fortunately, however, there is increasing evidence that manufacturers in the high-tech industries have learnt through past experiences and are actively taking steps to ensure that these problems are avoided in present and future product development.

Probably the best example of the advantages of this newfound understanding is that of the development of compact disc.

continued ➔

WHAT'S TO COME

Will CD-I be a consumer electronics revolution?

The compact disc is one of the most successful consumer electronics products ever introduced and its standard is universally accepted by the hardware and software industries. Philips, a leading researcher into laser and optical technology outlined the parameters for the compact disc digital audio system in 1978 and at the same time as developing their own hardware and software, they lobbied the support of other consumer electronics manufacturers, particularly in Japan, to adopt the system as a world-wide standard. It worked. According to Philips, "*this proved to be the single most important factor in the subsequent successful introduction of the CD system*". The first working model of a Philips CD player was shown to the world in 1979 and a cooperation agreement was subsequently signed by Sony who had contributed by developing an advanced error detection system. The agreed standard that followed was accepted by the Japanese Digital Audio Disc committee and partnership licenses were offered to interested player and disc manufacturers.

"this proved to be the single most important factor in the subsequent successful introduction of the CD system"

At this point in time the boom in personal computers was showing no sign of decline and computer manufacturers and software producers were taking a close look at CD. Because CD offers a massive storage medium for digital data, similar to that used by microcomputers, it was an obvious natural development that they should be used as memory storage devices. Thus the birth of the CD ROM. Once again a standard was agreed on the format of CD ROM storage making it internationally acceptable. However, because of the potential of optical memory storage to industrial and business computer manufacturers a group of software and hardware producers formed the 'High Sierra Group' which defined their own standards for CD ROM.

Anyway, back to Philips and CD. Why stop at audio and memory when digital data storage lends itself to so many other uses such as video and text? After all, the failure of consumer LaserVision was due merely to the lack of standardisation making it impossible for consumers to fathom the technicalities with so many alternatives to choose from. With a CD standard already accepted for audio and software the rest should be easy. And if European Interactive Media (EIM), a group formed by Home Interactive Systems (HIS) of Philips and Polygram, succeed in their aims it will be just that!

EIM's aim is to promote and be the prime mover in developing both hardware and software for CD-I, Compact Disc-Interactive. CD-I is said to be "*a powerful new media standard that simultaneously integrates audio, visual and text/data functions in a real time, interactive format with software operating on essentially self contained players and/or systems*". What does this mean, though, to the consumer?

"at this stage I can't divulge too much information on the actual mechanics of CD-I as it is proprietary information"

To answer this question, I asked Byron M. Turner, president of EIM and formerly Director of Creative Development in Europe for Activision Inc., exactly how CD-I will work and what it will actually do. After bewildering me with masses of information which, probably because of my short concentration span, I couldn't quite comprehend, he said "*at this stage I can't divulge too much information on the actual mechanics of CD-I as it is proprietary information*". Apparently I would have to become an effective CD-I licencee to have access to the 'Green Book Standard'.

What standard? Well it seems that the specifications of CD audio are laid down in the 'Red Book', CD ROM in the 'Yellow Book' and CD-I in the 'Green Book Standard'.

"*In simple terms,*" Mr Turner said, "*the CD-I standard specifies what data can be present on CD-I and how it should be encoded and formatted. It also dictates how the information will be processed and to what extent it can be processed*".

CD-I will allow up to 16 channels of audio with potentially more than 16 hours of audio/video. It may have up to 7,000 natural pictures, up to 13,768 colours for user-manipulated graphics and up to 256 for full programmed animation. Full motion video, of course, will be extremely limited but possible. The text/data capacity will be equivalent to 1,000 floppy discs or 3,000,000 typed pages.

What makes CD-I so unique is its ability to integrate all forms of media and provide interaction between the system and the user. It will find applications in publishing, video and adventure games, education, information analysis and many other forms of creative, leisure and business activities. For example, in education it may be used as an aid to learning geography with text, and audio supported by detailed maps and charts produced in high quality graphics or full TV definition. The user may be able to modify or manipulate the various images via some form of interactive interface. However, the facilities provided for this manipulation or modification are not necessarily fitted as standard to all CD-I players.

"We are committed to a global marketing strategy and our ultimate objective is to penetrate all applicable markets for the CD-I software catalogue to the greatest extent possible"

This is probably the most confusing aspect of the CD-I concept. Although the CD-I specification takes care of the way data is presented and how it may be processed, the level of possible interaction will be left up to individual manufacturers to provide through hardware and software. It is only through detailed examination of the Green Book Standard that it is possible to see the extent to which suppliers may provide these facilities. It is difficult to provide an analogy to this concept without understanding the full specification but if we take for example a standard sized floppy disc which will work on any disc drive of the right size no matter who the manufacturer, then we have the right idea about the actual CD-I discs. However the way that data is processed by the host computer is dependent on the model of computer and the correct disk interface and operating system is needed. In the same way data generated by CD-I can be processed in different ways dependent upon the system. The difference however is that the computer disk drive is controlled by the host computer but in the case of CD-I the system is controlled by built in intelligence and also by software provided on the disc itself. A stand alone computer will probably not be needed at all.

"the CD-I standard specifies what data can be present on CD-I and how it should be encoded and formatted. It also dictates how the information will be processed and to what extent it can be processed"

A CD-I unit may be a semi dedicated system designed, say, especially for video games whereby a joystick is provided. This will probably not exclude the facility to play ordinary music or CD ROMs. On the other hand a player designed for education purposes may have a keyboard interface for full interactive video and audio presentations.

The important thing is of course compatibility between machines and indeed existing software on CD audio and CD ROM which EIM says will definitely be compatible. However, I'm not sure that the 'High Sierra' specification is covered by this system.

One thing is certain, a system of this nature is bound to prove extremely popular providing there is sufficient support from both hardware and software producers. The track record of CD audio casts little doubt on that.

Furthermore EIM are very confident. Mr Turner said "*We are committed to a global marketing strategy and our ultimate objective is to penetrate all applicable markets for the CD-I software catalogue to the greatest extent possible.*" Mr Turner says that CD-I hardware will be available as soon as October 1987. We can't wait! PE

THE LEADING EDGE

REPORT BY BARRY FOX

The technology behind the products

Is the Japanese electronics export boom coming to an end and can the massive US computer control centre withstand a first strike?

SPARE a tear, if you have got one to spare, for the Japanese who are in an economic crisis. Yes, it's true. Japan has been so successful at selling to the West, that their yen currency has grown very strong. So it buys more and more dollars and pounds. This is fine for Japanese people holidaying in America or Britain but not so fine for Japanese industry.

When the yen is high, dollars and pounds buy less from Japan. This means that we in Britain and America have to pay more in pounds or dollars for Japanese electronics, like video and hifi. But we can't afford to. So the Japanese have to sell at a loss and cut down on their production. Hence what the Japanese now call their "economic crisis". One way of cutting costs is to install more and more robots on the production line, because they work free. Another way is to build factories in Taiwan or Korea where wages are low. Either way means an end to the famous Japanese tradition of lifetime employment. Japanese workers are no longer guaranteed a job for life with the company behaving like family. Already some of the smaller hifi and video companies are making people redundant. We hear tales of cutbacks in Sansui, Aiwa and Akai. Larger companies are getting by only by asking staff to volunteer for early retirement with redundancy pay-off. JVC, which is a relatively small company by Japanese standards, admits bluntly that if it weren't for the royalty which the company earns on the 120 million VHS video recorders sold over the last 10 years "we would be kaput – destroyed".

This poses an interesting question. What is going to happen to German video tape makers, BASF and Agfa? The German mark is as strong as the yen. Both BASF and Agfa have now slid into the bad habit of selling video tape on low price alone. They make little or no effort to communicate with the press. The can't go on giving away tape for ever. But when they put up the price in British supermarkets, their throats are cut.

I recently spent a little time in Colorado Springs in the shadow of Cheyenne Mountain. That's where the American military has its NORAD nerve centre for defence against nuclear attack.

They spent several years blasting an artifical cave out of the granite and then built a miniature town of two storey buildings inside the cave. The buildings are on spring suspension. If nuclear attack is imminent, the command staff shut giant metal doors in the mountain face and stay inside with the computers and enough food, air and water to last for thirty days. That's long enough to retaliate against anyone on the outside who is left living. The sprung mounts isolate the electronics from nuclear shock.

It's a bizarre concept which seems riddled with fallacies. The top of the mountain carries a forest of aerials for communication. Satellite dishes ring the entrance. Obviously these would evaporate at the first strike. Also if you can blast away granite with dynamite, you can presumably do it with a nuclear direct hit.

Perhaps the whole thing is just one big bluff. But perhaps not. Bluff or no bluff, all this makes Colorado Springs a first strike target. It's an eerie feeling.

The US military are building another underground complex on the other side of town to be called the "consolidated space operations centre".

When the Norad Cheyenne mountain centre was first under construction, the American army let tours of locals visit the cave. It was a good way of quietening public unrest about how much the whole scheme was costing. Now, only VIPs and a few selected members of the public get inside Cheyenne. You have to give six months notice and a social security number to prove that you are a genuine US citizen. The CIA and FBI then run a security check and if it comes up clean you get shown a little of what's inside.

There is a bizarre reason why the military now worry so much about letting visitors anywhere near the caves. Although every visitor is of course searched, the security forces are worried about terrorists getting in on a suicide mission. Anyone prepared to swallow an explosive charge with a timer could do a lot of damage on a suicide mission.

By a happy coincidence, I met some miners who helped build the system. They reckoned that the cave could withstand a one gigaton (that's 1000 megaton) nuclear blast. This is because the granite inside the mountain was removed in small chunks to avoid weakening the mountain structure from within. The miners had to drill a pattern of small holes, push in tiny charges and detonate them in a carefully delayed sequence to drive the fracture force inwards. The shattered rock could then be dug out to leave a tunnel. Then a wider ring of holes was drilled and plugged with explosives to enlarge the chamber. That way they were able to build artificial caves up to 600ft x 100ft in plan and tall enough for two or three storeys.

The computers and radio equipment inside the mountain are connected by underground cables to innocent-looking aerials and telemetry centres many miles away. The hope is that they won't be destroyed. Because the aerials on top of and around Cheyenne would be immediately blown away, there is automatic rock tunnelling equipment built into the mountain top. After a blast the equipment starts to burrow up through the rock to the surface, pulling replacement aerials behind it. These then pop out, like umbrellas.

The word is that although Cheyenne is supposed to have taken only three years to dig out, construction work is still going on. The new subterranean Space Control Centre will link up underground with the Cheyenne complex. It sounds far-fetched but I couldn't help noticing that the roads round Colorado Springs were surprisingly full of lorries carrying loads of freshly dug granite chips.

To end with, here's a tip from Colorado Springs that might be useful this side of the Atlantic. C Springs, as the locals call it, has a very dry atmosphere, with very low humidity. This means that anyone walking on a carpet with rubber shoes builds up a very high static charge almost immediately. So every time you touch a metal door knob or window frame you get a very nasty belt of electricity. Tip – walk around in your bare feet!

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All editorial correspondence should be addressed to the editor and any letters requiring a reply should be accompanied by a stamped addressed envelope. Please address editorial correspondence to: Practical Electronics, 16 Garway Rd., London W2 4NH. Tel. 01-727 7010

We regret that lengthy technical enquiries cannot be answered over the phone.

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MY BIT AT THE BEGINNING – 6

I always get confused at this time of the year. It's the beginning of November, I'm writing my bit at the beginning for the January issue of next year and it's due on the book shelves in December of this year. Should I be telling you to be careful on bonfire night, have a Merry Christmas or a Happy New Year? Well, whatever . . .

On a more serious note, the response to our competitions, editorial features, p.c.b. service, special offers and advertisements has been excellent over the past few months so, as far as PE's concerned, things are looking pretty good for '87. In fact we have had to increase our print order by a further 5,000 copies to keep up with demand.

We're not, however, simply resting on our laurels. To ensure that PE remains one of the best and most popular magazines for electronics enthusiasts, we are constantly looking for ways to improve it. To let you in on our plans, we expect to add more colour and more pages later on in the year.

We always welcome comments and suggestions (even though our postman's recently complained about a shoulder injury) from our readers, so if you have any constructive criticisms or ideas please don't hesitate to drop us a line. We can't answer or publish all letters but a prize of £10 will be given to the best letter published each month.

You have probably noticed that our news section has been expanding in recent months. We hope that by carrying more in-depth coverage of what's happening and what's to come in industry, the hobby world and the consumer sector, we will provide a much better service to our readers and advertisers.

With Catalogue Casebook, Firm Contact, Countdown and Chip Count, finding sources for information or components should be much easier. We're also introducing a new service this month, the PE HOTLINE, which is absolutely free. If you require any information on any product advertised in Practical Electronics, simply ring our hotline number with details of your query and we will pass on your name and address to the advertiser concerned. And by the way, Merry Christmas, Happy New Year and I hope you had a safe bonfire night.

Richard Barron

PE HOTLINE

This is an exclusive service available to PE readers. If you require any information regarding any advertisement appearing in PE, simply ring our hotline any weekday afternoon and we will pass on your details to the advertiser concerned. Please note that this is only applicable to advertisements and not news items or editorial features.

*01-221 5422 HOTLINE * 01-221 5422 * 01-221 5422 * 01-221 5422*

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34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways

	9	15	25	37
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Ang.Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
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St Pin	100	140	210	380
Ang.pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
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2 × 36-way	250p	—
1 × 43-way	260p	—
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For 2 × 32 way please specify spacing (A + B, A + C).

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20-way	85p	50-way	200p
26-way	120p	64-way	280p

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	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	-
20 pin	75p	-
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

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EXPERIMENTAL ELECTRONICS

BY THE PROF

Scrambling for privacy

While you cannot legally connect a scrambling device such as this to BT lines, there are many other applications and certainly room for experimentation. This project is fun to make, fun to use and reasonably inexpensive. Try it with a cassette recorder!

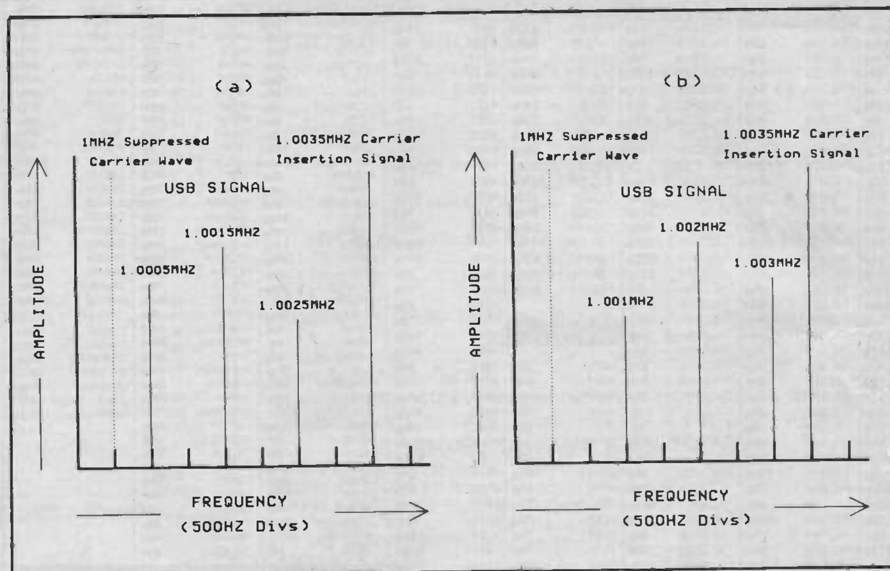


Fig.2. *(a) Inversion (b) Reinversion to restore original*

IN SPY films and television series of the late 1960s one of the standard gadgets was a telephone equipped with a "scramble" button. The idea was that when a highly confidential discussion took place both parties would activate their "scramble" buttons, and would be able to understand each other perfectly (or as well as the telephone system permitted), but anyone tapping into the line only received a garbled, unintelligible signal, making the conversation tap-proof. Eventually, of course, the bad guys got scramblers as well, and these devices gave way to more exotic gadgets.

Voice scrambling is not something that exists only in the realms of fiction, and I believe that voice scrambler telephones (to combat industrial espionage) were at one time on sale, and might be still for all I know. Rendering a voice signal unintelligible and then restoring the original signal is not actually that difficult, but the problem with any simple form of voice scrambling is that it is not too difficult for someone to record the processed signal and experiment a little until a suitable decoder circuit is produced. With encryption of digital signals it is possible to produce signals that are not truly uncrackable, but where it would take the fastest computers thousands or even millions of years to break the code. It is unlikely that the same degree of security could ever be obtained with a voice signal, but voice scrambling can make signals sent via electronic means uncrackable to all but the most determined of would-be tappers.

There must be many possible ways of scrambling a voice signal, but for the system to be really usable it must satisfy several requirements. Firstly, and most obviously, it must render the signal totally unintelligible, and the human brain is so well developed to understand speech that this is more difficult than one might think. Secondly, it must be possible to recover the original signal with sufficient fidelity for it to be easily understood by someone listening to the reconstituted signal. Thirdly, the bandwidth of the encoded signal must be comparable to that of the original, and should preferably be suitable for transmission over a voice link with a restricted bandwidth (2 or 3kHz).

There are several possible ways of distorting the signal so as to render it unintelligible, but most of these would involve the production of distortion products at relatively high frequencies. If these components were removed by a communications link with a fairly narrow bandwidth, this could modify the signal to the point where decoding it would fail to give a reasonably easy-to-understand output signal.

One system which does meet all three requirements very well is the so-called speech inversion system, and this is the standard approach to voice scrambling.

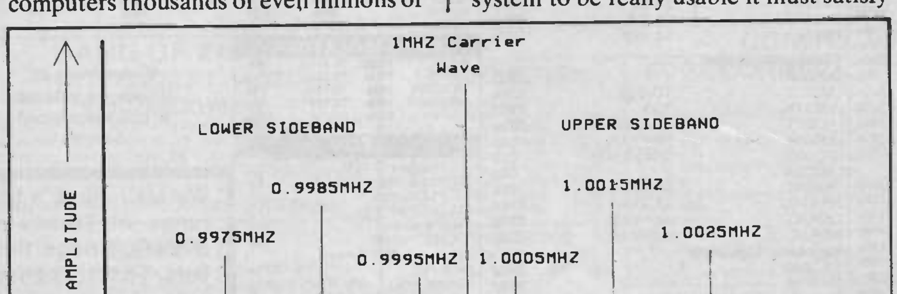


Fig.1. *Ordinary A.M. signal, USB, LSB and carrier*

We are not talking here of inversion in the sense of the waveform being inverted, which does, of course, not hinder intelligibility at all; this is an inversion in the sense that high frequencies are turned into low frequencies, low frequencies are converted to high frequencies, and middle frequencies remain little changed. Although you might not expect this processing to seriously impair the intelligibility of the signal, but instead to alter the character of the voice, it does in fact render practically every word completely unintelligible. It is just possible, at best, to make an intelligent guess at what the odd word here and there might be. It certainly gives an output that makes it totally impossible to follow what is being said, and the effective scrambling requirement is fully met.

The narrow bandwidth requirement is also met, with no spreading of the signal bandwidth at all. It is simply a matter of high and low frequencies being swopped over, and the system does not generate distortion products in the normally accepted sense. It is also possible to decode the signal to produce a reasonably noise – and distortion – free version of the original signal. In fact, like any inversion process, it is decoded by repeating the encoding process, so that the frequencies are reinverted back to their original values.

SSB

Although the frequency inversion process sounds quite easy, and can be achieved by a simple heterodyne process, in practice things are a little more difficult. It can be achieved using what is really a very basic s.s.b. (single sideband) transmission and reception process, and the inversion system of voice scrambling will probably be familiar to anyone who has been involved with s.s.b. communications equipment. There are two types of s.s.b. transmission; upper sideband (u.s.b.) and lower sideband (l.s.b.). If you try to receive an l.s.b. transmission in the u.s.b. mode, or vice versa, a scrambled and unintelligible audio output is produced. It is worth pointing out that this factor makes the inversion process of voice scrambling ineffective over an s.s.b. link, where it would presumably be possible to decode the signal simply by setting the receiver to the wrong sideband mode.

A single sideband transmission is a form of amplitude modulated signal, but it differs from the standard type of signal in that one sideband and (usually) the carrier wave are suppressed. In order to understand this process it is necessary to look at the spectrum produced by an ordinary amplitude modulation process. Fig. 1 shows the spectrum that would be generated by modulating a 1MHz carrier wave with audio inputs at 500Hz. 1.5kHz, and 2.5kHz. At the centre there is the 1MHz carrier wave, and symmetrically either side of this are the two sidebands, with each audio input frequency producing a signal in each sideband. For example, the 1.5kHz signal produces an upper sideband component 1.5kHz above the carrier frequency (1.0015MHz), and a lower sideband component 1.5kHz below the carrier wave (0.985MHz). The relative strengths of the sideband components are the same as the comparative strengths of the audio signals that generated them.

There are several methods of generating a single sideband signal, although these really just boil down to two basic methods; one using filtering and one relying on a phasing technique. Either system could be applied to voice scrambling, but the system I opted for was the filter method, which is probably the easier of the two. This relies on a high quality crystal, ceramic, or mechanical filter to remove one sideband while allowing the other to pass more or less intact. This system gives only a low level of carrier suppression, but this can be overcome by using a balanced modulator to generate a double sideband suppressed carrier signal, rather than using an ordinary amplitude modulator.

The normal way of demodulating a single sideband signal is to use a product detector, which is a form of balanced mixer. The single sideband signal is fed to one input and the output from a carrier insertion oscillator is fed to the other input. The output frequencies are the sum and difference frequencies of the input signals, and the carrier insertion oscillator should be at the same frequency as the suppressed carrier signal at the transmitter. The difference frequency signal is then the required audio output, and the sum signal is at high frequencies that are easily filtered out using the most basic of lowpass filters.

To produce the required frequency inversion it is a matter of shifting the carrier insertion oscillator away from its correct operating frequency, and out to the other side of the s.s.b. signal. Fig. 2(a) helps to explain this process, and as in our original example, there are three frequencies which are offset by 500Hz, 1.5kHz, and 2.5kHz from the correct carrier frequency. The signal is an upper sideband type, and to give the inversion effect the carrier insertion oscillator must be set to a frequency that is a little higher than the highest frequency in the signal. There is no hard and fast rule to govern exactly what frequency should be used, but in order to leave the bandwidth of the processed signal more or less the same as the original, it needs to be set symmetrically on the other side of the signal to the carrier signal. For the sake of this example we will assume that a carrier insertion oscillator frequency of 1.0035mHz is used. In other words, the operating frequency of this oscillator is set 3.5kHz above the original carrier frequency.

Calculating the audio output frequencies gives answers of 3kHz (1.0035MHz – 1.0005MHz), 2kHz (1.0035MHz – 1.0015MHz), and 1kHz (1.0035MHz – 1.0025MHz). Thus input frequencies of 500Hz, 1.5kHz, and 2.5kHz are respectively converted to frequencies of 3kHz, 2kHz, and 1kHz, giving the desired inversion effect.

As pointed out previously, the signal is decoded using exactly the same process as was used for encoding. Although I stated above that there is no hard and fast rule as to what offset should be used for the carrier insertion oscillator, for the encoding and decoding process to work properly it is essential that the offset should be the same in both cases, or at least that any discrepancy should be minimal. Any error will result in the decoded output frequencies being shifted slightly up or down from their correct values, giving a voice of slightly raised or lowered pitch. A small error will not significantly impair intelligibility, but errors of a few hundred Hertz or more would leave the signal at least partially scrambled and difficult to understand.

Fig. 2(b) shows the sideband signal frequencies that would be produced by feeding the example decoded signal back into the system. It is apparent from this that the difference frequencies are the original audio input frequencies of 500Hz, 1.5kHz and 2.5kHz.

ENCODER/DECODER

In order to provide full duplex (two way) communications an encoder and decoder are needed at each end of the communications link. The block diagram of Fig. 3 shows the basic setup needed to achieve encoding and decoding.

Starting with the encoder, the input signal is fed to a buffer amplifier which also incorporates simple 6dB per octave lowpass filtering. This filtering is needed to prevent stray pickup of radio frequency signals which could react with the oscillators to produce unwanted heterodyne tones on the output signal.

The output of the buffer stage is coupled to a balanced modulator which has its other input fed from a carrier oscillator. The modulator is actually a double balanced type which uses a system of phasing to suppress the carrier and audio input signals at its output, where only the sum and difference frequencies are produced. These are the upper and lower sideband signals respectively, and an s.s.b. filter is used to remove one or the other of these. The

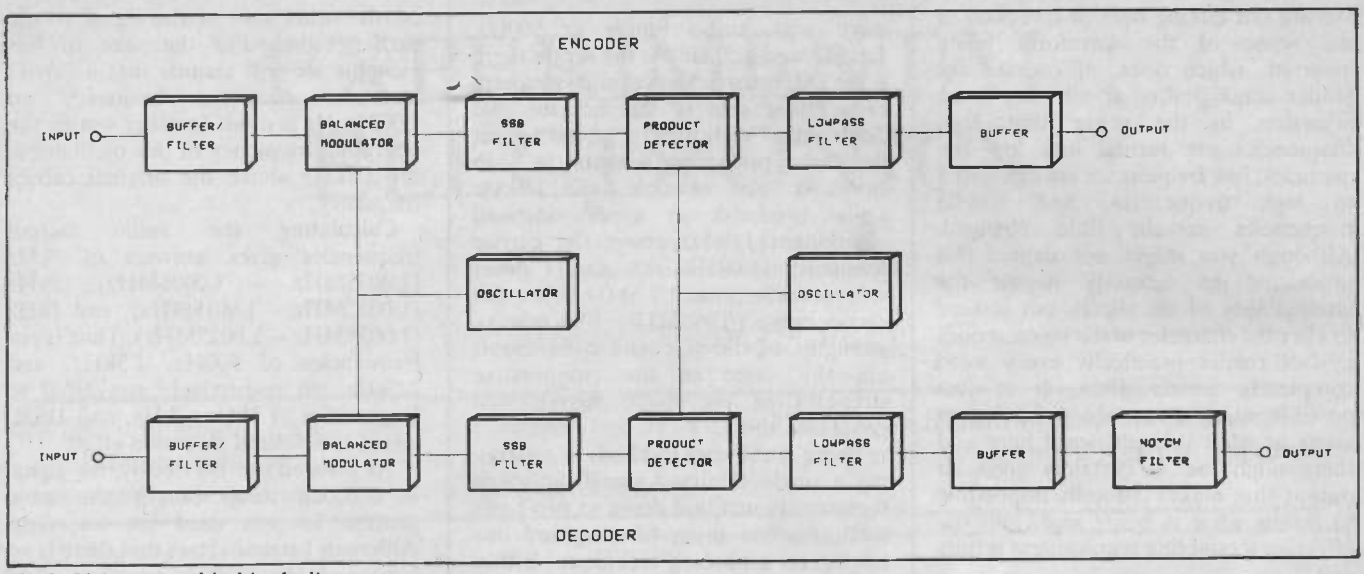


Fig.3. *Voice scramble block diagram*

s.s.b. filter is really just a form of bandpass filter, but it is a very high performance type which has a phenomenal attenuation rate when viewed in dB/ octave terms (several hundred dB per octave or more in fact). This is not quite as good as it seems, as the filter needs to provide a drop in gain of 40dB or more over a frequency range of 2 or 3kHz, but it is operating at frequencies of a few hundred kilhertz, or even a few megahertz. It is this high operating frequency which results in such a high figure being obtained when the response is considered in dB/octave terms. A suitably sharp response can not be obtained using ordinary R-C or L-C filters, and the filter used in this design is a ready-made ceramic type operating at the popular 455kHz intermediate frequency.

The single sideband signal is fed to a product detector where it is mixed with the output from a second oscillator which incorrectly demodulates the signal to give the required frequency inversion. A lowpass filter removes the sum frequencies to leave the demodulated audio difference signal. This is fed to the output socket via a buffer stage.

The decoder is basically the same as the encoder, and it shares the two oscillators used in the encoder. It only differs in that it has an additional filter stage added at the output. This is a notch filter which operates at a frequency of around 3 to 4kHz. Its purpose is to remove the low level audio tone that is otherwise likely to appear on the output signal due to heterodyning of the two oscillator signals.

CIRCUIT OPERATION

Fig. 4 shows the circuit diagram of the encoder, and the additional circuitry needed for decoding is shown in Fig. 5. For full duplex operation two complete encoder/decoder units will be needed,

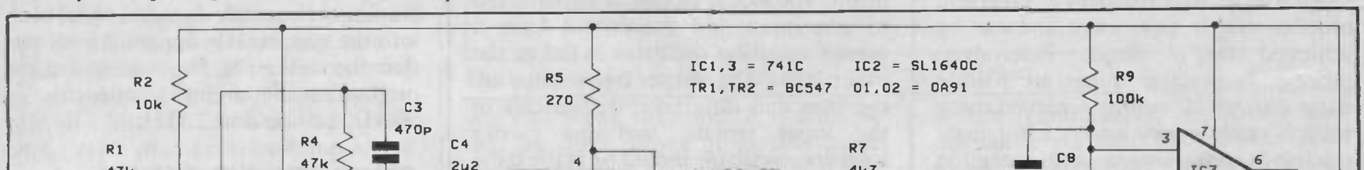


Fig.4. *Encoder circuit*

but it is possible to try out the system by building just one encoder circuit. This can then be used to scramble a signal which is recorded, and then to decode it again when it is played back.

IC1 is the input buffer stage, with C3 providing frequency selective negative feedback which gives the lowpass filtering. IC2 is the balanced modulator, and this is a device from the Plessey range of communications integrated circuits. This is not a particularly cheap component, but it is convenient to use, gives very high quality results, and does not need any balance adjustments in order to obtain a high degree of carrier suppression. The carrier signal is provided by TR1 which operates as a simple L-C oscillator with IF transformer T1 providing the frequency selective positive feedback. A simple oscillator of this type gives adequate stability for the present application, aided by the relatively low operating frequency of about 455kHz.

CF1 is the s.s.b. filter, and this is an inexpensive ceramic type which provides what is admittedly considerably less than the ultimate in performance. It is adequate for the present application though with its minimum -6dB bandwidth of 2.6kHz and maximum -50dB bandwidth of 8kHz (and typical figures which are much better than these). Its response is virtually symmetrical, and T1 can be adjusted so that the filter passes either the upper or the lower sideband, with no significant difference in performance between the two modes.

The product detector is a simple two diode type, which again gives somewhat less than optimum performance. It is perfectly adequate for the present application though, and helps to keep down the cost of the unit. TR2 is used in an L-C oscillator circuit that provides the carrier insertion signal, and this circuit is identical to the one used to provide the carrier signal. However, the product detector requires a higher level signal than the balanced modulator, and the output signal is taken direct from the emitter of TR2 rather than from a tapping on the emitter load resistance.

IC3 acts as the output buffer amplifier, and this does in fact have a certain amount of voltage gain which compensates for losses through the system and gives approximately unity voltage gain overall.

The circuit of Fig. 5 is almost identical to the signal processing stages of Fig. 4, and the balanced modulator and product detector stages are driven from the same oscillators as their equivalents in Fig. 4. To produce an exact complement of the encoding process the balanced modulator would be driven from TR2 instead of TR1, and the product detector would be driven from TR1 instead of TR2. However, as pointed out previously, it does not matter whether a u.s.b. signal is generated and decoded as l.s.b. type, or an l.s.b. signal is generated and demodulated as a u.s.b. type, as exactly the same frequency inversion effect will be obtained in both cases. You may like to try both methods of connection to prove this point (but remember to drive the product detector direct from the emitter of the transistor, and the balanced modulator from the tapping on the emitter load).

A twin T filter is used to provide the notch filtering at the output, and the filter is included in the negative feedback network of IC7 in order to sharpen up its response slightly. VR1 enables the filter to be set for optimum attenuation of the audio tone, and it effectively enables the filter to be tuned over a small range of frequencies.

CONSTRUCTION

Although this circuit handles radio frequency signals, the actual frequencies involved are not very high, and the component layout is not critical. On the other hand, the method of construction should be one which does not produce relatively large stray capacitances which could compromise the carrier and sideband suppression levels of the unit.

In the introduction to the first article in this seies it was stated that no printed circuit designs would be provided for the circuits. There has been a change in policy on this point as it has been quite fairly pointed out that some of the circuits, although suitable as the basis for further experimentation, also represent complete projects in their own right. Printed circuit board designs for some circuits in this series will therefore

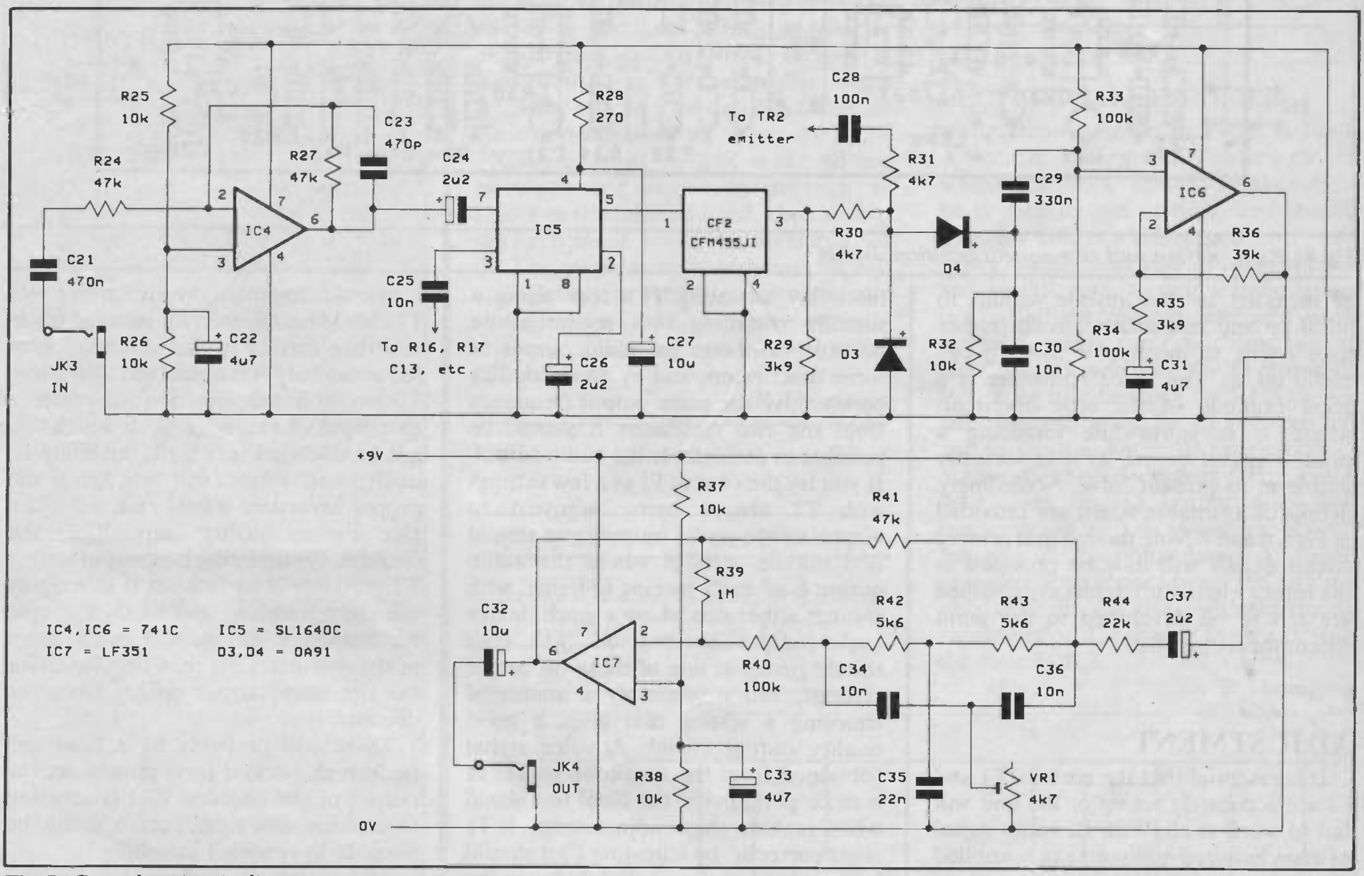


Fig.5. *Decoder circuit diagram*

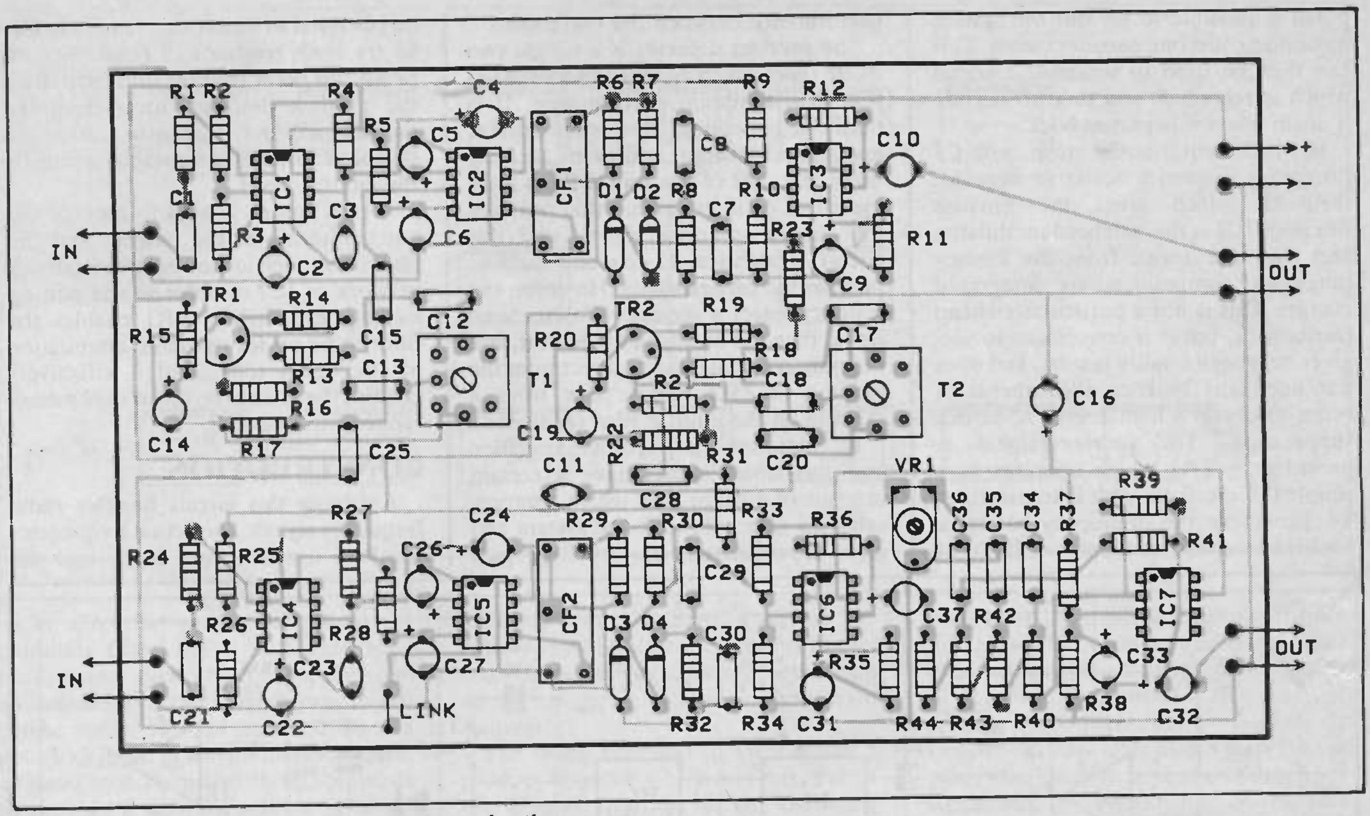


Fig.6. *P.c.b. design and component position details*

be included, so that anyone wishing to build up and test such a circuit, rather than trying to develop it further, can easily do so. The voice scrambler is a good example of the type of circuit where it is worthwhile including a printed circuit board, as it is perfectly usable in its present form. Accordingly, details of a suitable board are provided in Figs. 6 and 7. Note though that printed circuit details will only be provided in the future where the circuits as published are felt to be developed to the point where this is justified.

ADJUSTMENT

It is essential that the cores of T1 and T2 are accurately set up or the unit will fail to work at all. With an audio signal of a few hundred millivolts r.m.s. applied to the input of the unit it is quite likely that there will be no output at all from the encoder. This is due to the high amount of band attenuation of the s.s.b. filter. By adjusting T1's core using a suitable trimming tool it should be possible to obtain an audio output of some description, and by adjusting T2's core to give the same output frequency from the two oscillators it should be possible to descramble the audio output. If you try the core of T1 at a few settings with T2 always being adjusted to normalise the audio output, you should find middle settings where the audio output is severely lacking in treble, with settings either side where a much clearer audio output is obtained. T1's core should be set at one of these off-centre settings, and it is simply a matter of choosing a setting that gives a good quality output signal. A voice signal (obtained from the earphone socket of a radio perhaps) is the ideal test signal when making these adjustments. If T1 is set correctly, by adjusting T2 it should be possible to raise or slightly lower the pitch of the output signal, which should sound clean and free from any low frequency distortion products.

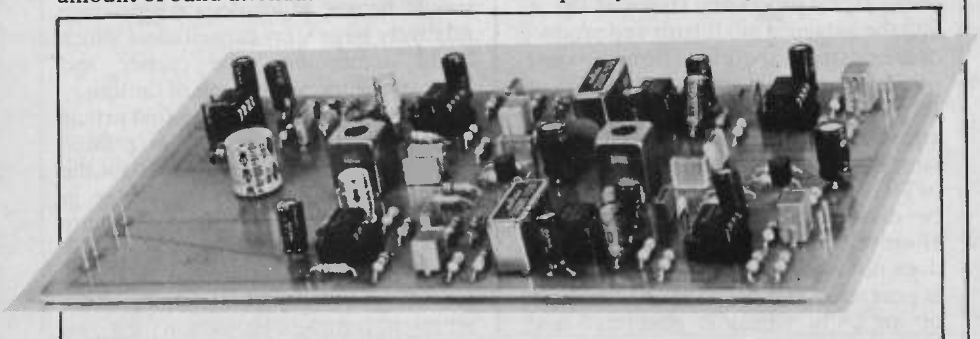


Photo 1. *The prototype p.c.b.*

In order to obtain the inversion effect T2 should be adjusted for reduced pitch, and then further in that direction until the audio output is scrambled. Adjusting T2 too far in this direction will result in an output of excessive pitch which will not be decoded very well, but using an inadequate offset will not give the proper inversion effect, and will again give a poor quality output from the decoder. Probably the best way of setting T2 correctly is to first set it at roughly the right position, and to then couple the output of the encoder to the input of the decoder. T2 is then fine-tuned for the optimum output quality from the decoder.

There will probably be a faint and fairly high pitched tone present on the output of the decoder. VR1 is adjusted to minimise this signal, and it should be possible to render it inaudible.

With a two-way system each encoder and decoder should first be set up as described above. With the two units linked, T2 at one of the units is fine tuned to give an audio output of the correct pitch from both units.

Of course, if suitable test gear is available then a more scientific approach to alignment of the unit can be adopted, but the method outlined above might give better subjective results anyway.

One point about using the unit which must be made is that connecting it to the public telephone system, or even using it with other forms of communications, is likely to be illegal. It is up to you to ensure that the unit is used in accordance with the appropriate regulations if it is used in earnest. PE

COMPONENTS. . .

RESISTORS

R1,R4,R24,R27,R41	47k (5 off)
R2,R3,R8,R25, R26,R32,R37,R38	10k (8 off)
R5,R28	270 (2 off)
R6,R16,R21,R29, R35	3k9 (5 off)
R7,R23,R30,R31	4k7 (4 off)
R9,R10,R33,R34, R40	100k (5 off)
R11	2k2
R12,R36	39k (2 off)
R13,R18	1k (2 off)
R14,R19	33k (2 off)
R15,R20	100 (2 off)
R17,R22	470 (2 off)
R39	1M
R42,R43	5k6 (2 off)
R44	22k

All 0.25W 5% carbon

POTENTIOMETER

VR1	4k7 sub-min hor preset

CAPACITORS

C1,C21	470n polyester layer (2 off)
C2,C9,C22,C31, C33	4μ7 63V radial elect (5 off)
C3,C23	470p ceramic (2 off)
C4,C5,C24,C26, C37	2μ2 63V radial elect (5 off)
C6,C10,C27,C32	10μ 25V radial elect (4 off)
C7,C15,C25,C30, C34,C36	10n polyester layer (6 off)
C8,C29	330n polyester layer (2 off)
C11	100n ceramic
C12,C17	3n3 polyester layer (2 off)
C13,C18	In polyester layer (2 off)
C14,C16,C19	100μ 10Vradial elect (3 off)
C20,C28	100n polyester layer (2 off)
C35	22n polyester layer

SEMICONDUCTORS

D1,D2,D3,D4	OA91 (4 off)
TR1,TR2	BC547 (2 off)
IC1,IC3,IC4,IC6	741C (4 off)
IC2,IC5	SL1640C (2 off)
IC7	LF351

MISCELLANEOUS

T1,T2 Toko YHCS11100 (2 off); CF1, CF2 Murata CFM4455JI (2 off); JK1, JK2,JK3,JK4 3.5mm jacks (4 off); printed circuit board, PE128; 8 pin DIL i.c. holder (7 off); wire, solder, etc.

INGENUITY UNLIMITED

LUXMETER

THE circuit, shown in Fig.1 is for a luxmeter, which uses three switched ranges to give a measurement of light from 10 to 10,000 lux. It has proved useful for checking ambient light levels on location, before setting up video equipment, and also when filming subjects against the light, when camera auto exposure systems have to be overridden.

An ORP12 l.d.r. is used to measure the light intensity. In this circuit, it is connected as the current setting resistor of an LM334Z current source. The output of this is given by the formula:

I (mA) = 67.7/Rset

As the resistance of an ORP12 varies inversely with the light falling on it, an output is produced which is directly proportional to lux. This current is converted to a voltage by the range resistors, and then used to drive a meter via an op-amp buffer.

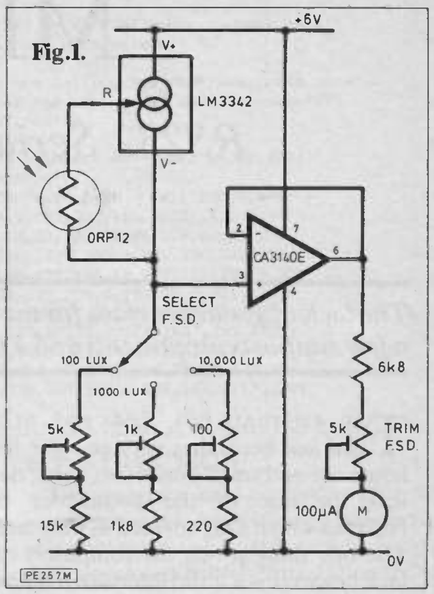
Calibration of the unit is carried out by substituting resistors for the l.d.r., as shown in the table of Fig.2, then adjusting each range preset for an output of lV. The meter is then trimmed for full scale deflection. Although the resistance change of an ORP12 follows a logarithmic law, a linear meter with ten divisions may be used.

P. Thompson

Fig.2.

LUX	RESISTANCE
100	1·2 k
1,000	150 Ω
10,000	18 Ω

Fig.1.



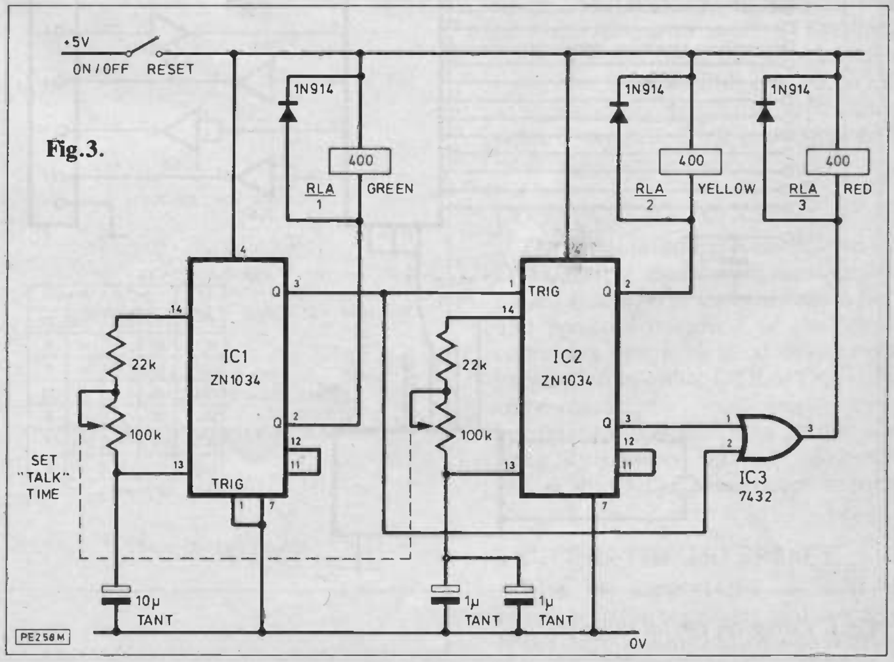
LECTURE TALKER TIMER

THE circuit, shown in Fig.3, is for a lecture talker timer. This is a device which indicates to a public speaker when he is running out of time, and should draw his talk to a conculsion.

The circuit uses two ZN1034 timers, and an OR gate, to switch three lamps in a traffic light configuration, with green for 'talk', yellow for 'finish', and red for 'time up'. At switch-on the Q output of IC1. goes low, bringing on RLA1 for a talk time which can be set between ten and fifty five minutes. At time up the Q output goes high, switching off the green light, and the Q output goes low, triggering IC2. This switches RLA2, bringing on the yellow lamp. A ganged potentiometer is used to set the on time of both of the ZN1034s, with the timing capacitors of IC2 chosen to give 20% of the time of IC1.

P. Thompson

Fig.3.



MICRO FORUM

RS232 Serial Interface for the Amstrad computer

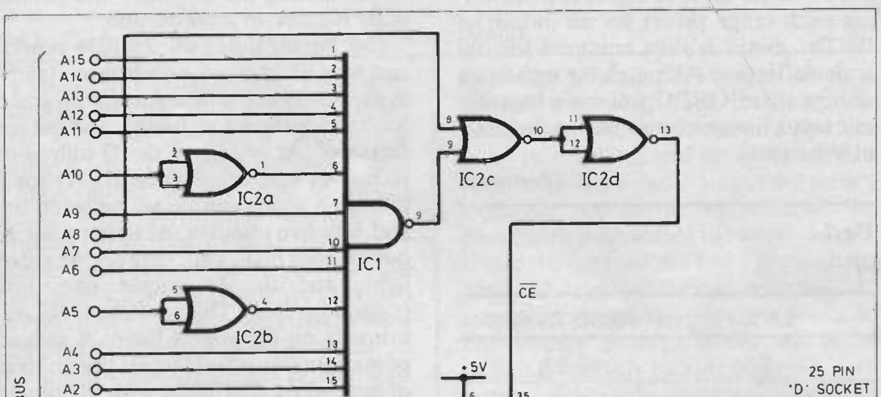
DESIGNED BY S. DEAN

The lack of serial interface for the 464, 664 and 6128 can be easily overcome for just a few pounds. Just six i.c.s., a few support components and a piece of stripboard is all you need to improve your Amstrad communications.

THE AMSTRAD 464, 664 and 6128 are fast becoming very popular for home use and small businesses alike, not least because of the abundance of facilities which are provided as standard. The one thing which the computers do lack however is a serial interface to allow communication with other computers, modems etc. Amstrad themselves do of course make an excellent serial interface add-on, but this is expensive (about £50.00). The serial interface described here is largely software compatible with the Amstrad interface yet can be made for around £20.00. It can be used under CP/M or, by using the simple programs provided, from Amstrad's BASIC.

CIRCUIT DESCRIPTION

As can be seen from the circuit in Fig. 1, there isn't an awful lot to it. The vast majority of the hard work is performed by the Z80A DART (dual asyncronous receiver/transmitter) i.c.3. This chip isn't the world's easiest one to drive, but was chosen in order to maintain compatibility with CP/M I/O routines. Address decoding is performed by i.c.1/i.c.2, the actual addresses used are as specified for the serial interface in the Disc Firmware Manual (Soft 158A) i.e.



IC NO	SUPPLY PINS +5V	+12V	-12V	0V
IC1	16	–	–	8
IC2	14	–	–	7
IC3	9	–	–	31
IC4	16	–	–	8
IC5	14	–	–	7
IC6		14	1	7

Fig.1. *Complete circuit diagram*

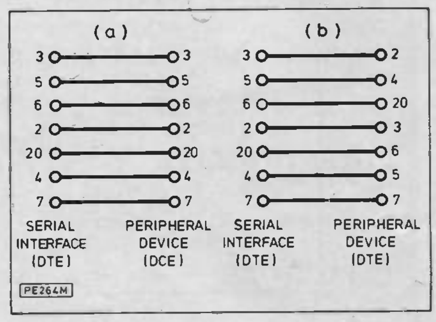


Fig.2. *Connections for DTE or DCE peripheral devices*

FADC – channel A data
FADD – channel A control
FADE – channel B data
FADF – channel B control

Addresses specified.

The Amstrad serial interface uses the Intersil 8253 chip to divide down the 4MHz system clock to obtain baud rate settings, but to keep down costs and simplify board layout, a C-MOS 4060 oscillator/divider is used in this circuit. Six rates from 150 Baud to 4800 Baud are provided.

The DART inputs and outputs are TTL levels, and need to be converted to RS232 levels. This is done by i.c.5 for inputs, and i.c.6 for outputs.

The interface requires +5V and =/ −12V to operate; the former is obtained from the Amstrad expansion connector, but the =/− 12V will need to be provided externally. The actual voltage is not critical, and the simple circuit shown in Fig. 3 may be used. Alternatively, a 5V to =/−12V converter can be used from the Amstrad's expansion socket; the unit may even be powered by two 9V batteries if this is more convenient.

PROGRAM 1

```
10 CLS:PRINT"To set up the UART, enter the following-"
20 PRINT
30 INPUT "No of data Bits (5,6,7,8)";n
40 tn=234:rn=193
50 IF n=5 THEN tn=138:rn=33
60 IF n=6 THEN tn=202:rn=129
70 IF n=7 THEN tn=170:rn=65
80 INPUT "No. of Stop Bits (1,1.5,2)";n
90 sb=4
100 IF n=1.5 THEN sb=8
110 IF n=2 THEN sb=12
120 INPUT"Parity (N)one, (E)ven, (O)dd";p$
130 p=0
140 IF p$="e" OR p$="E" THEN p=3
150 IF p$="o" OR p$="O" THEN p=1
160 INPUT "Use RX/TX handshake lines (Y/N)";p$
170 IF p$="y" OR p$="Y" THEN rn=rn+32
180 OUT &FADD,&18
190 OUT &FADD,3:OUT &FADD,rn
200 OUT &FADD,4:OUT &FADD,p+sb+64
210 OUT &FADD,5:OUT &FADD,tn
220 FOR a=&A000 TO &A063:READ b:POKE a,b:c=c+b:NEXT
230 CLS
240 IF c<>11778 THEN PRINT"error - check data!"
250 PRINT"Setting up complete!"
260 PRINT
270 PRINT"Before calling the routines, make sure"
280 PRINT"that the string has been previously"
290 PRINT"defined!!"
300 PRINT:PRINT
310 PRINT" To transmit A$ - call &A000,@A$"
320 PRINT:PRINT
330 PRINT" To receive B$ - call &A02B,@B$"
340 DATA 254,1,192,221,110,0,221,102,1,94
350 DATA 35,78,35,70,105,96,229,62,23,205
360 DATA 30,187,225,192,1,221,250,237,120,203
370 DATA 87,40,239,126,11,237,121,35,29,200
380 DATA 3,24,229,254,1,192,30,0,221,110
390 DATA 0,221,102,1,86,35,78,35,70,105
400 DATA 96,229,62,23,205,30,187,225,192,1
410 DATA 221,250,237,120,203,71,40,239,11,237
420 DATA 120,254,13,40,7,119,35,28,123,186
430 DATA 56,225,221,110,0,221,102,1,115,201
```

PROGRAM 2

```
                 10 ;RS232 SEND/RECEIVE ROUTINES
                 20 ;BY S.DEAN 22/6/86
A000             30          ORG  £a000
                 40 ;SEND ROUTINE
A000  FE01       50          CP   1             ;ONLY 1 PARAMETER PASSED?
A002  C0         60          RET  NZ            ;IF NOT THEN RETURN
A003  DD6E00     70          LD   L,(IX+0)
A006  DD6601     80          LD   H,(IX+1)
A009  5E         90          LD   E,(HL)        ;LENGTH OF STRING
A00A  23        100          INC  HL
A00B  4E        110          LD   C,(HL)        ;STRING START LSB
A00C  23        120          INC  HL
A00D  46        130          LD   B,(HL)        ;STRING START MSB
A00E  69        140          LD   L,C
A00F  60        150          LD   H,B
                160 ;HL NOW CONTAINS START ADDRESS OF STRING
A010  E5        170 LOOP:    PUSH HL
A011  3E17      180          LD   A,23
A013  CD1EBB    190          CALL £BB1E         ;IS CTRL KEY PRESSED ?
A016  E1        200          POP  HL
A017  C0        210          RET  NZ            ;IF PRESSED THEN ABORT
A018  01DDFA    220          LD   BC,£FADD      ;SIO STATUS REG
A01B  ED78      230          IN   A,(C)
A01D  CB57      240          BIT  2,A           ;IS TX BUFFER READY
A01F  28EF      250          JR   Z,LOOP
A021  7E        260          LD   A,(HL)        ;GET CHARACTER FROM STRING
A022  0B        270          DEC  BC            ;SIO DATA REGISTER
A023  ED79      280          OUT  (C),A         ;SEND THE CHARACTER
A025  23        290          INC  HL
A026  1D        300          DEC  E             ;IS IT LAST CHAR?
A027  C8        310          RET  Z             ;YES!
A028  03        320          INC  BC            ;SIO STATUS (AGAIN)
A029  18E5      330          JR   LOOP
                340
                350 ;RECEIVE ROUTINE
A02B  FE01      360          CP   1
A02D  C0        370          RET  NZ
A02E  1E00      380          LD   E,0           ;ZERO STRING LENGTH COUNT
A030  DD6E00    390          LD   L,(IX+0)
A033  DD6601    400          LD   H,(IX+1)
A036  56        410          LD   D,(HL)        ;GET STRING LENGTH
A037  23        420          INC  HL
A038  4E        430          LD   C,(HL)
A039  23        440          INC  HL
A03A  46        450          LD   B,(HL)
A03B  69        460          LD   L,C
A03C  60        470          LD   H,B
A03D  E5        480 RXLOOP:  PUSH HL
A03E  3E17      490          LD   A,23          ;CONTROL KEY NUMBER
A040  CD1EBB    500          CALL £BB1E
A043  E1        510          POP  HL
A044  C0        520          RET  NZ            ;CTRL WAS PRESSED
A045  01DDFA    530          LD   BC,£FADD      ;SIO STATUS REG
A048  ED78      540          IN   A,(C)
A04A  CB47      550          BIT  0,A           ;IS THERE A CHARACTER AVAILABLE
A04C  28EF      560          JR   Z,RXLOOP
A04E  0B        570          DEC  BC
A04F  ED78      580          IN   A,(C)         ;READ IN THE CHAR
A051  FE0D      590          CP   13            ;CARRIAGE RETURN CHAR?
A053  2807      600          JR   Z,END
A055  77        610          LD   (HL),A        ;PUT CHARACTER INTO STRING
A056  23        620          INC  HL
A057  1C        630          INC  E
A058  7B        640          LD   A,E           ;TEST LENGTH OF STRING
A059  BA        650          CP   D
A05A  38E1      660          JR   C,RXLOOP
A05C  DD6E00    670 END:     LD   L,(IX+0)      ;SAVE STRING LENGTH
A05F  DD6601    680          LD   H,(IX+1)
A062  73        690          LD   (HL),E
A063  C9        700          RET
```

CONSTRUCTION

The interface may be built with a 50-way double sided p.c.b. edge connector soldered onto the board, in which case the completed unit is fitted directly to the expansion socket. Alternatively the interface can be mounted in a case with the 12V supply, and a 50-way ribbon cable used to connect it to the computer. The author's prototype was built in this fashion on a 160 x 100mm prototyping board. The interconnecting lead to the computer should be kept as short as possible to keep inter-lead capacitance to a minimum. With lengths of more than about 450mm problems could be encountered. Obviously the RS232 lead can be very much longer, and at lower baud rates may be up to ten metres or more! The connector chosen for the RS232 connection is a 25-way "D" type socket which, although fairly expensive, is the "standard" connector employed for this purpose. If the terminal is intended to be used with the CPC464 with DD1 disc interface, it will be necessary to extend the Amstrad expansion bus "through" the serial interface, to allow the disc drive to be fitted also. (Why haven't they done this on the DD1 interface?) CPC664/6128 users will not have this problem! The baud rate is set by fitting a link to i.c.4 as shown in Fig. 1; alternatively, a single pole, 6 way switch will allow the rate to be changed more easily.

CONNECTING TO RS232

The serial interface is configured as a DTE (data terminal equipment), which means that data is transmitted on pin 2 and received on pin 3 of the 25-way connector. The peripheral device could be wired to be either DTE or DCE (data communications equipment); this information will be given in the operating instructions for the equipment. Fig. 2 shows the connections required for each case.

TESTING THE INTERFACE

With the supply OFF, connect the interface to the computer, and switch on. If the normal Amstrad sign-on message does not appear, switch off immediately and check all connections, paying particular attention to address and data lines. If all appears to be well, the testing can be continued by entering the following BASIC lines:

```
OUT &FADD,&18 <ENTER>
OUT &FADD,&82 <ENTER>
```

The DTR and RTS lines should then go high (approx +10V).

USE UNDER CP/M

The interface can be used from CP/M, using PIP.COM to transfer files to or from the Amstrad by specifying the devices RDR: for input and PUN: for output, or byTTY: for both. For example, PIP FRED.TXT=RDR: will create a file on the disc called FRED.TXT, containing characters received through the interface. PIP PUN:=FRED.TXT sends the contents of FRED.TXT down the interface. More details on the use of PIP and other CP/M commands can be found in the Amstrad manual. The parameters of the interface are set in the following way:

Baud rate – Set by links (see Fig. 1)
Data bits – Set by CP/M's SETUP.COM
Parity – Set by CP/M's SETUP.COM
Stop bits – Set by CP/M's SETUP.COM

Note that the Baud rate setting part of SET.COM will have no effect

USE FROM BASIC

If desired (or if you can't afford a disc drive), the machine code routines in the setup program (Program 1) can be used to send and receive data. Assembler listings of the machine code routines are also given (Program 2) which may be modified if required. The routines will send and receive text using BASIC string variables, and it is essential that the strings are defined before calling the routines.

Lines 10-190 of the program configure the DART as required, by outputting the correct data to its registers. The rest of the program pokes in the machine code starting at A000hex. If this area of memory is to be used for other things, the start address in line 200 may be changed as desired. The code is 64hex bytes long.

To output a string to the RS232 port, use the following line (assuming that A$ has been defined earlier in the program):

```
CALL &A000,@A$
```

To abort sending, simply press the CTRL key – whereupon the computer will continue executing your BASIC program from the next statement. Note that a carriage return is not sent unless this is included in the string to be sent.

To get an input from the RS232 port, first define a string whose length is equal to the maximum required input, e.g.

```
B$=SPACE$(10)
CALL &A02B,@B$
```

Input will terminate when a carriage return character is detected (as with a BASIC INPUT statement) or the maximum number of characters, in this case 10, have been received. Again pressing the CTRL key will abort.

The addresses used for the two calls above assume of course that the machine code was poked in from A000hex, and if this is changed, the calls should be changed accordingly.

If the interface does not seem to be communicating, but passes the earlier tests with flying colours, it is likely that the cause of the problem is either the RS232 interconnecting lead or that the device you're trying to communicate with is not ready. Handshaking (or lack of it!) could also be the cause. In order to send data, the DART requires the CTS (clear to send) to be high, while to receive the DARTrequires the DCD line to be high. Note that the DCD line is taken to pin 6 of the 25-way instead of pin 8, because the DART monitors this line as if it were the DSR (data set ready) signal. The setup program allows the option of ignoring handshakes, which may be worth trying in difficult cases, but don't forget that the device that you're communicating with may be expecting them! PE

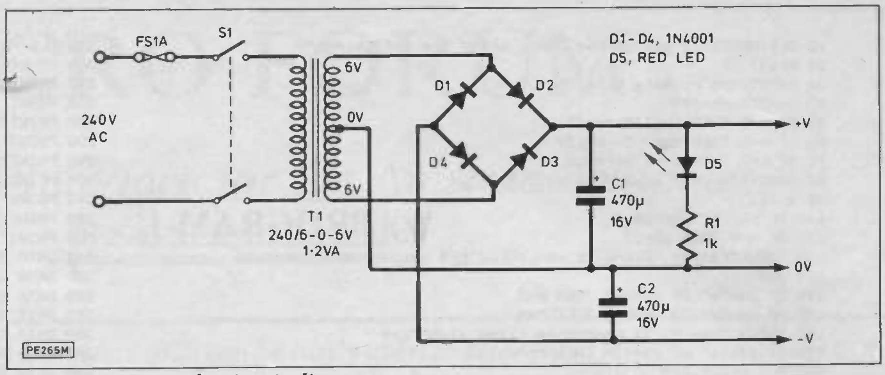


Fig.3. *Power supply circuit diagram*

COMPONENTS

RESISTORS

R1	2K2
R2	1M

CAPACITORS

C1	10nF ceramic capacitor

SEMICONDUCTORS

IC1	74LS133 13 input nand
IC2	74LS02 quad 2 input nor
IC3	Z8470A Z80A DART
IC4	4060 oscillator/divider
IC5	MC1489 quad RS232 receiver
IC6	MC1488 quad RS232 driver

MISCELLANEOUS

X1 2.4576MHz quartz crystal; 25-way "D" type socket; 50-way double sided p.c.b. edge connector; printed circuit board or prototyping board.

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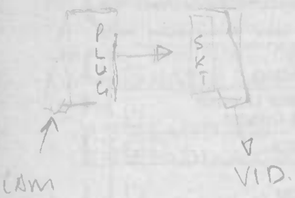
As yet there are few books to aid would-be computer repairers, and this one is a welcome addition. The first part of the book deals with some microprocessor basics, and this is followed by details of various types of test gear needed for checking microprocessor circuits. The final part of the book is a reference section which covers such things as circuit symbols and TTL integrated circuit details. I can't help feeling that most of the information in these sections is superfluous, as it is the type of thing that anyone contemplating microcomputer servicing should be very familiar with already or they should not be thinking seriously about delving into a computer's innards. It is the middle chapters of the book which are likely to prove most useful, and these cover fault diagnosis, tape and disc drives, and printers and monitors. The treatment is fairly comprehensive, and includes advice on how to replace devices without causing more damage than you repair, as well as the technicalities of fault diagnosis.

Servicing any electronic equipment is a situation where experience counts for more than anything, but this book should get the reader started on the right lines.

VIDEO FADER

BY R.A. PENFOLD



Don't mix – fade it in!

The cost of a video mixer, for most enthusiasts, is prohibitive but there is an alternative. Using the fading technique provided by this inexpensive project allows easy cutting from one scene to another.

WHILE video mixers have a lot in their favour when it comes to putting together a video, the problems with synchronising the two input signals properly are such that the cost of a video mixer is well beyond what most video enthusiasts are prepared to pay. A more cost effective approach is to use a fade-down and fade-up technique to cut from one scene to another, and some pieces of video equipment have a built in fader. With those that do not, a simple external unit such as the one described in this article can be used. The unit works with a standard composite video signal, and although it is very simple and inexpensive to build it achieves a reasonable level of performance.

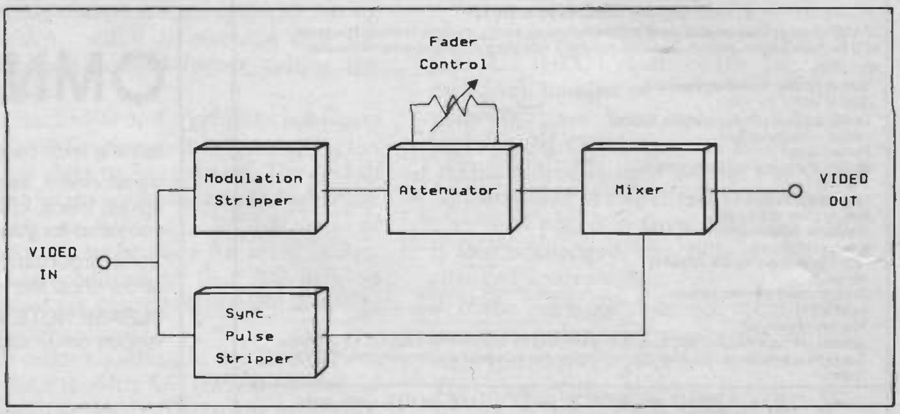


Fig.1. *Standard video fader block diagram*

FADER OPERATION

Although on the face of it a simple volume control type variable attenuator is all that is needed for this application, in practice things are not as easy as this. A volume control type circuit would certainly give the required fading action on the picture signal – but, unfortunately, it would also tend to fade down the synchronisation signals. This would result in synchronisation being lost well before the picture had been anything like fully faded out. Another problem with a simple volume control type circuit is that it could introduce significant variations in frequency response over the relatively wide bandwidth involved with video signals. A third point is that the action of a fader is effectively to decrease the amplitude (contrast) and DC bias level (brightness) of the picture, and not just the amplitude.

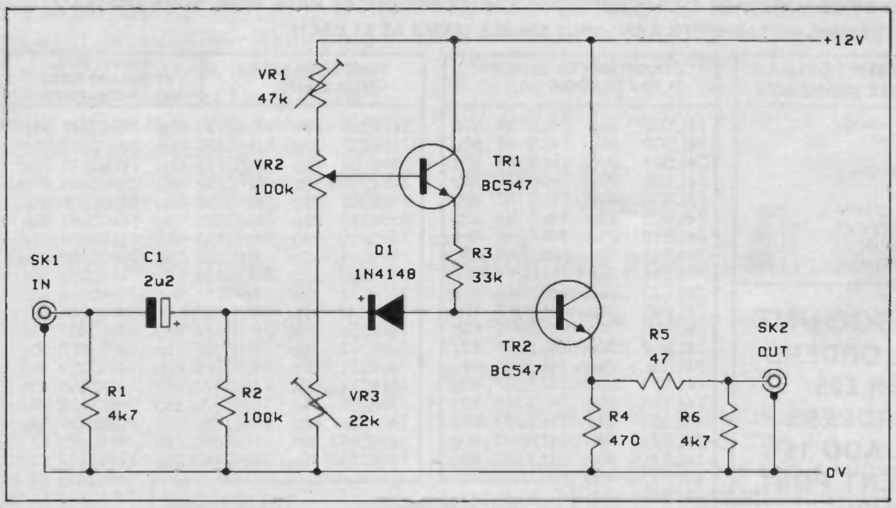


Fig.2. *Video Fader circuit diagram*

Ideally then, some form of wide bandwidth electronic attenuator is preferable, and the circuit must be designed to preserve the synchronisation signals at full level even when the picture signal has been faded to zero. It must also reduce the DC bias level as the picture modulation level is decreased.

The block diagram of Fig.1 shows the standard approach to the problem. The input signal is split two way, with one part of the signal stripping off the modulation and the other removing the synchronisation pulses. This process is not particularly difficult as the picture modulation is positive while the synchronisation pulses are negative. With the two signals separated, the picture signal can be faded up and down using an electronic attenuator having a suitably wide bandwidth, with this circuit also providing the necessary varying of the DC bias level. A mixer is then used to recombine the modulation and synchronisation signals.

In the fader circuit of Fig.2 a slightly simplified approach to the problem has

been adopted, and the circuit does not really use the normal splitting and recombining process. It is more a matter of letting the synchronisation signal pass more or less straight through while processing the modulation signal. At the centre of the circuit there is nothing more complex than an ordinary silicon signal diode (D1). This lets the negative synchronisation pulses pass through to the input ofTR2 which acts as an emitter follower buffer stage at the output of the unit.

Operation of the circuit on the positive going picture signal is perhaps less than obvious, but is pretty straightforward, TR1, in conjunction with the three potentiometers, acts as a variable voltage source, and this provides a forward bias to D1 via R2 and R3. With VR2 adjusted for maximum voltage, this gives a potential of several volts at the anode of D1, and only about half a volt or so less at its cathode due to the usual voltage drop through a silicon junction.

With the input signal on a negative half cycle the voltage at the cathode of D1 is taken lower, pulling the anode of D1 (and therefore the output voltage as well) down in voltage by an almost identical amount. Thus, as one would expect, the negative synchronisation signal is coupled through to the output. On positive going half cycles the cathode of D1 is taken more positive, and the anode tends to be pulled higher in voltage by TR1, so that the signal is still fed through to the output.

If VR2 is backed off somewhat so as to give reduced voltage, the DC output voltage of the circuit reduces, and on positive peaks the voltage supplied by TR1 becomes inadequate to pull the output voltage sufficiently high on signal peaks. The effect of backing off VR2 is therefore to reduce the brightness of the picture by diminishing the DC output voltage, and to cut down the contrast by decreasing the peak signal level, which is exactly what is required. Fig.3 shows the sort of output waveforms that would be obtained using a sinewave input signal. Obviously in audio terms the clipping method of attenuation provided by this circuit would be quite useless, but with a video signal it gives perfectly acceptable results.

If the voltage provided by VR2 is made very low, TR2 will start to cut off on negative signal peaks and the synchronisation signal would be lost. However, in practice the picture will fade down to nothing before the synchronisation signal becomes seriously attenuated. VR1 and VR3 are adjusted so that the full adjustment range of VR2 just about cover the full maximum to minimum signal range. The output signal is tapped off from the emitter of TR2 via the potential divider formed by R5 and R6, and with VR2 set at maximum the circuit should give no significant change in picture brightness or contrast.

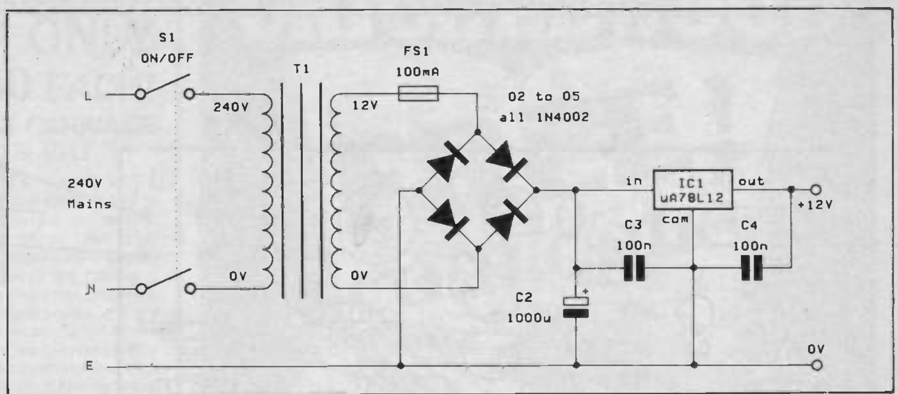


Fig.3. *(a) With a sinewave test signal an output of this type is obtained with VR2 at maximum. (b) The signal is faded by a process of positive clipping rather than true attenuation.*

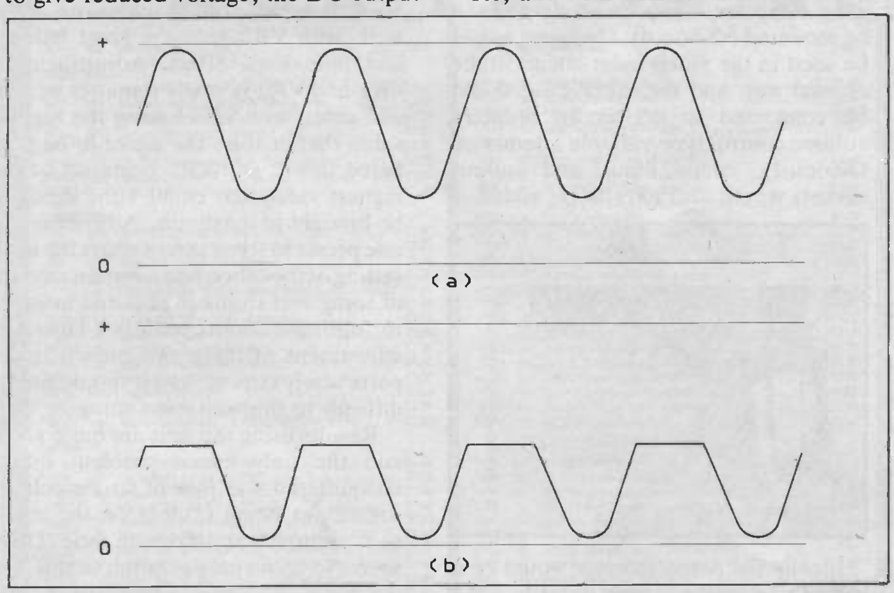


Fig.4. *Power supply*

PSU CIRCUIT

A well smoothed and reasonably stable 12V supply is required, and the supply current reaches a maximum of only about 15mA with VR2 fully advanced. A mains power supply is used and the circuit diagram appears in Fig.4.

The power supply circuit is entirely conventional with full wave (bridge) rectification and voltage regulation provided by IC1.

Details of the printed circuit board and wiring are provided in Fig.5. FS1 is mounted on-board in a pair of fuseclips. FS1 should be an antisurge type, as with a quick blow there is a likelihood that it

COMPONENTS . . .

RESISTORS

R1,R6	2k7(2off)
R2	100k
R3	33k
R4	470
R5	47

All resistors 1/4W 5%

POTENTIOMETERS

VR1	47k hor sub-min preset
VR2	100k 1in
VR3	22k hor sub-min preset

CAPACITORS

C1	2μ2 63V radial elect
C2	1000μ 25V radial elect
C3,C4	100n ceramic (2off)

SEMICONDUCTORS

D1	1N4148
D2,D3,D4,D5	1N4002 (4off)
TR1,TR2	BC547 (2off)
ICI	μA78L12 (12V 100mA regulator)

MISCELLANEOUS

S1 d.p.s.t. toggle switch; FS1 20mm 100mA antisurge; Sk1,Sk2 PCM phono socket (2off); T1 mains primary, 12V 100mA secondary; metal instrument case about 150x100 x50mm; pair of 20mm fuse clips; printed circuit board PE 127 see p.c.b. service; control knob; mains lead, plug, cable retaining grommet, pins, wire, etc.

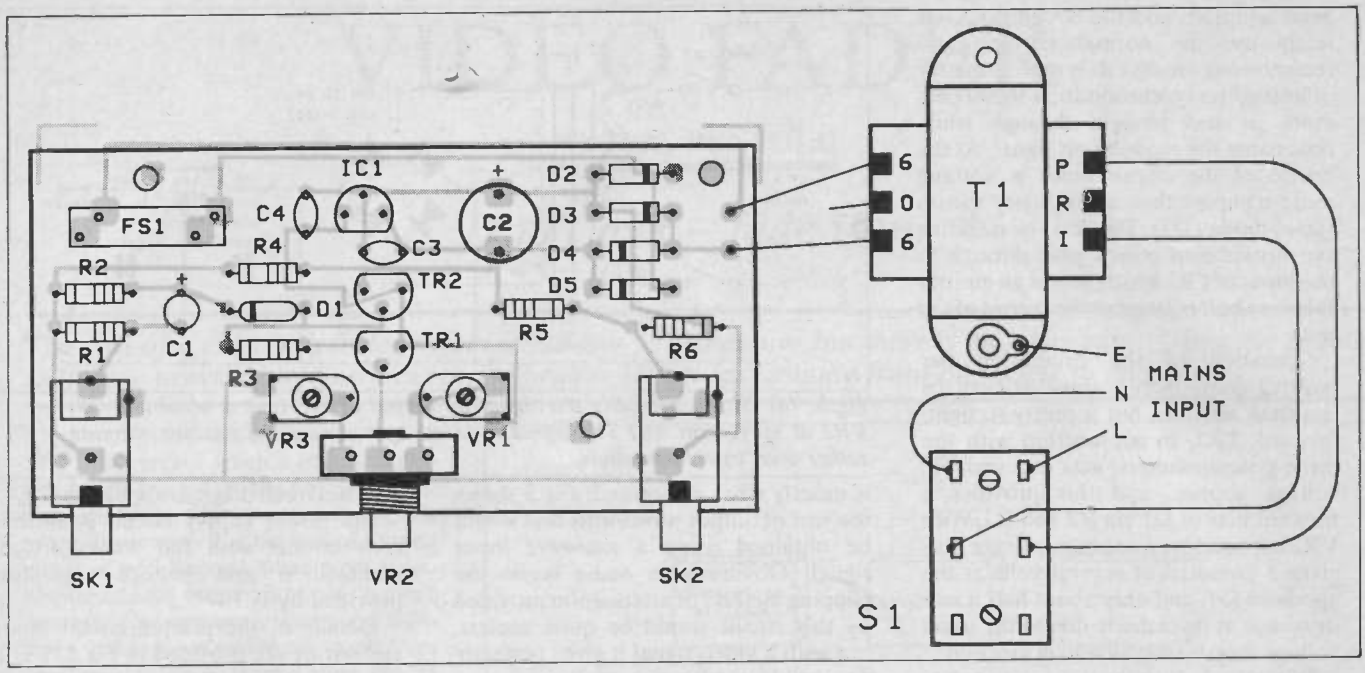


Fig.5. *P.c.b. and wiring details*

will blow a switch-on due to the high surge current as the smoothing capacitor charges up, SK1, SK2, and VR2 can also be mounted on the board, but this assumes that printed circuit mounting phono sockets and a 0.2in (5m) pitch printed circuit mounting potentiometer are used. In this case the board is mounted on the front panel of the case via the mounting bush of VR2, but the front panel must be drilled with holes to take SK1 and SK2 as well. VR2 alone will not provide a mounting of adequate strength, and the two mounting holes at the rear of the board can be used to fix the board to the base panel of the case, with spacers of appropriate length being used over the mounting bolts.

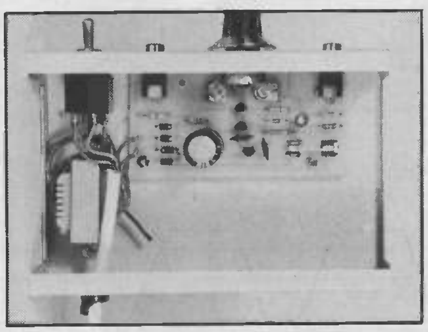
Alternatively the two sockets can be ordinary panel mounting types and VR2 can be mounted off-board as well. The board is then mounted on the base panel of the case using three M3 or 6BA bolts.

T1 is mounted on the base panel of the case, and a soldertag is fitted on one of the mounting bolts to provide a chassis connection point for the earth lead of the mains lead. The chassis of T1 and the case (if it is a metal type) must be earthed to the mains earth lead for safety reasons. T1 can be any mains transformer which has a secondary rating of 12V at about 50mA or more, and probably the best choice for this component is a 6V-0V-6V 100mA type with the 0V leadout cut short and otherwise ignored. Assuming that T1 is a miniature type, a case having dimensions of about 150 by 100 by 50m will comfortably accommodate all the components.

The small amount of point to point wiring is illustrated in Fig.5, and as with any mains powered project, due care should be taken when dealing with the power supply wiring. A cable retaining grommet should be used in the entrance hole for the mains lead so as to protect the cable and provide strain relief.

AUDIO SIGNAL

It has been assumed here that the unit must only control the video signal, and that any audio fading will be handled via a separate audio mixer (or whatever). If desired it would be quite possible to have the unit fade down the audio and video signal simultaneously, and to do this VR2 would have to be replaced with a dual gang component (which would have to be mounted off-board). One gang would be used in the video fader circuit in the normal way, and the other gang would be connected to act as an ordinary volume control type variable attenuator. Obviously audio input and output sockets would also have to be added.



Ideally the potentiometer would be a logarithmic/linear type, with the logarithmic gang being used in the audio circuit and the linear gang being wired into the video fader circuit. If a suitable component proved to be difficult to obtain the best compromise would probably be to use a twin gang logarithmic type.

With a stereo signal things would be less easy as a three gang potentiometer would be needed, and would almost certainly prove to be elusive. It might be necessary to resort to a dual electronic attenuator with the two circuits controlled by a second gang on VR2 connected so as to generate a suitable control voltage range.

IN USE

The unit is wired into the system using 75Ω coaxial leads fitted with the appropriate plugs (probably phono to phono or phono to BNC leads). With VR1 and VR3 set at about half maximum resistance the unit should work quite well, with VR2 giving a good fade-up and fade-down effect. Adjustment of VR1 and VR3 is really a matter of trial and error, with VR3 having the highest value that enables the signal to be fully faded down, and VR1 being set at the highest value that enables the signal to be brought to maximum. Adjustment of one preset to some extent alters the ideal setting of the other, and a certain amount of toing and froing is required in order to optimise both settings. However, adjustment of these two presets is not particularly critical, and it should not be difficult to find suitable settings.

Results using the unit are quite good, and the only minor problem that I encountered was that of strong colours sometimes being evident on the signal as it approached maximum fade. There seems to be no easy solution to this, but it is really only a minor problem and one that can be lived with.

As the unit is effectively voltage controlled (with the control voltage applied to the base of TR1) it would not be difficult to generate ramp voltages to provide a switched fade-up and fade-down action at preset rates, and this is something which would be an interesting modification for experimentally minded readers to try. PE

STE BUS

PART TWO BY RICHARD WHITLOCK

The Omnibus is here!

We are now down to the nitty gritty of the STE bus timing and control. This month we deal with the Read and Write cycles of data transactions. It is easy to see why the STE bus is gaining so much popularity amongst both designers and users.

HOW THE STE BUS WORKS

Now we have sketched the actors, let us get on with the play. There are four sorts of transaction available on the STE bus:

(1) The Read Sequence
(2) The Write Sequence
(3) The Read-Modify-Write Sequence
(4) The Burst-Mode Transfer Sequence

Of these only the first two are of universal importance, as the others are optional extras, to be used only if the hardware of the masters and slaves involved has the specific capabilities required. It is, however, necessary to take these optional modes into account when designing slave interfaces to the STE bus, so as to ensure that their use does not cause an unplanned response from a slave that is not intended to be involved.

Before becoming involved in the discussion of the signalling sequences for these four types of bus transaction let us look at exactly which signal lines are involved in particular sorts of bus cycle. Table 2 summarises these, and, like Fig.1, indicates the source of the signal. The following additional points should be noted:

(a) During a bus cycle in which an I/O slave is addressed CM2 High, CM1 Low, the levels of signals on lines A12–A19 are of no consequence.
(b) During a bus cycle in which a bus vector byte is to be read CM2 Low, CM1 High, CM0 High, the levels of signals on lines A3–A19 are of no consequence.
(c) The following combinations of signal levels on the command lines have no assigned function. They are reserved for future enhancements of the standard. No board produced at present may make any use of them or respond to them through incomplete decoding.

CM2	*CM1*	*CM0*
L	L	L
L	L	L
L	H	L

(1) The Read Sequence (see Fig. 2). This basic form covers memory reads, I/O reads and bus vector fetches. These three read operations differ only in the number of address lines which convey significant information and the levels of command lines CM1 and CM2 which define the slave function addressed.

If Fig. 2 looks a bit daunting, fear not. All the time periods with labels containing numeric subscripts have a common feature. That is t_1, t_2 . . . t all have a minimum length of 0nS and no defined maximum length. They are there solely to indicate the sequential order of events. They indicate that the two events that they link can happen simultaneously, or the right-hand event can happen at any time after the left-hand event, but that the right-hand event must not be allowed to happen before the left-hand event (the signal levels pictured in Fig. 2 are those to be found by attaching high impedance, low capacitance probes to the relevant lines of the backplane). Thus when testing a new board design one should ideally test to make sure that the correct signal sequences are received at each other slot in the system. By specifying the signal sequences in this way it is left up to the board designer to ensure that the design meets the standard, regardless of the particular characteristics of the bus drivers and internal timing logic that are employed.

The maximum and minimum periods of the intervals labelled with alphabetic subscripts are to be found in Table 3. These represent the more restrictive aspect of the standard, but, as can be seen, they are very few in number and affect only the beginning and end of a bus transfer sequence.

On with the motley! Assuming that our master has requested and received control of the bus, it now wants to perform a memory read from a slave memory card. Its address bus buffers, command line bus buffers and even its data bus buffers and ADSTB* and DATSTB* bus buffers may have been partially, or even fully, enabled by the process of receiving bus control. This is allowable provided that, during accesses to internal memory and I/O within a period of bus control, the master does not drive the ADSTB* or DATSTB* lines of the bus itself low. Obviously the data bus buffers will have to be set in output mode during such internal operations, if they are enabled at all. Time efficient designs are likely to have the address buffers and command line buffers permanently enabled during periods of bus control, with the data bus buffers being enabled by a combination of address decoding, command line CMO, and finally the relevant BUSAK* signal having the power of veto. ADSTB* and DATSTB* are more diffi-

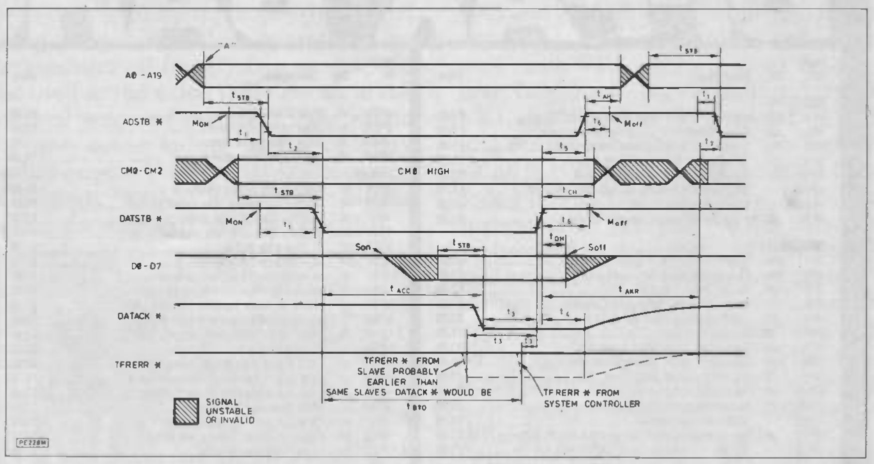


Fig.2. *The Read sequence*

TABLE 2. THE BUS LINES INVOLVED IN THE VARIOUS STE BUS TRANSACTIONS

BUSTRANSACTION TYPE	BUSTRANSACTION SUB-TYPE	ADDRESS LINES	DATA LINES	COMMAND LINES CM2 CM1 CM0	Comments
The read sequence	Memory read	A0–A19 (M)	D0–D7 (S)	H (M) H (M) H (M)	A0–A19 define 1Mb memory map.
	I/O read	A0–A11 (M)	D0–D7 (S)	H (M) L (M) H (M)	A0–A11 define 4 kilobyte I/O map.
The write sequence	Memory write	A0–A19 (M)	D0–D7 (M)	H (M) H (M) L (M)	
	I/O write	A0–A11 (M)	D0–D7 (M)	H (M) L (M) L (M)	
The read-modify write sequence	Memory RMW	A0–A19 (M)	D0–D7 (S:M)	H (M) H (M) H:L (M)	Read followed by write to same address. Address lines stable throughout. ADSTB* asserted throughout.
	I/O RMW	A0–A11 (M)	D0–D7 (S:M)	H (M) L (M) H:L (M)	
The bus vector fetch sequence	Special, read only	A0–A2 (M)	D0–D7 (S)	L (M) H (M) H (M)	
The burst-mode transfer sequence	Memory read	A0–A19 (M)	D0–D7 (S)	H (M) H (M) H (M)	An indefinite series of reads *or* writes. Address lines stable throughout. ADSTB* asserted throughout. Command lines stable throughout.
	Memory write	A0–A19 (M)	D0–D7 (M)	H (M) L (M) L (M)	
	I/O read	A0–A11 (M)	D0–D7 (S)	H (M) L (M) H (M)	
	I/O write	A0–A11 (M)	D0–D7 (M)	H (M) L (M) L (M)	
	Bus vector fetch	A0–A2 (M)	D0–D7 (S)	L (M) H (M) H (M)	

NOTE: A complete DATSTB* (M)/DATACK* (S) handshake takes place for each byte transferred on the bus regardless of the direction of the transfer.
KEY: (M) = line driven by master, (S) = line driven by slave, (S:M) = slave drives on read, then master drives on write, H:L = CM0 high on read then low on write.

TABLE 3. TIMING DIAGRAM INTERVALS

INTERVAL LABEL	DESCRIPTION OF INTERVAL	MIN. VALUE	MAX. VALUE	COMMENTS
t_1	Strobe bus buffer enabled to start of strobe signal transition.	0ns	none	
t_2	ADSTB* low on bus to DATSTB* low on bus.	0ns	none	
t_3	DATACK* low on bus to start of DATSTB* positive going transition.	0ns	none	External master's external stimulus to response.
t_4	DATSTB* high on bus to DATACK* open collector driver disabled.	0ns	none	External slave's external stimulus to response.
t_5	DATSTB* high on bus to ADSTB* high on bus.	0ns	none	
t_6	Strobe signal high on bus to strobe bus buffer disabled.	0ns	none	
t_7	DATACK* high on bus to ADSTBN* low on bus.	0ns	none	
t_8	DATACK* high on bus to DATSTB* low on bus.	0ns	none	Applicable to read-modify-write and burst mode only.
t_{STB}	Information lines stable on bus to relevant strobe low on bus.	35ns	none	
t_{AH}	ADSTB* high on bus to first change in address line signal levels.	0ns	45ns	Use 25ns to 45ns.
t_{CH}	DATSTB* high on bus to first change in Command line signal levels.	0ns	45ns	Use 25ns to 45ns.
t_{DH}	DATSTB* high on bus to first change in data line signals, caused by data bus buffers being diabled i.e. data stable into tri-state.	0ns	45ns	Use 25ns to 45ns Conservative interpretation of "grey area"
t_{ACC}	Overall access time of slave from DATSTB* low on bus to DATACK* low on bus	As specified by the manufacturer.		Check that your master's microprocessor can WAIT long enough.
t_{BTO}	User selectable bus timeout period.	<8μs	As available in design	Must be greater than max. t_{ACC} in system.
t_{AKR}	DATSTB* high on bus to DATACK* high on bus.	0ns	120ns	Determined by bus loading

STE BUS CONTINUED PAGE 34 ➔

PE PROMENADER

PART TWO BY MIKE DELANEY

35-channel disco lights controller

Continuing from last month. We now deal with the power supply and final constructional details of the Programming module of the Promenader. Next month we will be looking at the display.

Please note in the text of Part One, page 28 second column, reference was made to the 2046. It should read '2532'.

IC2 is configured to give a stepped-up output voltage. No capture diode or external current boost required, since the current requirement of the 25V line is a mere 50mA. The 497 contains its own capture diode, and can supply more than enough current. VR2 sets the output voltage to 30V, and this can be checked on TL2. If necessary this loop can be cut, to aid fault finding. The output from IC2 is taken to one of the most versatile power supply chips on the market, in my opinion, the 723. In this configuration the output current is limited by R9, and the voltage is adjusted by VR3. This should be set to 25V +/− 0.2V BEFORE a PROM is inserted into the ZIF socket. C8 decouples the VPP output.

When ROM PROG Switch, S1 is closed, +5V appears on R15 of the power supply board. This switches on TR3, which turns off TR2. Pin 9 of the 723 is allowed to float, and this enables the output stage of the 723, and the VPP appears on its output.

If the 5V line should happen to fail for any reason the VPP output will be clamped low by TR2, avoiding damaging the PROM.

CONSTRUCTION

PROMENADER is designed onto two printed circuit boards, and one small piece of Vero board. The boards are interconnected using plugs and sockets, and a 24-way ribbon cable and header plug/socket.

When making up the large board I suggest that, due to the large numbers of through-hole connections necessary, all diodes and resistors are fitted first, and then all the through connections are made. There are a few which must be fitted beneath some of the ICs, so it is important these are fitted prior to the IC sockets. Resistor R11 must be selected after the board is up and

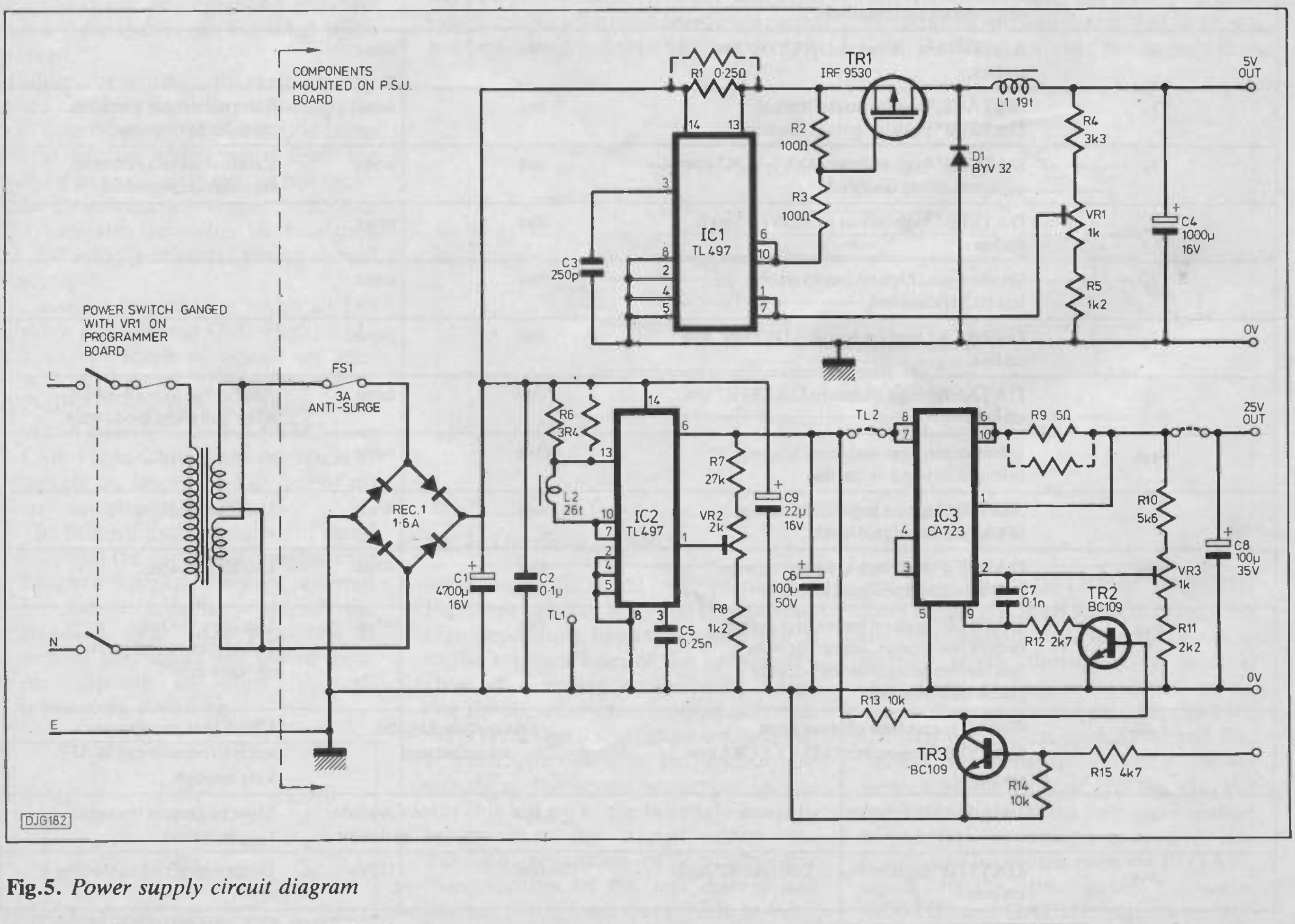


Fig.5. *Power supply circuit diagram*

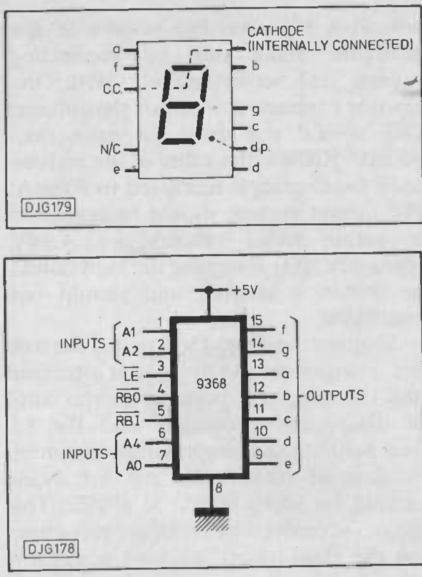


Fig.6. *Miscellaneous details of the display*

running. It is selected to give a positive PROGRAMMING pulse of 50ms, on TP2. If a 100k/ohm is fitted initially this is a reasonable starting value. It can of course be trimmed by gluing another in series with it or in parallel, to give exactly the right time. All the usual cautions apply . . . check for solder bridges, polarities and so on. And NOTE, some of the i.c.s are mounted upside down, so be very careful, compare the board with the layout drawing, Fig. 10, and with the photos as you go along.

The output socket from the main p.c.b. to the PROM Z1F socket is mounted on the reverse of the main board. This makes connecting and disconnecting easy during the building stage, and the p.c.b. takes this into account.

The l.e.d. are the usual 0.2 in red devices, and should be mounted close to the surface of the p.c.b. I'll not take bets, but . . . I reckon you are doing well if you can mount all forty the right way round first time! Resistor networks of three different styles have been used in this design. RN1 can be mounted either way round, as can RN3 to RN8, however, make sure RN2 is inserted the right way round before soldering it in place. An error here will be very difficult to correct.

Switches S1, S2, S3 and S7 are mounted direct to the p.c.b. but require a bit of careful trimming of the metalwork to avoid shorting to the tracks passing near them. The best way to tackle this is to offer them up, noting how much of the support needs to be trimmed, removing and trimming them using a sharp pair of wire cutters. The metal is moderately strong, so it should not bend your favourite snips. If you feel particularly brave you could always borrow the household scissors – but don't mention my name when you do!

COMPONENTS . . .

MAIN PCB

RESISTORS

R1,R14,R21,R24,	4k7 (5 off)
R2,R3,R4,R7,R8, R9,R23,R26,R27, R28,R29,R30,R31, R32,R33,R34,R35	10k (17 off)
R12,R20,R36,R37	68k (4 off)
R10,R15,R22	3k3 (3 off)
R13	1k
R16,R18	100k (2 off)
R201	1k8 (½W)
RN1	10k x 4
RN2	10k x 7
RN3,RN4,RN5, RN6,RN7,RN8	270R x 7 (6 off)

All 0.25W 5% unless noted.

CAPACITORS

C1,C2,C3,C5,C6, C7,C8,C11,C13	10n disc (9 off)
C4	470n polyester
C9,C10,C12,C18, C19,C20	10μ 16V tant (6 off)
C4,C15,C16	47μ 6.3V tant (3 off)
C17	100n 35V tant
C201	10μ 25V elect

SEMICONDUCTORS

D1–D12	1N4148 (12 off)
LED1–LED41	0.2 in red (41 off)
DISPLAY1 to 3	HP5082 7760 (3 off)
TR1	BC109
IC1	4001
IC2,IC3	4081 (2 off)
IC4	4069
IC5,IC6	4071 (2 off)
IC7,IC8	4011 (2 off)
IC9	4075
IC10	4073
IC11	4013
IC12	4017
IC13,IC14,IC15	555 (3 off)
IC16	4516
IC17	4503
IC18	4040
IC19,IC20	4049 (2 off)
IC21	4068
IC22	2532
IC23,IC24	6116 (2 off)
IC25,IC26,IC27, IC28,IC29	4599 (5 off)
IC30,IC31,IC32, IC33,IC34	2003 (6 off)
IC35	4028
IC37,IC38,IC39	9368 (3 off)

MISCELLANEOUS

S1,S2,S3,S7 s.p.d.t. p.c.b. mounting (4 off); S4,S5,S6,S8,S9,S10,S11,S12 Keylite k.k.s.w. SPC/O, momentary (8 off); S13,S14,S15,S16,S17 soft action KEF10901 s.p.s.t. momentary (5 off); TX1 0/9, 0/9 2A toroidal; filtered mains inlet socket IEC; chassis mounted fuse holder 20mm; p.c.b. mounted fuse clips 20mm (2 off); ZIF Socket 24 pin DIL; VR1 250k lin. with dp switch; ribbon cable & header, to suit case, 24 pin d.i.l.; case (see text); mounting hardware; turret tags; crimped connector plug/socket if desired; knob; printed circuit board; vero board, 3½" x 2"; wire, solder, etc.

POWER SUPPLY

RESISTORS

R1	4 X 1Ω in parallel = 0.25Ω (see text).
R2,R3	100R (2 off)
R4	3k3
R5,R8	1k2 (2 off)
R6	2 x 6.8Ω in parallel = 3.4Ω
R7	27k
R9	2 x 10Ω = 5Ω
R10	5k6
R11	2k2
R12	2k7
R13,R14	10k
R15	4k7
VR1,VR3	1k cermet preset
VR2	2k cermet preset

CAPACITORS

C1	4700μ 16V elect
C2	100n ceramic
C3,C5	250p tube ceramic
C4	1000μ 16V elect
C6	100μ 50V elect
C7	100p disc ceramic
C8	100μ 35V elect
C9	22μ 16V solid tantalum

SEMICONDUCTORS

REC1	4A in line (RS)
D1	BYV32 (or equivalent)
TR1	IRF9530
TR2,3	BC109
IC1,2	TL497
IC3	CA723 (must be ten pin type)

MISCELLANEOUS

Ferrite cores for L1 & L2 RS No. 228-258 (RM 10/400); 20 s.w.g. wire for L1 (19 turns) and L2 (26 turns); fuse clips (2 off); p.c.b.; aluminium for heatsink; mounting hardware; wire; turret tags; heatsink compound.

LOOP THE LOOP

Make up the test loops out of 22swg wire, cut and bent to a length sufficient to allow a scope clip to be connected if need be. After soldering in the l.e.d. it is necessary to connect each of their cathodes to the current limit resistor networks, RN3 to RN8. This is best done using the very fine insulated wire used in wire-wrapping and proto-wiring. The reverse of the board is marked to assist in this wiring. If a mistake should be made at this stage no real damage should be done, it will merely operate the wrong l.e.d. and will take a lot of sorting out! Do the wiring one row at a time, then check it before doing the rest. The check is easily done: simply put the instrument into programming mode and try to TOGGLE the l.e.d. high in turn.

The ZIF socket is mounted on a piece of Vero board approximately 3½in x 2in, along with R201, C201 and LED201. The resistor and capacitor are mounted on the underside of the board, directly to the pins of the ZIF socket. Is this 'Surface Mount' I ask myself? LED 201 should be mounted last, ensuring that the leads are left sufficiently long for it to poke through the case.

The ribbon cable should be split up and the conductors soldered direct to the pins of the ZIF socket. Be sure to check that this part of the assembly is correct before plugging a PROM in, otherwise the result could be terminal, and the PROM would suffer permanent amnesia! The easiest way of checking the wiring is to solder say pins 1 and 24 (both at the same end of the socket), and take a quick resistance check to the RAM sockets. Pin 1 should of course go to pin 1 and so on.

The power supply should not offer any great problem. The thing which puts off many constructors is the need to wind L1 & L2. Although not really necessary, TR1 and D1 are mounted on a heat sink made up from a thin aluminium strip, and bolted to the p.c.b. This is as much for strength and support of the f.e.t. as heat dissipation. The f.e.t. will, in fact, run quite cool even under full load conditions.

Presets VR1, VR2 and VR3 should be good quality cermet types, for good long term stability. Mains earth should be connected directly to the casing if a metal enclosure is used. This will help to reduce radiated noise from the power supply, as well as protect the user in event of a fault occurring in the wiring. The mains transformer is mounted directly to the chassis. In the author's case a toroidal type has been used, in order to reduce the overall project size.

If you intend using a toroidal type, make sure that the mains fuse is slow-blow, since this type of transformer has a relatively high surge current at switch-on.

The programmer unit is mounted in a slope-fronted case measuring approximately 17in x 8¾in. The power supply is mounted on the base and the large p.c.b. is mounted beneath the top so that the switches poke through holes cut in the metal. It is probably a good idea to make a template of holes by using the p.c.b. before fitting any of the components.

The ZIF socket is mounted through the casing as well, and is positioned in any convenient space. A useful addition is a piece of conductive foam glued to the case next to the ZIF socket, as this can hold a PROM ready for use, while preventing static damage.

Two pieces of red Perspex may be glued to the inside of the top cover in order to enhance the contrast of the l.c.d. and displays. The accompanying photos should clarify the mounting method used. Before mounting the large p.c.b. it is as well to check that none of the components are too high off the board. The double throw switches on the l.h. side require a depth of 12.56mm, so all the other components must be mounted closer than this. The boards are then spaced off from the case with threaded standoffs, and countersunk screws are used to enhance the appearance.

TESTING

Having completed the construction of the boards, we now come to the check-out stage.

Before connecting any two boards together the power supply must be set up. If you have a bench power supply, so much the better, as this will avoid connecting the mains to the unit. Set the supply to give 12v. d.c. at 1.5A, and connect it to the a.c. input tags of the p.s.u. board. The supply should be heard to start oscillating. This is not the fundamental frequency, but the much slower on/off oscillator timing, caused when the supply turns on to top up the reservoir capacitors on the output.

With a DC meter check that the voltage at pin 14 of IC1 is 10.5 to 11 volts with respect to TP1 (0V). Adjust VR1, monitoring the voltage present at the 5V output pin, and check this will swing through 5.1V by at least +/−100mV. Set to 5.1V and, if a scope is available, check the ripple at the output. This should consist of two components, a low frequency and a high frequency. With no load the l.f. should be seen as a negative going ramp, whose period is about 15ms, of amplitude peak to peak of 10mV.

Superimposed on this ramp will be seen the h.f. component. It is normal for this to exhibit a higher p-p than the l.f., and for the whole waveform to jitter as the capacitor goes through its charge/discharge cycle.

Take a 10Ω, 2W resistor and load the output, taking care because it will get hot. If a high wattage resistor is not available make one by connecting several in series/parallel. With the resistor connected, monitor the voltage. This should not drop by more than 100mV. Reduce the value of the resistor until the loading is increased to 800mA. The output voltage should be regulated to within 5.1V − 120mV, i.e. 4.98V. Recovery after removing the load should be within a second, and should not overshoot.

Scoping the output will reveal the true h.f. component. As the load is increased the l.f. ramp will become shorter until it disappears altogether and the l.f. component takes over. With a maximum loading of 800mA the p-p h.f. noise should be about 60mV, at 45kHz. This noise is removed by tantalum capacitors on the main board, so don't worry if it sounds a bit excessive.

This completes the 5V checks.

Adjust VR2, monitoring TP2, and check that the voltage here will set to 30V. Scoping TP2 will reveal the same sort of waveform as on the 5V line, and

	B.C.D. ADDRESS	DATA	HEX ADDRESS
a	0 0 1	0 0 0 0 1	0 0 0
	0 1 0	0 0 0 1 1	0 0 1
	0 1 1	0 0 1 1 1	0 0 2
	1 0 0	0 1 1 1 1	0 0 3
	1 0 1	0 0 1 1 1	0 0 4
	1 1 0	0 0 0 1 1	0 0 5
	1 1 1	0 0 0 0 1	0 0 6
	MSB	LSB	
b	0 0 1	0 0 0 1 0	0 0 7
		0 0 1 1 0	0 0 8
		0 1 1 1 0	0 0 9
		1 1 1 1 0	0 0 A
		0 1 1 1 0	0 0 B
		0 0 1 1 0	0 0 C
	1 1 1	0 0 0 1 0	0 0 D
c	0 0 1	0 0 1 0 0	0 0 E
		0 1 1 0 0	0 0 F
		1 1 1 0 0	0 1 0
		1 1 1 0 0	0 1 1
		1 1 1 0 0	0 1 2
		0 1 1 0 0	0 1 3
	1 1 1	0 0 1 0 0	0 1 4
d	0 0 1	0 1 0 0 0	0 1 5
		1 1 0 0 0	0 1 6
		1 1 0 0 0	0 1 7
		1 1 0 0 0	0 1 8
		1 1 0 0 0	0 1 9
		1 1 0 0 0	0 1 A
	1 1 1	0 1 0 0 0	0 1 B
e	0 0 1	1 0 0 0 0	0 1 C
		1 0 0 0 0	0 1 D
		1 0 0 0 0	0 1 E
		1 0 0 0 0	0 1 F
		1 0 0 0 0	0 2 0
		1 0 0 0 0	0 2 1
	1 1 1	1 0 0 0 0	0 2 2

DJG184

Fig.7. *Display examples*

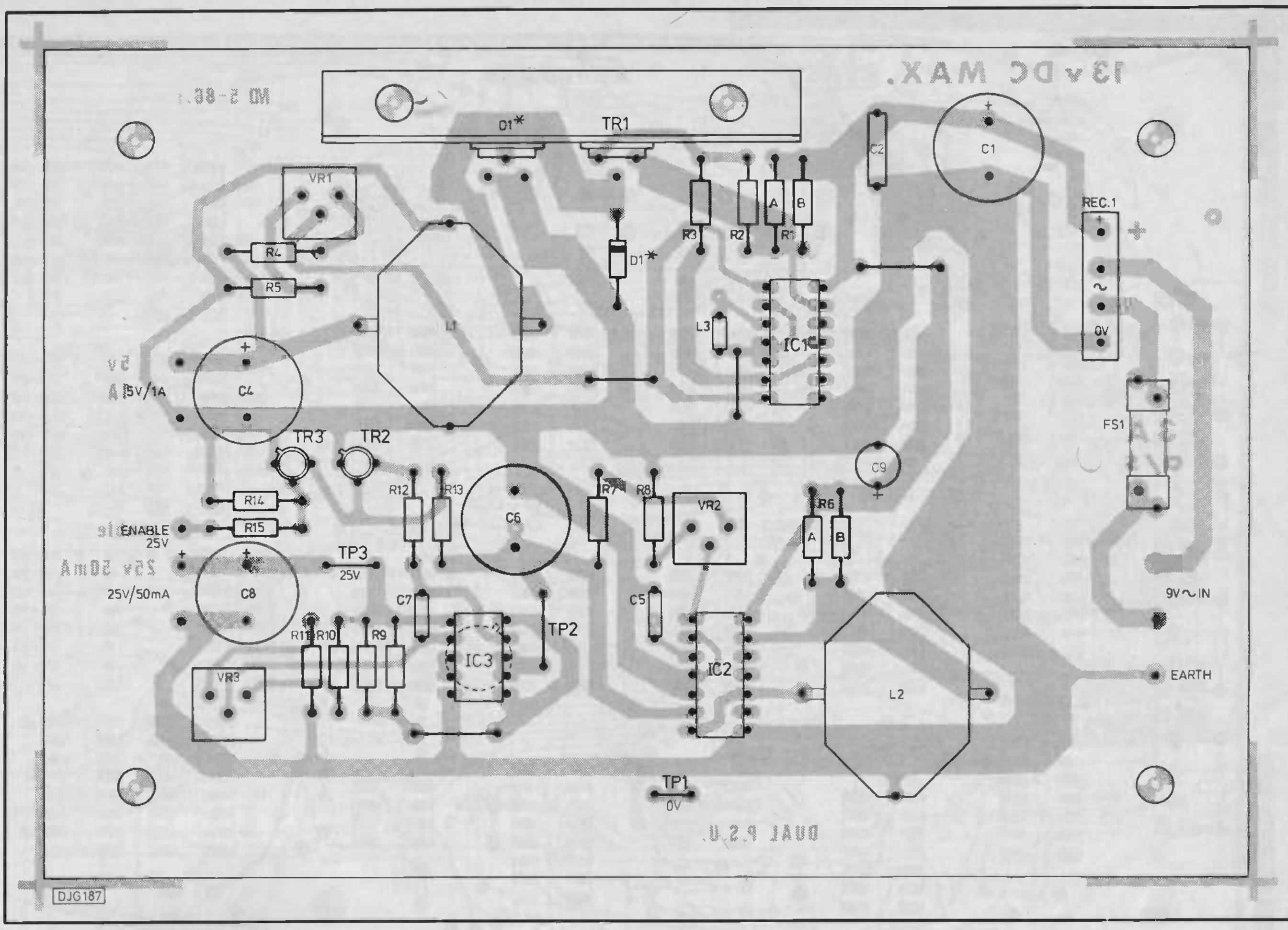


Fig.8. *P.c.b. design and component layout of the PSU*

this time the jitter will appear more pronounced. Connect a jumper lead directly from the 5V output to the ENABLE input, located next to the 0V output connector. This will enable the 723 regulator.

Now meter the 25V output line and adjust VR3 to give a precise 25V output. With no load on the output the p-p noise at this point should be very low, in the region of 5mV. Load the output with a 470Ω resistor and monitor the result. The noise should not increase in amplitude, although the frequency will be a lot higher. The regulator should cope with this load, and the output voltage should not change by more than a couple of millivolts (I can't measure any difference at all on my 3½ digit d.v.m.). The audible noise will disappear when the output is loaded. This was caused by the 497 having to put more charge into the capacitor on the 30V line, so that the l.f. component is no longer present.

The problem which might be encountered in setting up the power supply is likely to be lack of output current. As mentioned in the circuit description, the output current is set by R1 (5V), and R6 (30V). The author's resistor selection for R1 consists of FOUR separate resistors! There are 4 x 1Ω in parallel. The p.c.b. is designed to accept two resistors in this position, so it was necessary to piggy-back the extra two. The actual value required here is 0.25Ω, to give an I_{pk} of 2A (I_{pk} = 2 x I). If you have in your odds and ends box a resistor of sufficient rating and the correct value then it can be used instead of multiples. When mounting the limiting resistors on the p.c.b. it is a good idea to mount them clear of the surface. This allows a bit of air to circulate and stops the heat from discolouring the board. The limiting resistor on the 25V line needs to be 3.3Ω. The nearest value I had was 2 x 6.8Ω in parallel. As a personal note, I'm not sure of the suitability of using wire-wound resistors in the current limit position, because of their high inductance. I have always used carbon resistors here, and have never encountered problems. Perhaps someone would like to clarify this for me, via the editor's letter page?

When mounting the chokes, don't forget to clean the ends of the wire thoroughly and tin them before inserting them into the board.

The efficiency of the power supply was checked and found to be in the region of 65%, quite an acceptable figure.

MAIN BOARD

After checking and setting up the power supply the main board can also be tested.

It is a good idea to power up the main board first with the bench supply, setting the output to 5V at 500mA. The supply may be connected directly to the legs of C16, located next to the input plug. It is not necessary to have the ZIF board

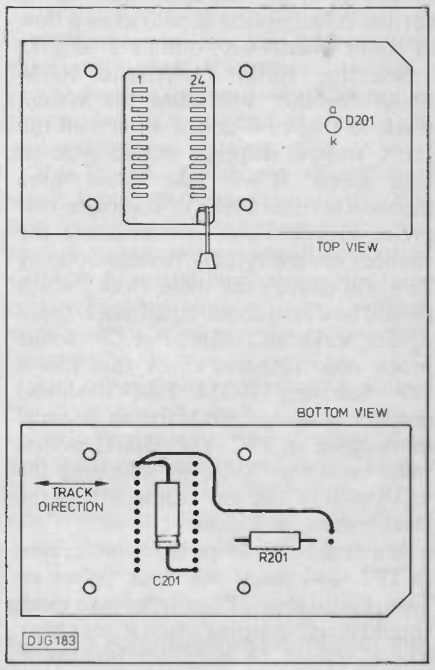


Fig.9. *Z.i.f. socket details*

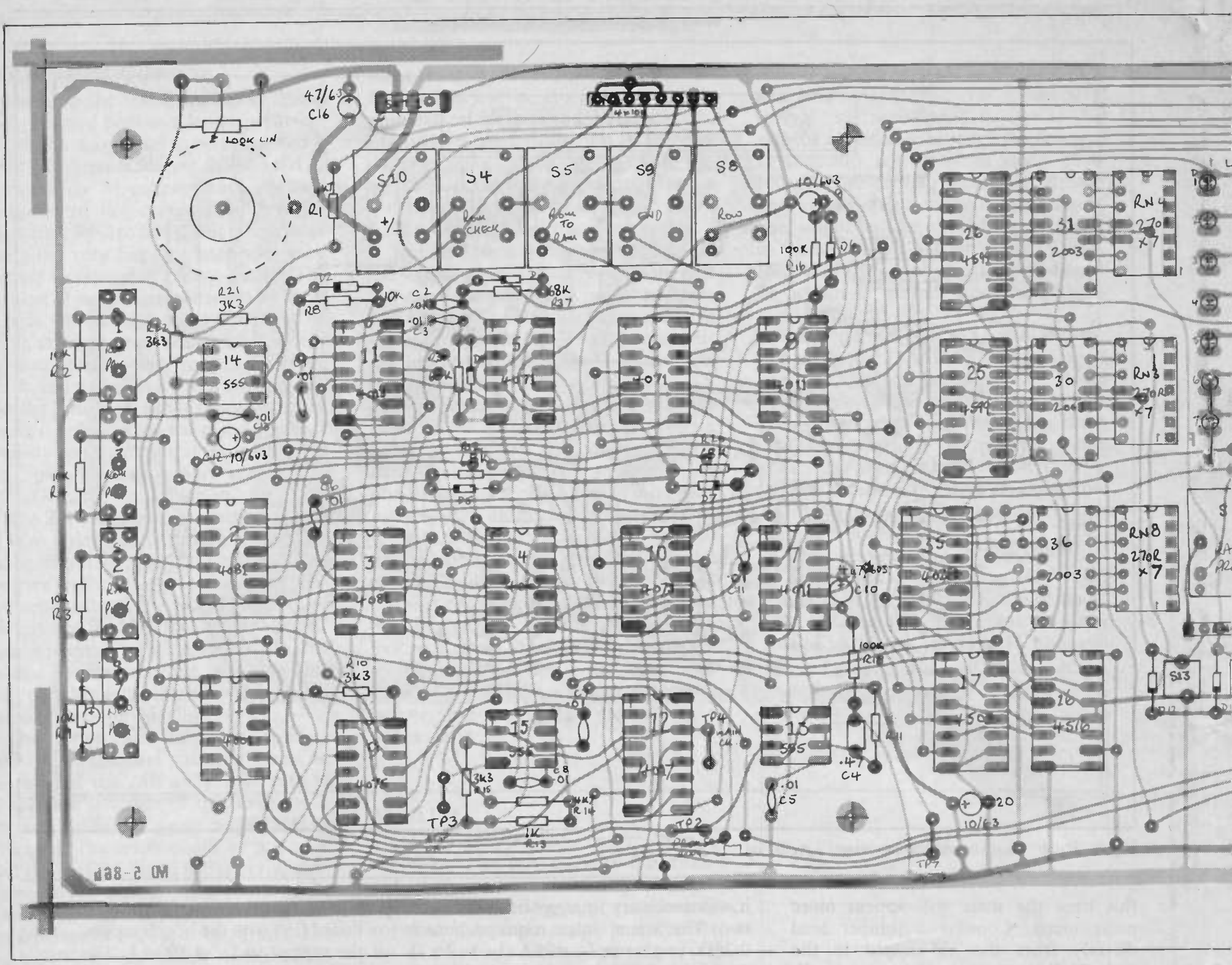


Fig.10. *Printed circuit board design and component layout of the main board (double sided)*

connected at this stage. Monitoring the current consumption should show a flow of about 400mA with one l.c.d. alight.

Selecting ROM PLAY and RAM PLAY together will allow the system clock to free-run, and if all is well the HEX address displays should cycle at high speed. It will take about three seconds for the MSD to complete one cycle. Provided this is reasonable the chances are everything is well. Scoping TP4 will display the main clock, which should be a just-about-equal mark-space square wave at 15kHz. Put the scope probe onto TP2 and check that this is low. Selecting ROM PROG should produce a square waveform of unequal mark-space at TP2. The HIGH period must be set to 50ms, by adjusting the value of R11. The low period will be ten clock cycles, or 1–2ms.

If a dual-beam scope is available, sync to TP2, and count the clock pulses on TP4. Every time TP2 goes low the clock should start, stopping when it goes high. There should be no jitter present at either point.

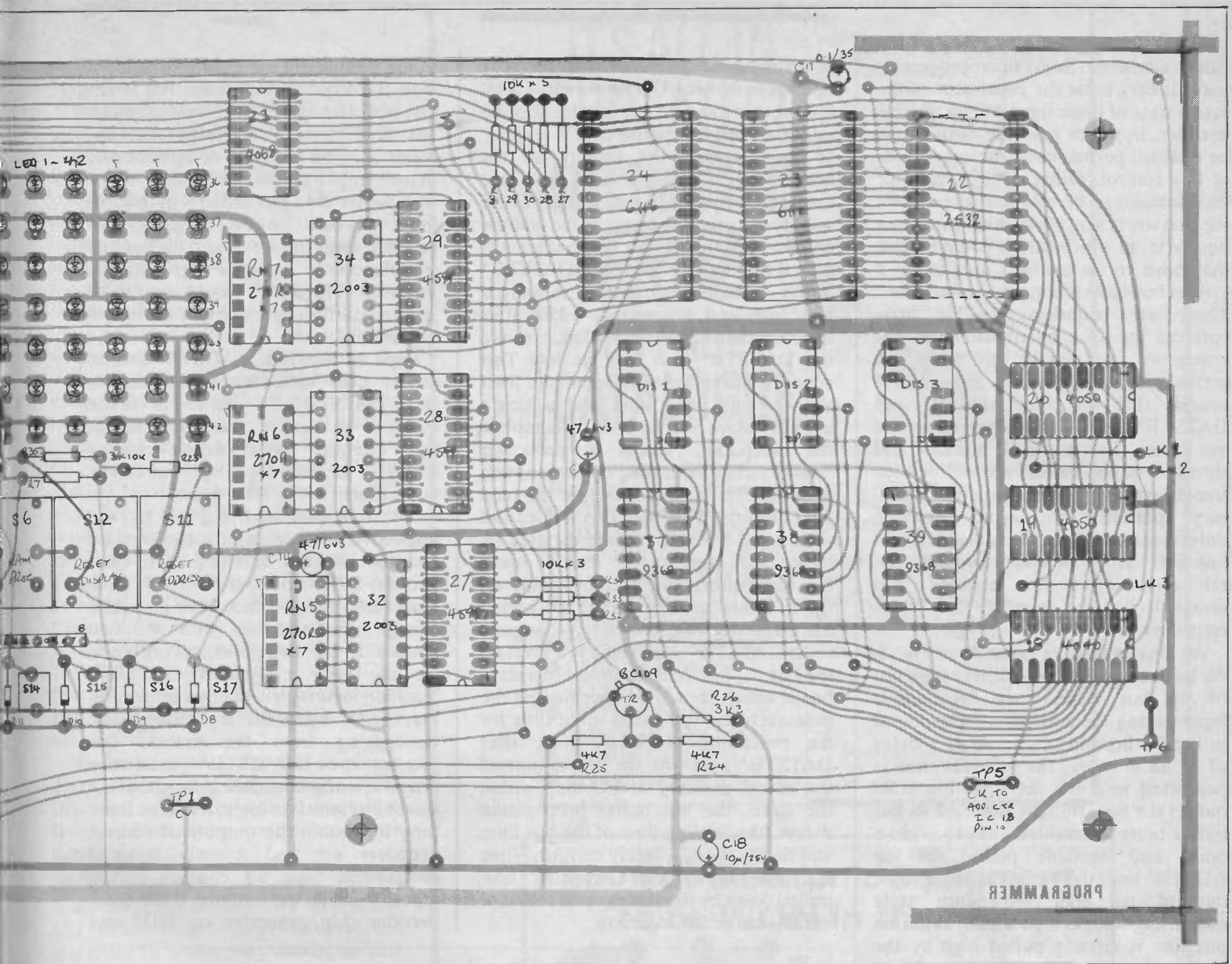
Select ROM PLAY alone, depress ROM to RAM, check the display cycles through at high speed, and that the six l.e.d.s on the bottom row are all lit. This confirms that all the data bus bits are being pulled high by their resistors. Pressing +/− will extinguish the right-hand five l.e.d.s, and this shows that both this switch and the data lines are OK.

Release ROM to RAM and check that the ADDRESS DISPLAY now cycles through at a speed dependent upon the setting of the speed control, VR1. The address should pause at every address (the MSBits are always decimal 7, 111 BCD). Now is a good time to check that the displays are working properly, and that all the digits are selected and displayed correctly, with no missing segments.

Select RAM PLAY alone, and check that the data transfer was correct and all the bits are set high at all the 2046 address locations. This can be done at minimum setting of VR1, since any error will flash a l.e.d. and can be easily spotted. Select NEW and RAM PLAY, check the clock stops, RESET ADDRESS, RESET DISPLAY, and check all of the 7 x 5 matrix l.e.d.s are out. Press ROW and check the left hand column l.e.d.s come on in sequence, and that rapid switch operation is blocked by the debounce circuit. Check that on position eight, all 40 l.e.d.s are extinguished.

Starting from address 000H, press RAM PROG ten times, checking each time that the address advances by seven, so that on the tenth operation the address displayed is 046H (70 decimal). RESET ADDRESS again, deselect NEW and check the replay is correct, i.e. that the address changes rapidly, and with it the Lamp display, pausing after each group of seven for a time dependent on the setting of VRT. Run through this again, this time holding down END, to check that playback stops at address 046H.

Select RAM PLAY and ROM PROG and check that the left hand l.e.d.s are strobed through at low speed and in sequence, from top to bottom, for the whole of the 046H addresses stored on RAM. At the end of these addresses the bottom six l.e.d.s should remain lit, and the cycle time will be much shorter, only one seventh in fact.



RESET ADDRESS and RESET DISPLAY, now overwrite the first 046H addresses with a simple program using the TOGGLE switches. Run through the playback of this a few times to get the feel of the procedure. Check that holding down all the TOGGLE switches and repeatedly pressing the ROW switch will turn on each row of l.e.d.s in turn, corresponding to the position of the ROW l.e.d., and try the +/− switch as well, by turning them off.

Switch off the bench supply and connect the power supply board, taking care to ensure the 25V line goes to the correct place, and observing the polarity of the 5V line. Set the bench supply to 12V at 1A again, and connect as for the power supply checks. Monitor the 5V line; this should be a steady 5.1V with all the l.e.d.s lit, and the f.e.t. should not get more than slightly warm. The system may now be checked again, with a weather-eye kept on the 5V line.

Remove the power and connect up the ZIF socket assembly. *BEFORE* inserting a PROM, power up and check that the power supply to the ZIF socket is where it should be – that is, +5V to pin 24 and 0V to pin 12. Check these voltages actually on the ZIF socket.

INSERT A PROM

When you are happy that this is all right, power down and insert an empty PROM. Do a quick ROM TO RAM transfer to reset the RAM, and have a go! The acid test comes when, after powering the system down, the program is still present in the ROM, and will successfully transfer into RAM with a ROM TO RAM transfer. If for whatever reason this does not work, refer to the oscillographs and the circuit diagram. These will usually be sufficient to find any fault which might occur.

The final check is the mains transformer. Install all three boards into the case, but leave the power supply disconnected. Wire in the mains switch, and fit the transformer, and input socket with fuse. Switch on, and check that, with the fuse removed from the power supply p.c.b., the secondary voltage is approximately 10V r.m.s. If so, switch off and put the fuse in the holder. This should be a 3A, 20mm type.

Power up again and confirm the d.c. voltage at pin 14 of IC1 does not exceed 13 volts. Check the output voltage is 5.1V, enable the 25V line and confirm this is still correct. If all seems to be OK, power down at the input socket, and plug the two boards together. Power up again and recheck the voltages.

Now for that acid test. Check that when ROM PROG is selected the 25V line is enabled; if so, proceed with the final programming tests. If all works out, you will have the beginnings of a very comprehensive light show, limited mainly by your patience and imagination.

An oft-repeated warning I know, but . . . do be very careful when checking or running this or any other unit if it is connected to the mains supply. The editor does not like to lose his readership, so please PLAY IT SAFE!

NEXT MONTH: Circuit description plus full constructional details of the PE Promenader Playback Unit.

➤ CONTINUED FROM PAGE 27

cult to advise on. Some microprocessors make it easy to tie the generation of the active state of these signals to an address decoder, in which case the buffers can be enabled permanently during periods of bus control. Other devices more or less demand to be allowed to generate the two strobes on every microprocessor bus cycle, in which case it is the buffers that have to be enabled only when a system bus cycle is required and allowed. There are countless possible logic patterns for each microprocessor, just remember, no system bus cycle, no active strobes on the bus. Figs. 2 to 4 assume that the lines ADSTB* and DATSTB* are tri-stated between system bus cycles, and that both masters' and slaves' data bus buffers are enabled for something close to the minimum necessary periods, to avoid possible unforeseen conflicts. The Mon/Moff and Son/Soff labels indicate where the relevant buffers are enabled and disabled by the master and slave respectively.

We finally start at point A of Fig. 2. We have a stable set of address lines out on the bus, bearing the logic levels representing the address to be accessed in the forthcoming cycle. After a delay of 35 nS *or more,* the ADSTB* line is permitted to reach the logic low state out on the bus. Initially however its bus buffer must be enabled and, to avoid a noisy and unstable period on the ADSTB* line, the bus buffer must come out of its high impedance state outputting a logic high signal, since the bus line is already pulled high by the action of the termination network. As soon as the bus buffer is fully enabled and able to source or sink its full current rating, or at any time thereafter, it may drive the line low. Thus we have two events that must happen before the ADSTB* line can make its transition. Note that the two timings relate to different points on the trace of ADSTB*'s signal level. t_{STB} specifies that the address lines shall be stable not less than 35nS before the ADSTB* line attains the logic low level, whereas t_1 specifies that the bus buffer shall be driving the line at full power at or before the time that the line voltage drops below the logic high minimum. This distinction is important. On a heavily loaded bus there can be a time interval of 10 to 20nS between a line dropping below the logic high minimum voltage and reaching the logic low maximum voltage. On the STE bus, with active low signalling, delays on low to high transitions slow things up a bit but are not generally of such significance.

ADSTV* reaching the low level confirms to the slaves on the bus that the information on the address lines is valid. At this point up to three slaves may be in the early stages of passing the address information through their address decoders. At this stage it is impossible to distinguish between a 20-bit memory address, a 12-bit I/O address and a 3-bit bus vector address. It could also be either a read or a write that is coming. In parallel with the activity on the address lines the command lines are settling to the required levels. These specify the sort and extent of the address and provide the answer to whether it is a read or a write access. The DATSTB* buffer turns on, outputting initially a logic high, and, at least t_{STB} = 35nS after the command lines have settled, can take the DATSTB* line to logic low. This action confirms that the command lines are carrying valid data and a single memory slave will be able to complete the decoding, access a particular memory chip for a read operation, and open its data buffers to output the read data onto the STE bus. This it does and then waits a period of time dictated by its internal logic for the data to reach the bus buffers and become stable on the STE bus data lines. After this period has elapsed a total time of t_{ACC} has gone since DATSTB* achieved a low level on the bus. t_{ACC} is a characteristic of a slave board which should be specified by the manufacturer. It is made up of time for the remaining decoding, done after DATSTB* goes low, the access time of the actual memory or I/O chip within the slave, the bus buffer propagation delays, the settling time of the bus lines and finally the t_{STB} safety margin. When t_{ACC} has elapsed the DATACK* line, pulled down by the slave's open collector buffer, can reach logic low.

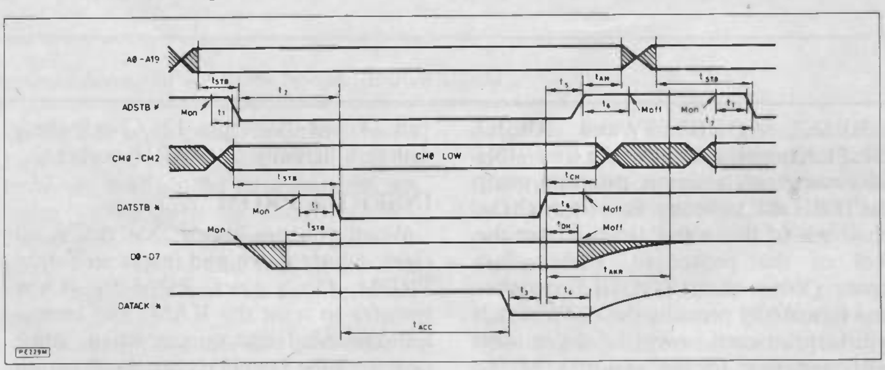


Fig.3. *The Write sequence*

If for some reason no slave responds to the information that the master has output, by pulling DATACK* low, within the timeout period set up in the system controller, then the system controller must pull TFRERR* low, again with an open collector buffer. If the slave is sufficiently sophisticated internally as to be able to detect malfunctions or chips not present then it too may pull TFRERR* low and will probably get round to it in rather less than t_{ACC}. This slave function is optional and seldom implemented. TFRERR* serves to inform the master that it may complete the bus cycle, and thus avoid "hanging up" the whole system. It is up to the designer of the master to equip it with the logic to recognise that it has just read a lot of garbage from the system bus and to take whatever remedial action may be possible. A sophisticated master might use the TFRERR* signal to close its data bus buffers, gate some innocuous data like a NO OPERATION op-code onto the internal data bus and simultaneously cause a non-maskable interrupt. TFRERR* would have to be ignored during other masters' periods of bus control.

Back at the Master, ADSTB* can be driven high simultaneously with, or after, DATSTB*, i.e. the levels on the bus can change in that relationship; again beware signal delays causing ADSTB* to reach logic high out on the bus before DATSTB* does. Now we come to another wart. t_{CH} and t_{AH} the respective hold times of the command and address lines with respect to their strobes, DATSTB* and ADSTB*, have minimum values of 0nS. They may then change simultaneously with the two strobes. In fact this poses real problems for the poor old slave. DATSTB* reaching logic high is the first intimation that the slave gets that it is time to start disengaging from the present bus transfer. Even if DATSTB* is used as an active-low master-enable throughout the slave's bus interface logic, it takes a finite time to disable the outputs of address decoders etc and it only takes a comparable time for changes in the inputs to reach the outputs. If the same decoder chip generates say RD* *and* WR* strobes it could issue spurious WR* pulses long enough to affect TTL latches etc, at the very end of what was supposed to be a read transaction. Better to let DATSTB*, and ADSTB* as well, have time to do their work in disabling devices before letting the master's other signals change. Treat t_{AH} and t_{CH} as if their real ranges were, say 25 to 45nS, rather than 0 to 45nS. Finally after DATSTB* and ADSTB* have reached logic high, their bus buffers may be disabled at any time. Note that once DATACK* has reached the high level, (or TFRERR*, which responds to DATSTB* reaching the high state in exactly the same way as DATACK*), a new cycle can begin with

ADSTB* going low if the address lines are stable and t_{STB} has been observed.

Assuming all goes well with our read operation DATACK* going low signals that there is valid data out on the bus, the master opens its bus buffers and latches the data internally, DATSTB* can now be driven high and the master's data bus buffers disabled again. The slave responds to DATSTB* achieving the high state by disabling its data bus buffers and ceasing to pull DATACK* low. The data bus lines must be undriven within 45nS of DATSTB* reaching the high state. (t_{DH}, at its right-hand end, indicates not a signal level but the point in time at which the data bus buffers have, to all intents and purposes, ceased to source or sink current.) The DATACK* line, and the data lines that were being driven low, will not drift up relatively slowly, under the influence of the termination network. The data lines do not matter, as they will be driven by powerful buffers to their new levels during the next bus transaction, but the bus is now effectively paralysed as a signalling system until DATACK* reaches the high level. With a worst case, fully loaded, 20 board backplane this can take 110nS.

We have covered the read sequence pretty exhaustively, and exhaustingly, so the other sequences will be treated to shorter discussions concentrating on significant differences.

(2) The Write Sequence (see Fig. 3). This basic form covers memory writes and I/O writes. The master initiates the sequence in a way very similar to that of the read. The first difference is that the master opens its data bus buffers and outputs the data to be written. This data must be stable on the bus t_{STB} before DATSTB* achieves the low state. The slave, recognising that it is addressed sometime after detecting DATSTB* low, enables the particular internal device addressed and, after opening its bus data buffers for input and allowing the internal data bus to settle, generates whatever write strobes are required by the addressed device. Only when the data is being latched internally does the slave pull DATACK* low. On detecting DATACK* low the master may begin to wrap up the transaction in exactly the same way as in the Read, with the additional aspect of having to disable its data bus drivers within 45nS (t_{DH}) of DATSTB* reaching the high state. t_{DH} is subject to the same suggested interpretation as are t_{AH} and t_{CH}, as the internal write signals of the slave may have active trailing edges and short set-up times.

NEXT MONTH:
Part three, the final part, looks at the other main specifications of the STE bus.

MICROWAVES

PART ONE – BY ANDREW ARMSTRONG

Whats cooking in technology today?

For some people the word 'microwave' conjures up the image of a kitchen appliance for cooking dinners. Others may think of radar or satellite communications. Microwave technology covers many fields, and it is an area of technology which touches almost everyone.

THERE has not been quite the revolution in microwave technology that occurred in the highly visible field of microprocessors, but rather, a fairly rapid and steady progress. As well as everyday applications such as cookers and radar speed traps there are others which use exciting new technologies. Needless to say, the Japanese are beavering away in these hi-tech areas.

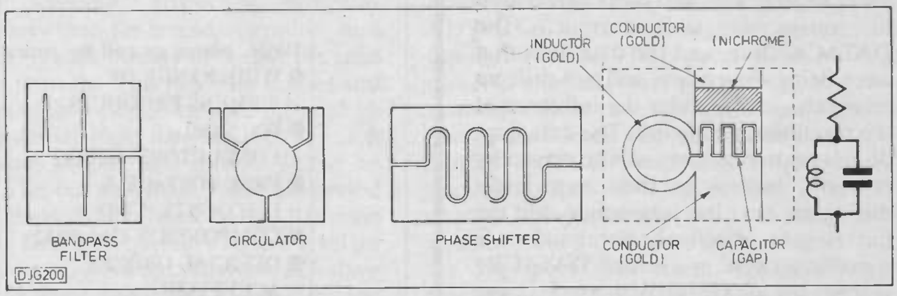


Fig.1. *Microstrip components.*

THE NATURE OF THE WAVE

There is not a completely clear division between microwaves and u.h.f. at the low end of the spectrum, or optics at the high end of the spectrum. It is generally accepted that microwaves start at 1GHz and occupy all the frequencies higher than that until, somewhere in the hundreds of GHz, it becomes more appropriate to refer to optics.

There is considerable crossover between optic and microwave technologies in the hundreds of gigahertz region, and this gives rise to surprising and interesting applications, such as plastic lenses to focus what is, ostensibly, r.f. Generally, however, in considering microwaves it is more reasonable to consider the r.f. field rather than to think of currents flowing in wires. Traditionally microwaves are routed through waveguides rather than coaxial cables, the dimensions of the waveguide being chosen to suit the frequency band in use.

A waveguide is a hollow duct through which microwaves can propagate, but not escape. Both rectangular and circular cross sections are possible, though the rectangular type is more common. A waveguide can do more than guide the wave to where it is needed. Waveguides with cavities, adjustable vanes, pieces of ferrite, and other inclusions serve as impedance matching devices, directional couplers, attenuators, and many other necessary functions. Such items are known as waveguide components.

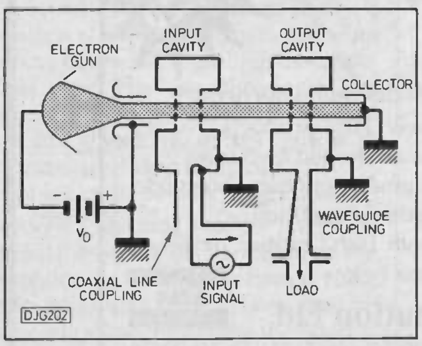


Fig.2. *Two cavity klystron amplifier*

MICROSTRIP

There is an alternative to waveguide components. Much signal generation and processing can be carried out on microstrip circuits, which are rather like surface mount p.c.b.s, but built on a ceramic substrate. Fig. 1 shows an example of simple microstrip components.

The principle is simple; a track on the surface guides the wave, and the electric field is mostly between the top track and the earthplane on the bottom of the substrate. In addition to microstrip components, surface mounting microwave components can be used. Microwave hybrid integrated circuits can be made in this way, including amplifying devices, bulk passive components, surface acoustic wave resonators, etc.

MICROWAVE GENERATION

There are many different generating devices to choose from, depending mainly on the power and frequency required. Thermionic devices which generate or amplify microwaves have been around for a long time, and even now the klystron exhibits lower close in-phase noise than semiconductor sources. This is particularly important in local oscillator applications.

The main thermionic devices in use are the klystron, the travelling wave tube, and the magnetron. There are many others, but these are largely variations on the same themes.

The Klystron shows a development of valve design for operation at frequencies for which the conventional valve mechanism of space charge control is not relevant. Instead of modulating the density of a diffuse electron flow by repulsion from a grid, the velocity of a focused beam is modulated. As can be seen in Figs. 2, 3 and 4 the various types of klystron all utilise resonant cavities, and are therefore each suitable for a narrow range of frequencies.

In fact, the reflex klystron (Fig. 3) is simply an oscillator which can work over several different, narrow, bands according to the repeller voltage used. Varying the repeller voltage is very much like varying the size of a supplementary cavity, so that when phase conditions are correct oscillation can occur in different modes.

The multicavity klystron (Fig. 4), with three cavities, is a means of providing extra amplification and higher output powers. If the middle cavity is loaded to broaden its bandwidth a little, usable gain is availáble over a significant bandwidth. To give an idea of the available power, a high powered klystron might give ten kilowatts output at a frequency of 5GHz.

Travelling wave tubes are able to operate over a wide range of frequencies. As with most active devices, the design of the tube may be optimised for different parameters, such as low noise or high power. A typical tube is illustrated in Fig. 5.

In the travelling wave tube, the r.f. field is not confined to a limited space as in the klystron, but instead is distributed along a helical wave propagating structure. The r.f. field interacts with the electron beam along the length of the helix. The helix is referred to as a slow wave structure, because it is designed so that the phase velocity of the wave is considerably less than that of light – typically about ten per cent of light speed.

The velocity of the electron stream is set to be approximately equal to the phase velocity in the slow wave structure. Then, when a wave is fed into the helix, it interacts with the electron beam in a coherent manner, causing bunching of the electrons. This bunching in turn induces additional waves further along the helix, and the net effect is that d.c. power from the electron beam is converted to r.f. power in the helix. Efficiencies of around 30% are common.

The magnetron is perhaps the most interesting of the tubes, both for its history and its current wide range of applications. Fig. 6 shows the structure of a magnetron. As you can see, there is an r.f. output but no input. This device is a simple high powered oscillator. Its frequency stability is slightly dubious, but it is rugged and reliable and largely problem-free. Its main uses are in microwave cookers and some types of radar.

The resonant cavity magnetron was developed by Randall and Boot at Birmingham University during the Second World War in an attempt to make a practical airborne radar. This was a very successful venture, and the resulting radar was credited with giving the decisive edge which won the battle of the Atlantic. The magnetrons then in use would typically have worked at

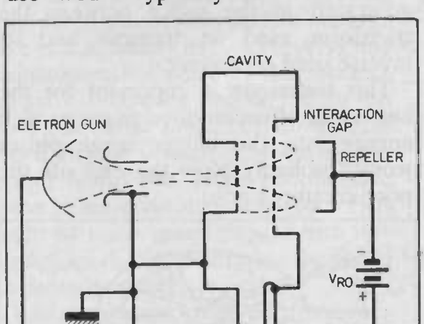


Fig.3. *Reflex klystron*

10GHz. Thousands of them were manufactured in America for the RAF.

The magnetron, as its name implies, works by virtue of a magnetic field. A strong field is imposed axial to the cathode, so that electrons leaving the cathode spiral round past the cavities. As with the klystron, the field in the cavities interacts with the electron flow to cause bunching which induces further field etc. Power is extracted from one of the cavities by means of a pickup loop in this example. The frequency of oscillation is affected to some extent by the anode voltage, but mainly by the cavity size.

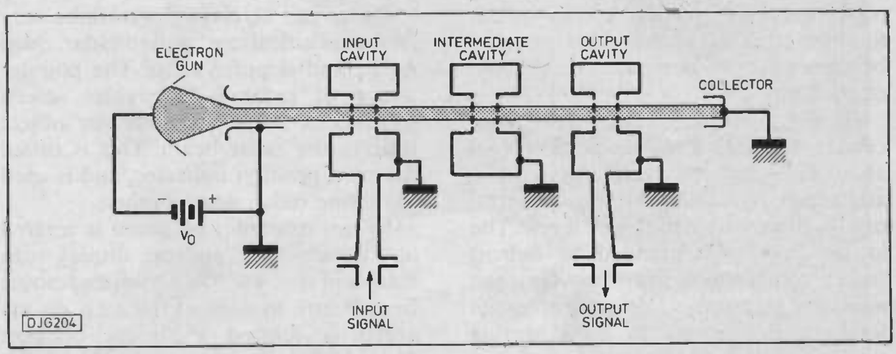


Fig.4. *Three cavity klystron amplifier*

SEMICONDUCTORS

Generation and amplification of microwave signals by means of semiconductors is far more glamorous than tubes. It is also preferable, where it is appropriate, for the same reasons that semiconductors are preferable for other applications.

For a long time, two terminal devices, Gunn and Impatt diodes, have been the main contenders. Now there is a third class of devices, MESFETS, as well as microwave i.c.s. These latter are only for low level amplification.

The Gunn diode is not made from silicon, as it needs to be made from a material with two discrete conduction bands at different energy levels. Galium arsenide or indium phosphide are suitable. Electrons gain energy from the applied electric field, and begin to transfer to a higher energy conduction band in which the mobility is smaller. As a result, the higher the field, the lower the current, giving rise to instability. Narrow areas of high electric field are produced, and these travel through the device, with the frequency of the resulting oscillation depending mainly on their transit time.

By contrast, the Impatt diode works by having a localised avalanche region at one end, followed by a low conductivity region with a lower field, across which the carriers, generated by the avalanche, drift. The current is controlled by the avalanche voltage, but changes in the current are delayed by the transit time of the carriers. With an effective negative resistance and a delay, oscillation occurs. This oscillation can be adjusted over a wide range of frequencies.

Powers of several hundreds of milliwatts continuous are available from Impatt diodes. They can also serve as small signal amplifiers.

M.e.s.f.e.t.s are very fast f.e.t.s, partly by virtue of the metalised gate structure. In general, f.e.t.s have more potential for high frequency operation than bipolar transistors because they do not suffer from the effects of carrier storage. The main frequency limitation of f.e.t.s is the time taken to charge and discharge the gate capacitance. In this respect the low resistivity of the metalisation helps by keeping the internal time constant of the device short.

M.e.s.f.e.t.s able to provide hundreds of milliwatts at frequencies of up to 30GHz are under development.

APPLICATIONS

For many people, the most familiar microwave devices are microwave cookers. This type of cooking appliance is capable of heating and cooking food (in most cases) much more rapidly than conventional methods. However, microwave heating does not produce the same surface browning and crisping of food as other methods.

In principle the method of cooking with microwaves is simple. Microwave energy at the allocated frequency of 2.45GHz is fed into a screened enclosure in which the food is placed. The microwave energy is absorbed by moisture, fat, and other components of food, and most of the energy is absorbed in the outer centimetre. Contrary to popular myth, the food is not cooked from the inside out. However, heating directly to a depth of one centimetre is much quicker than waiting while the heat conducts into the food from the outer surface.

There are some disadvantages with microwave cooking. Apart from the lack of browning and crisping, the distribution of microwave energy in the enclosure is usually uneven – and so is the cooking. In the past microwave

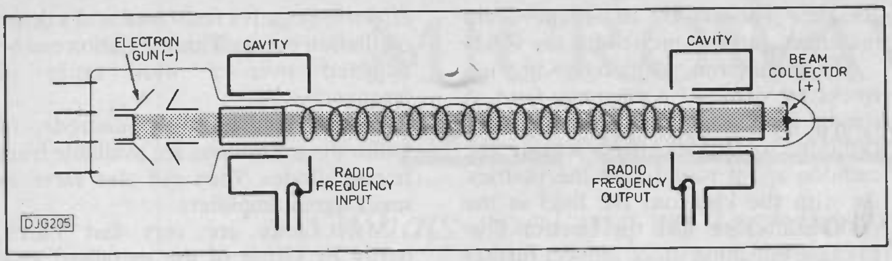


Fig.5. *Basic helix travelling-wave tube. The magnetic beam-focusing system between input and output cavities is not shown.*

cookers used rotating multi-vaned 'mode stirrers' to disturb the energy pattern in the (usually vain) hope that it would average out. Most modern cookers now use a turntable to move the food round in the cooker. This seems to be more effective at evening out the rate of cooking.

The typical domestic microwave cooker provides a maximum power of about 650W, and has a turntable, a timer, and either an adjustable power control or else three switched power levels. The lowest power is intended to defrost frozen foods much more rapidly than room temperature, while preventing the food from starting to cook during thawing. Otherwise, there is a tendency for hot spots to develop during defrosting, as ice is a poor absorber of microwaves, and water a good one. Higher powers are used to reheat or cook food.

The method of power control is surprising at first. To reduce power from high to medium if there are just three switched positions, it is normal to switch in a high voltage a.c. rated capacitor in series with the secondary of the transformer supplying the h.t. to the magnetron. This added a.c. impedance reduces the current. No smoothing of the h.t. is used, so the duty cycle of the capacitor is reasonable. On the other hand, because the magnetron is being supplied from a pulsed d.c. source, its frequency is not constant and a fairly broad frequency spectrum is generated. This has been known to cause television interference.

This method cannot be used to provide the lowest power because the magnetron would not work reliably at that power level. Therefore burst fire is used, so that the magnetron is run at full power for a few seconds and is then switched off for an interval, giving low average power.

Microwave cooking is now widely used in homes, and to reheat prepared portions of food in cafes and takeaways. To increase its applicability further some manufacturers have added a hot air generator to provide crisping and browning. Personal experience (in the name of research, of course) shows that a roast chicken cooked in this way can be ready in under half an hour and is similar in all respects to one cooked in an ordinary electric or gas heated oven – delicious.

RADAR

Radar can be divided into three very broad classifications: pulsed radar, chirp radar, and doppler radar. The popular image of radar is a circular screen showing a 'blip' wherever an object reflects the radar beam. This is called the plan position indicator, and is used in marine radar, among others.

In this example, an aerial is rotated at a steady rate, and the display scan rotates in sync with the aerial, and moves from centre to edge of the c.r.t. As the aerial is rotated a stream of high powered microwave pulses is transmitted, and reflected pulses are received and displayed on the screen. The further away the object reflecting the pulse, the longer the reflection takes to arrive, and the further across the screen the scanning beam has moved. This results in a spot at a point on the screen corresponding with the angle and distance of the object from the radar transceiver.

A single reflection from an object would not be very visible on the screen, but because the aerial rotates relatively slowly and the p.r.f. (pulse repetition frequency) is fairly high, a number of reflections will occur even from something small. It sounds simple but the reality is more complex. The transmitted pulse must be short, and of a very high power. Ideally, the pulse should have a square amplitude characteristic, and the frequency should be constant throughout the pulse. To approximate this sort of pulse, a network of inductors and capacitors designed to simulate a length of transmission line is charged up to a high voltage and then discharged into a magnetron by means of a thyristor.

Unfortunately, this does not provide a perfectly square pulse, so that the frequency of the magnetron alters during the pulse. Remembering that the frequency spectrum of a square pulse of r.f. is of sin(x)/x form, the actual pulse from the radar has an asymmetrical smeared sin(x)/x form, which makes the design of receiver bandpass filters more difficult.

Another problem with receiver design is that the received signal strength follows an inverse fourth power law with range, because of the loss in each direction. It is normally necessary to sweep the receiver gain approximately following a fourth power law to compensate for this effect. Of course, the dramatic gain changes must not affect the frequency response, which imposes another design constraint.

Finally, lest the job seem too easy, the frequency of the magnetron is affected by its temperature, which alters the size of the cavities. The receiver must track this change. Of course, there is no continuous carrier to which an a.f.c. system can be locked so the receiver is locked to the breakthrough of the transmitted pulse into the receiver. There is always substantial breakthrough despite the best transmit/receive switching available.

Because the transmitted pulse has an asymmetrical frequency spectrum, it is difficult to stop the receiver from tuning itself off centre. Does anyone want to take up radar receiver design??

This type of radar obtains its positional resolution by using a pulse which is short in time and hence in space. Short range radars may use pulses 50 or 100ns long, giving resolutions of about 50 or 100 feet respectively. The peak power is very high, because there must be enough energy there to make the receiver respond adequately. Semiconductors cannot perform in this way.

FREQUENCY SHIFT

In a chirp radar, the same principle that bats use is employed to lower the peak pulse power while keeping the energy content high enough to be useful. The frequency of the transmitted pulse is swept in a controlled manner during transmission. Though the pulse may be physically very long, the length at any particular frequency bandwidth is short. If the inverse of the function used to smear out the frequency spectrum over time is employed at the receiver, the pulse is effectively compressed as accurately as the match between the transform used on transmit and its inverse used on receive.

This technique is important for the bat, as the effort required to get enough energy into the longer range pulses would probably blow the end off the poor creature's nose.

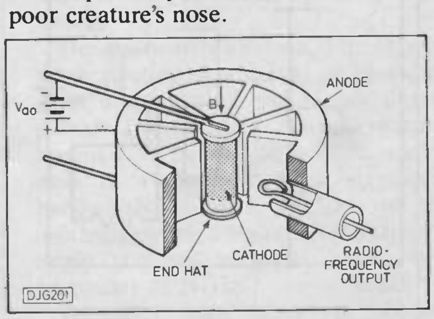


Fig.6. *Magnetron oscillator*

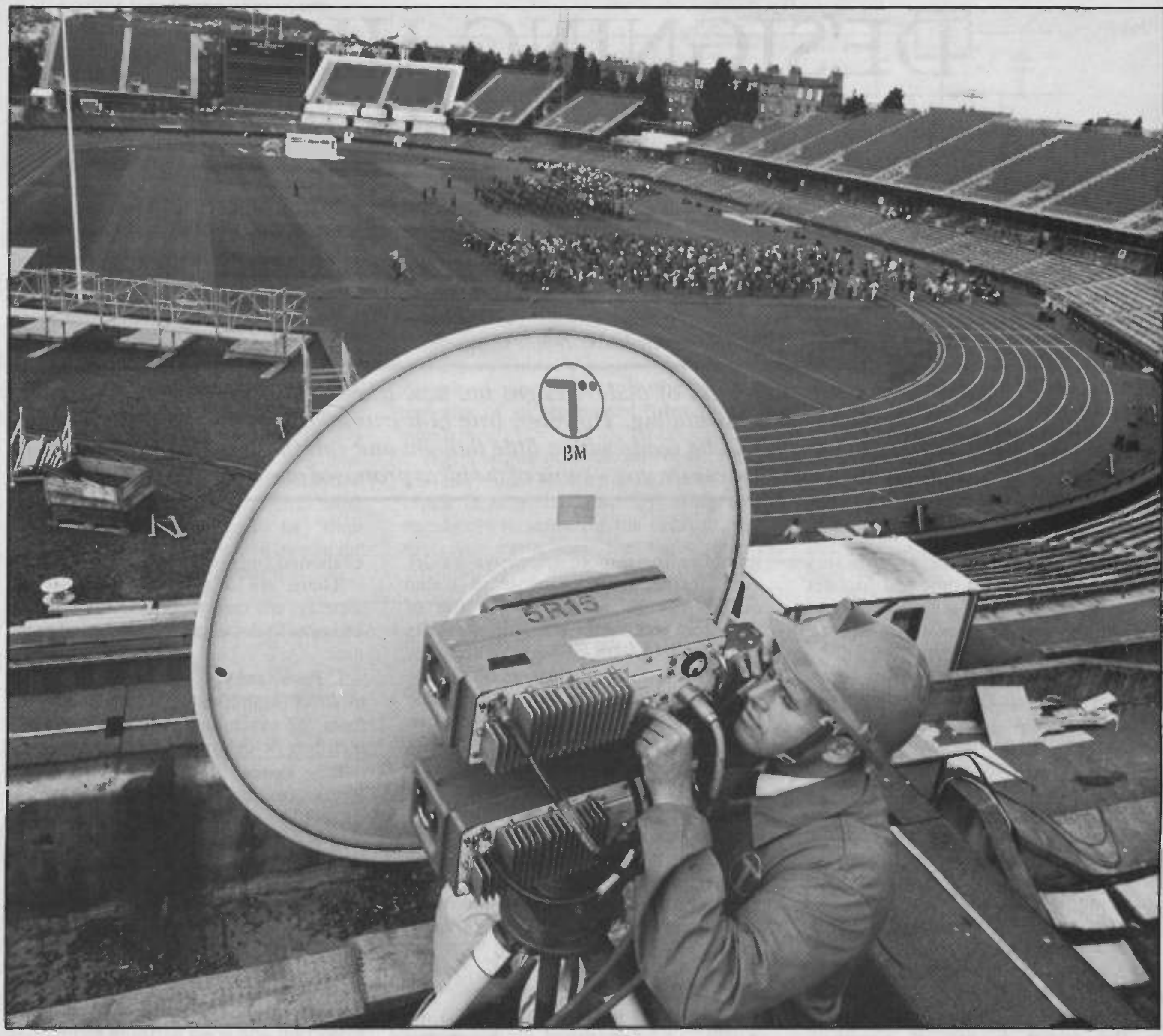


Photo.1. *Shows a B.T. engineer making final adjustments to the microwave dish which carried broadcast transmissions of the opening ceremonies of the 1986 Commonwealth Games.*

The chirp may be generated by feeding a pulse into a dispersive surface acoustic wave (s.a.w.) delay line. An inverse line reconstitutes the pulse in the receiver. The s.a.w. technology needed to do this is a whole other topic. Although radar helped Britain considerably during the Second World War, some people have reason to regret its invention – motorists caught by radar speed traps, which rely on doppler shift to determine the speed of a moving object.

This change in received frequency applies to electromagnetic radiation as well as to sound. The effect is not enough to interfere with a car radio when driving fast, but it can be measured. In the case of a radar speed trap, a reflected signal is compared directly with the original source, so that a difference is easily detectable. A beat frequency is generated between the microwave source and the reflected wave, and because the doppler shift acts on both the transmitted and reflected waves the beat frequency is doubled.

The doppler shift on each path is:

Shift = Frequency * velocity/speed of light

Taking both paths into account, and assuming that a transmit frequency of 10GHz is used, the doppler shift is approximately 30Hz per m.p.h. It is possible to measure frequencies in the appropriate range with good accuracy, so in principle doppler speed measuring equipment is very accurate. As the formula above demonstrates, the frequency of doppler shift on low frequencies would be much less than at microwave frequencies and would be more difficult to measure accurately.

As usual, practice is more difficult. Stray reflections from objects other than the target can confuse the system; for example, a corrugated fence on the other side of the road could act as a diffraction grating. It has been known for this effect to give readings bearing little relation to the speed of the vehicle when reflection from the grating is progressively cut off by the vehicle's bulk.

NEXT MONTH: More Doppler applications, communications and sharp end technology.

My thanks for information and explanation to: John Chambers of Aldwyn Associates; Andrew Emmerson in the Telecom press office; and Alwyn Seeds of University College London. PE

DESIGNING HI-FI AMPLIFIERS

BY GRAHAM NALTY

No noise please!

The electronics hobby press used to be full of audio designs but now it seems that with the cost of off-the shelf hi-fi being so low that interest is dwindling. However, true hi-fi enthusiasts claim that improvements in sound of many existing designs could be made with a little thought and careful re-design. This article is a guide to designing hi-fi amps – and let me warn you – some of the ideas proposed may be controversial!

DESIGNING hifi amplifiers can be very rewarding. Every time you discover a way to improve the sound quality of an amplifier, whether as a professional designer or as a hobbyist, you will be privileged to enjoy, in your own home, works of the greatest musicians with increased realism.

For many years, the design of audio amplifiers has almost stood still, with new designs offering little advantage over the old ones. But all the time there has been a dedicated hard core of audio enthusiast designers whose quest for better sound has led them to question old assumptions, and in doing so discover new ways of achieving better sound reproduction. Such a new movement in audio design has been gathering momentum which can be witnessed by the marked improvement in the sound quality of amplifiers manufactured in the last three years. My own research shows that we have only seen the tip of the iceberg, and that there are many amazing new developments which I shall cover briefly in this article. The technology is not so new, but the understanding of its real importance is new.

A successful New York manufacturer of ice cream was asked on his retirement the reasons for his success. He answered in three words: "Use good ingredients". The same principle applies to the design of hifi amplifiers. The quality of components used in an amplifier is very important in determining its sound quality. Each resistor, capacitor and even semiconductor can sound different. Many hifi enthusiasts are learning that if they change resistors and capacitors in their amp to higher quality versions, such as metal film resistors and polyester or polycarbonate capacitors, the sound quality is substantially improved at a very low cost compared with trading the amplifier for a more expensive model. And further improvements in sound quality can be gained by the use of precision metal film resistors normally associated with high accuracy instrumentation, polypropylene capacitors, and long life computer-grade electrolytics for the power supplies. These components are very expensive in comparison with the components normally used in audio amplifiers, but the improvement they make more than justifies the cost in the context of a hifi system. In no instance is the use of such components more justified than in the rebuilding of old favourite valve amplifiers by Quad, Leak and Radford.

REQUIREMENTS

So what are the requirements for the design of good hifi amplifiers? The textbooks will tell you that these are a flat frequency response from 20Hz to 20kHz, and low harmonic distortion of sine waves over the whole range. You will soon learn from practical experience that these parameters are almost irrelevant. Two amplifiers with identical frequency responses may sound tonally very different. On the other hand, a valve amplifier with very poor distortion measurements may sound considerably better than a transistor amp with extremely low distortion. The answer is to consider why we listen to music and how music gives us pleasure.

This is not the place to talk about the qualities of great music. Suffice to say that great music can convey emotion, tell a story, excite, hold our attention by continuously changing tempos, and impress by the beauty of human voices or of instruments. A good high fidelity amplifier must bring all these qualities to the listener. To achieve this every aspect of performance needs to be evaluated and the highest standards set.

There are a number of important aspects of design which I wish to examine in detail in this article and these are:

1. Power supply. The source of power to drive amplification circuits derived from the mains, via a transformer and rectifiers or derived from batteries.

2. Power Supply Electronics. Regulators and other circuitry improves the quality of the d.c. supply.

3. Power Supply Ripple Rejection. The ability of an amplifier to prevent ripple voltages on its supply reaching the audio output.

4. Components. The factors which affect the sound quality of different components.

5. Earthing. Poor earthing introduces distortion and good earthing techniques must be used.

6. Cables. Factors which affect the sound quality of different cables.

7. Circuit design. A good circuit not only works, but does so without requiring components which degrade the sound.

8. Slew rate limiting and high frequence response: its importance on sound quality.

9. Amplifier output stages. Class A or Class B and the effect of output stages on sound quality.

10. RF Interference: its effect and how to eliminate it.

The power supply is perhaps the most important part of an amplifier for determining the quality of sound. It is the power supply which supplies all the current required by the amplifier to drive the loudspeaker. For a mains powered amplifier, the mains transformer is the heart of the power supply and its most important part.

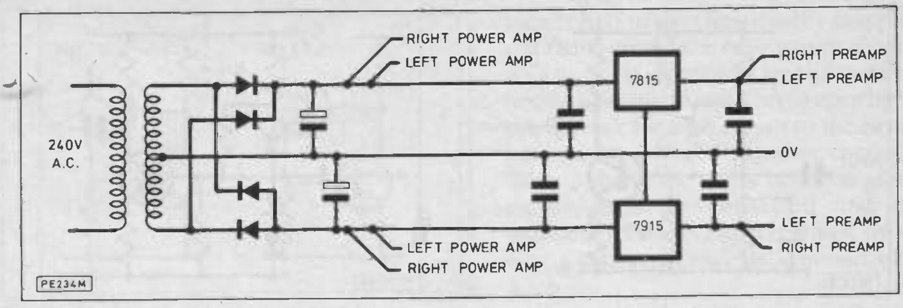


Fig.1. *Typical 20W-30W integrated amp p.s.u.*

One of the simplest rules in hifi is that the larger the transformer, the better the sound. Many top quality preamps use transformers rated at 100VA, 200VA or 300VA though their circuits only consume about 1 watt of power. The same energy efficiency ratio cannot be used in power amplifiers, but the use of a transformer twice or even four times the maximum rating of the power amp will result in a substantially better sound.

The choice of both the size and the type of reservoir capacitor is important. If the reservoir capacitor is too small the amplifier will sound as if the low frequency output has been reduced. If it is too large, the transformer will have difficulty in recharging after bass transients and the bass notes will sound resonant and lacking in clarity. Long life computer grade electrolytics with low e.s.r. and high ripple current ratings give improved sound over standard industrial and commercial types, but are more expensive. Improvements to their performance can be achieved by placing lower-value film types in parallel.

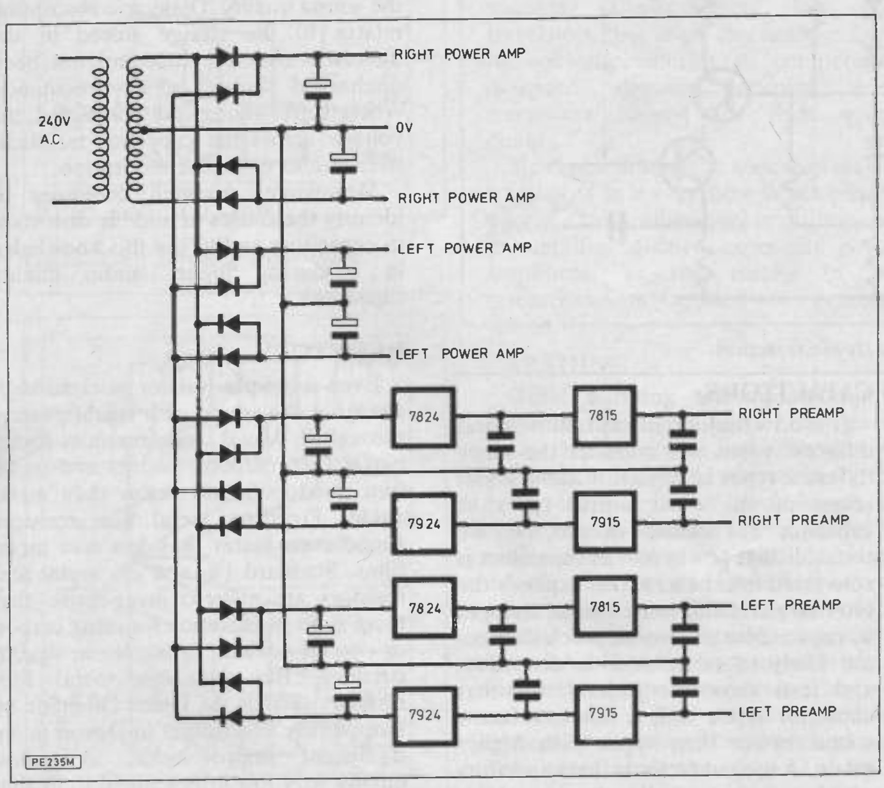


Fig.2. *Improved p.s.u. electronics*

POWER SUPPLIES

When talking of power supplies, few people are aware of the value of good power supply electronics. The purpose of power supply electronics is to provide a clean d.c. power supply for each stage of amplification, unaffected by the currents drawn by other stages or channels, or the 100Hz ripple in the reservoir capacitors. In achieving these objectives the power supply electronics must not itself colour the sound. The circuit in Fig. 1 shows the power supply of a typical 20W amplifier. The current drawn by one channel will generate a ripple on the supply, which will modulate the other channel. Also, the ripple from the power amps will reach the preamp supplies in an attenuated form via the regulators.

Fig. 2 shows how the power supplies for each stage can be isolated to give much improved sound. By using two regulators in series for the preamp, the reservoir capacitors for the preamp circuits can be much smaller (typically one tenth) than the main power amp reservoirs.

If power supplies are so important in an amplifier, why don't we design amplifiers that are immune to power supply ripple? That would be wonderful, but however elaborate the circuit which filters out ripple voltages, the final sound can still change if the main power supply is changed. I have experimented with some very elaborate designs in the past! The best way to design an amplifier is to use *both* a 'heavy' low impedance power supply *and* amplifier circuitry with good power supply ripple rejection.

It is not difficult to find amplifier circuits with poor ripple rejection. Fig.3 shows a simple low level single stage amplifier. Ripple from the power supply can reach the audio signal in two ways, either via the bias circuitry or via the collector load. The fact that the ripple voltages are out of phase is no help, as it would be impossible to cancel them out. Fig. 4 shows how ripple at mid and high frequencies can be filtered, but low frequency is likely to be more trouble. Fig. 5 shows a circuit which effectively filters all frequencies. The major proportion of ripple fed into the signal is now via the collector load. Small variations in the collector voltage will modulate the gain of the transistor. If the collector can be held at a d.c. voltage that does not include the a.c. ripple on the power supply line, this modulation would be considerably reduced. We can achieve this by the cascode circuit of Fig.6. The cascode configuration has been used for a long time, especially to extend the high frequency response in valve circuitry, but it is very useful in audio circuits to reduce power supply ripple. For the best possible ripple rejection, the base of the cascode transistor should see a low dynamic impedance to ground and high dynamic impedance to the supply. The voltage across the collector load resistor now has very low ripple. We cannot feed that signal to the next stage because we would also be feeding the whole ripple voltage from the power supply. By using an identical circuit based round a p.n.p. transistor, we can invert the signal and eliminate the ripple with respect to ground (Fig. 7).

Another means of improving the power supply ripple rejection of an

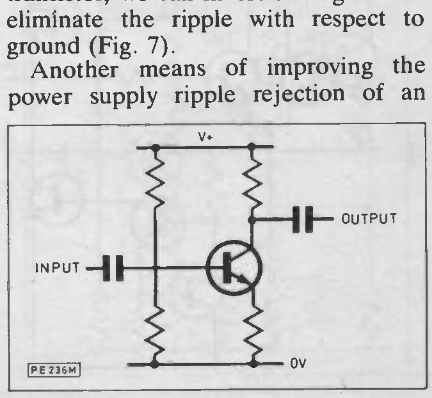


Fig.3. *Single stage amp*

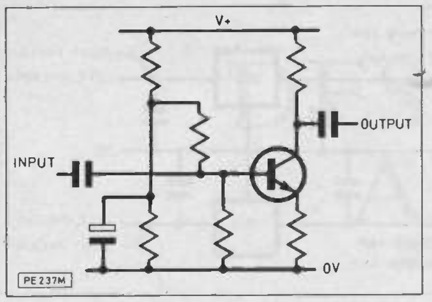


Fig.4. *Better PSRR at mid and high frequencies*

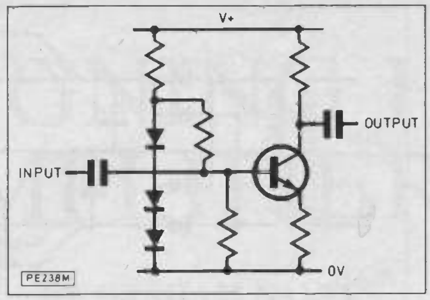


Fig.5. *Bias voltage with tipple rejection*

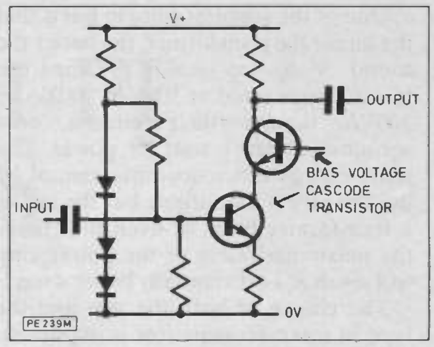


Fig.6. *Improved ripple rejection with cascade transistor*

amplifier, and hence the sound is to increase the dynamic impedance of current sources. Fig. 8 shows a much simplified circuit of a power amplifier. On the negative supply, ripple voltages due both to rectified ripple and ripple caused by the loudspeaker drive current will be converted into a ripple current through resistor R. If we replace R with a constant current source with the same

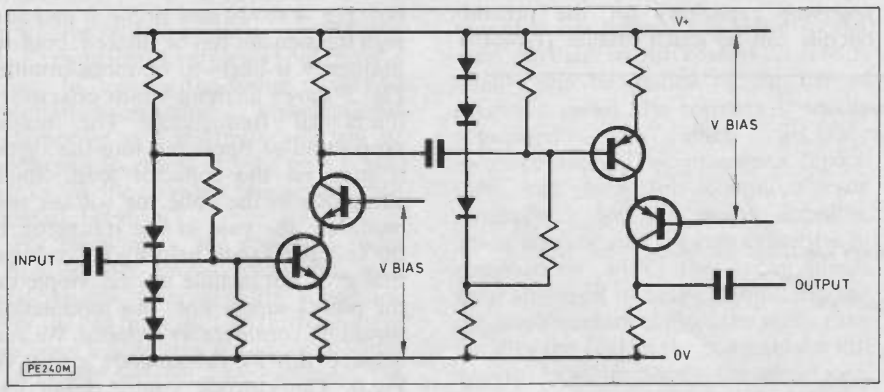


Fig.7. *Amplifier with excellent power supply ripple rejection*

static current, but higher dynamic impedance, we reduce the amount of ripple current reaching the input transistors, and increase the rejection ratio of the amplifier.

Fig. 9 shows a common type of constant current source in audio amplifiers. Its performance is not particularly good; the circuit of Fig. 10

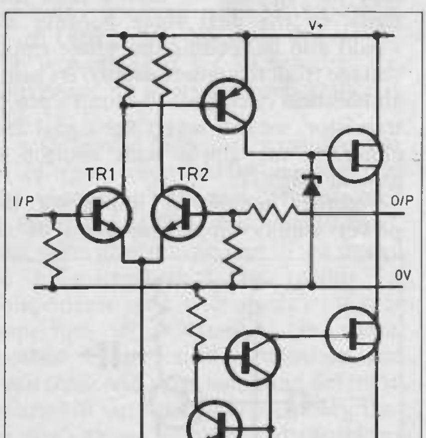


Fig.8. *Simplified power amp*

is far better. For a –30V supply and 1mA current source as required for the input pair, the dynamic impedance of the resistor is 30kΩ, of the Fig. 9 circuit about 90kΩ, and of the Fig. 10 circuit, about 330k ohms. For a circuit in which the 27k resistor is replaced by a 1mA constant current diode the impedance is of the order of 25MΩ. The higher the impedance, the better the sound.

CAPACITORS

It is no wonder that capacitors sound different when you consider the many different types of capacitor. Table 1 lists seven of the most useful types of capacitor for audio circuits. If we consider that power loss in capacitors is converted into heat, which expands the internal parts and causes small changes in capacitance as a result, such changes are likely to cause audible distortion, and tests show the general rule that capacitor types with a low loss factor sound better than types with higher losses. A second factor is that capacitors which are physically large exhibit inductance, which limits the useful high frequency range available. To some extent this can be cured by bypassing (placing in parallel a capacitor of lower value that is physically smaller). Some designers will always bypass an electrolytic capacitor with a polyester polycarbonate type. Others may bypass a polyester or polycarbonate with a lower value polystyrene capacitor. In the absence of perfect capacitors, bypassing is a useful technique.

Most audio amplifiers operate in the sound field of the loudspeaker they are driving. Capacitors and other components are subject to air pressure variations caused by the sound. Such forces may induce mechanical resonance inside capacitors of soft mechanical construction or simply cause very small movement of the capacitor plates, changing the capacitance value and distorting the music.

Dielectric absorption in capacitors is another factor which is believed to affect the sound quality. Dielectric absorption relates to the charge stored in the dielectric after the capacitor has been discharged through a low resistance. When the resistance is disconnected, the voltage across the capacitor terminals rises due to dielectric absorption.

Meanwhile, research continues to identify the causes of audible distortion in capacitors and to use this knowledge in producing higher audio quality capacitors.

RESISTORS

Even a simple resistor is capable of changing the sound of a signal passing through it. Metal oxide resistors sound better than carbon resistors and metal film resistors sound better than metal oxide. Precision metal film resistors sound even better than low cost metal films. Standard 1% and 2% metal film resistors are now so inexpensive that there is no justification for using carbon or metal oxide resistors in audio circuitry. But precision metal film resistors such as the Holco H8 made by Holsworthy Electronics in Devon make significant improvements in sound quality over low priced metal films that is a joy to experience in an amplifier.

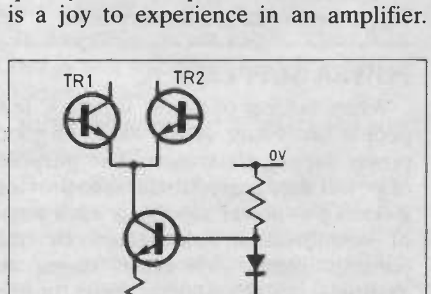


Fig. 9. *Constant current source*

This cannot be explained by the specification, but I have no doubt that greater care in manufacturing and the use of materials of higher purity are relevant factors.

Upgrading an amplifier by changing resistors is usually quite easy as precision resistors are usually no larger than those they replace.

SEMICONDUCTORS

Different types of semiconductor affect the sound quality of amplifiers. The sound quality of a low power zener in a regulator circuit can be improved by replacing it with a constant voltage

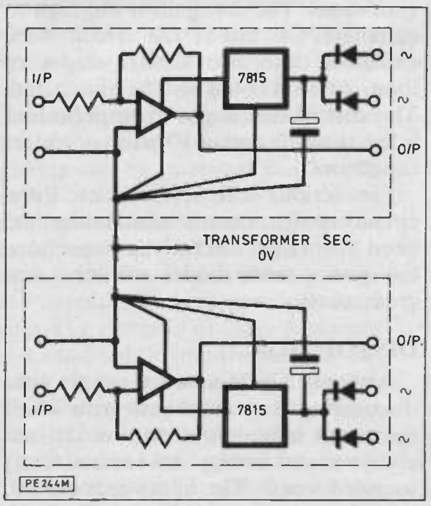


Fig.12. *Poor earthing techniques*

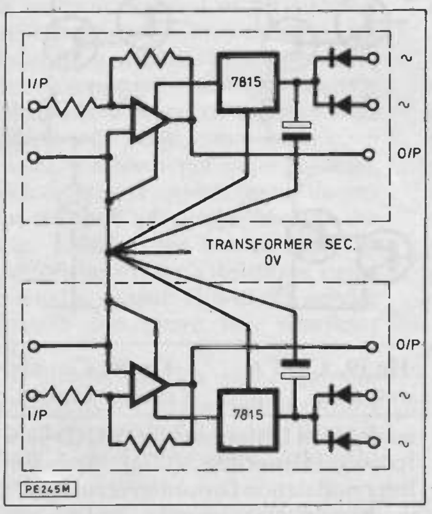


Fig.13. *Good earthing techniques*

supplied by resistors and transistors. This came to light during the development of the Classic Series 2 A25 amplifier. In order to cut production costs, zeners were used to replace some transistor based constant voltage elements which had been designed to achieve lower dynamic impedance than the zeners. On listening to the amplifier, it was obvious that the sound had deteriorated in a way that greatly reduced listening pleasure, although it might seem very small on a

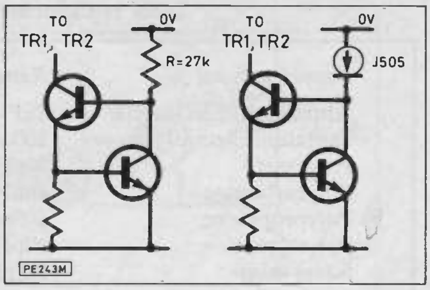


Fig.10, Fig.11. *Alternative high performance constant current sources*

quick A–B comparison. The difference in sound quality could not be sufficiently explained by the difference in impedance, and changing back to the original circuit produced the expected sound quality.

More recent tests indicate that all semiconductors degrade sound quality, some more than others, and I am currently researching to identify the best transistors for sound quality. High quality integrated circuits may well sound better than modestly designed discrete circuits using low cost transistors, but even the best i.c.s will be sonically inferior to competently designed discrete circuits using transistors chosen for their sound quality.

As research into the sound quality of transistors is a very new development, we can expect substantial improvements in amplifier quality, especially power amplifiers, as the results of my researches are applied to practical design.

EARTHING

Good earthing techniques require clear thinking. Each part of each earth return has resistance, capacitance and inductance. As earth returns carry the earth return current, each length of earth return, whether cable or p.c.b. track, will have a small voltage developed across it. If it carries two or more returns from different parts of the circuit, the voltage developed across it will contain parts of both currents which may be fed into the circuit. This will cause hum, reduce stereo separation, decrease dynamic performance and may even cause oscillation. Fig. 12 shows a MC head amp circuit which is likely to have more hum than music on its output due to poor earthing. Fig. 13 shows how to earth the circuit correctly. A special point to note is the use of separate earths for regulator common and smoothing capacitors. If the earths are shared, the output voltages from the regulators will contain a small amount of 100Hz ripple. As a result a small ripple current will flow through the amplifier and be heard as hum from the speakers.

The ideal form of earthing is the star earth in which each separate earth connection is made at the same point. This can be achieved either by solder tags bolted to the chassis or by mapping out radial earth lines from a central point on a p.c.b. In a practical amplifier it may not be possible to use a separate wire or p.c.b. track for each return so the earths have to be grouped together correctly. Table 2 shows the order in which group earths could be connected and the numbers relate to Fig. 14, which shows how a star earth may be achieved on a p.c.b.

CABLES

For many years, hifi enthusiasts have been upgrading their cables. Newer and better cables have been discovered (i.e. a high grade cable found to have good sonic performance) or specially developed. Many people have argued that if the sound quality can be improved by better cables between equipment, then it can be improved by better cables inside equipment. Even with expensive cables costing several pounds per metre, rewiring an amplifier or pair of speakers is a very cost effective means of upgrading.

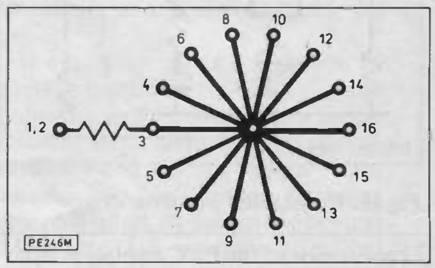


Fig.14. *Mapped p.c.b. earth*

Choosing a cable is not easy. There are many different cables available and some of the best of them are large and awkward to use, especially inside an amplifier.

Cables made from conductors of high purity have better sonic performance. Oxides on the outside of cables will degrade the sound quality, especially at connections. Some cables are silver plated to reduce corrosion, though there is a body of opinion which believes that plating the outside of a conductor is in itself capable of degrading sound quality.

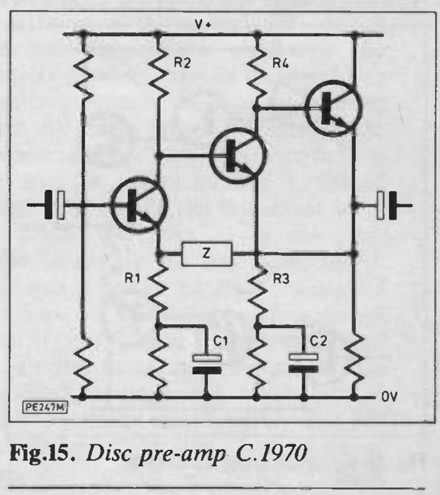


Fig.15. *Disc pre-amp C.1970*

In recent years new cables with much larger crystal structures have become available. If each crystal junction over which the signal passes has a slight effect on the signal, then a long cable made from a semiconductor with a larger cystal structure will sound better than a standard cable of similar length. These cables are advertised as Monocrystal (Van den Hul) or LC (Hitachi and Audio Technica).

Cable insulation is very important. All insulators exhibit dielectric loss, just like the dielectrics of a capacitor. Cables with polythene, polypropylene or teflon insulation are likely to sound superior to those with the more common PVC insulation. On more than one occasion,

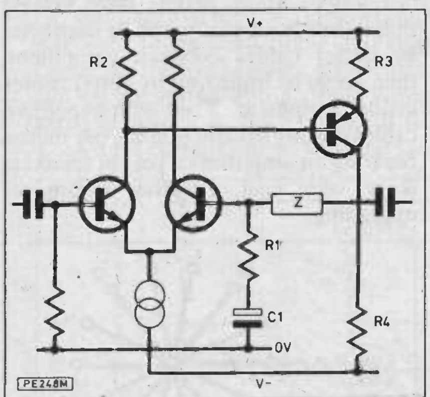


Fig.16. *Recent disc pre-amp design*

I have removed the PVC insulation from a cable and thought that I had gained a small improvement in sound quality. Some cables are microphonic – when used in a low level circuit, touching them gives rise to a sound from the loudspeaker. Such cables are not suitable for audio use. Many cables known for their sound quality have a very rigid mechanical construction.

High frequency signals travel on the skin of a conductor whereas low frequencies are distributed evenly over its cross section area. Some loudspeaker cables are made from a combination of one or more large conductors in parallel with several smaller diameter cores. A typical example are Soli-core cables by

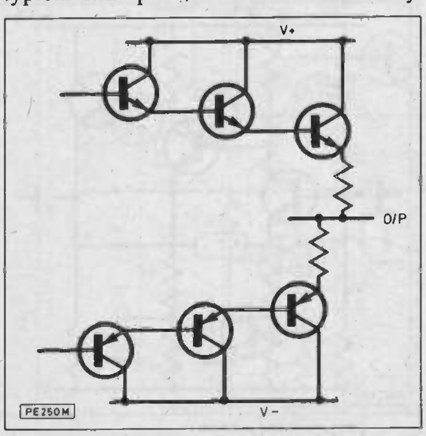


Fig.21. *Output stage example*

Table 1. *Capacitors used in audio circuits.*

Capacitor types	*Range of values*	*Power Factor Loss*
Aluminium Electrolytic	1uF–68,000uF	0.8–0.16
Tantalum Electrolytic	100nF–220uF	0.04–0.1
Polyester	10nF–22uF	0.0075–0.015
Polycarbonate	10nF–22uF	0.003–0.005
Polypropylene	100pF–10uF	0.0005–0.0015
Polystyrene	10pF–1uF	0.0003–0.0005
Silver mica	2.2pF–20nF	0.0003–0.0025

Cable Design. At one time, the use of multistrand cable was universal, but many people have observed increased clarity of sound from the use of single-core cables. One explanation is that impurities on the surface of individual strands cause any current that flows between strands to have a non-linear relationship with the voltage. Voltage differences of a small magnitude will exist between conductors because the cross sectional areas of different strands will not be exactly the same. A practical way to overcome this problem is to use several cores individually insulated, as used by Deltec on their high performance loudspeaker cables.

There are many approaches to selecting cables for audio use and ultimately the best is to sit down and listen to as many different types as possible and decide which sound best to your ears. If you have to choose a cable by its specification, look for high purity conductors, insulation of low dielectric and mechanical loss, and a cable diameter or current rating suitable for the application.

Many people who have built hifi amplifiers from designs published in the past are now seeking to upgrade those designs with the latest high quality components. At some stage in the process a dead end is reached at which a component of poor sonic performance cannot be eliminated or replaced at reasonable cost. Most common are large electrolytics used to bypass emitter resistors or to achieve unity d.c. gain in a negative feedback network or used as a bootstrap in power amplifiers. Fig. 15 shows a typical disc preamp from about 15 years ago. Note the use of capacitors C1 and C2 to increase the gain at audio frequencies. Fig. 16 is a modern equivalent in which C2 has been eliminated. The d.c. gain is too high to eliminate C1, but if the circuit were expanded into two similar stages of lower gain C1 could also be eliminated. The cost of two stages of amplification is less than the cost of 100μF in polyester capacitors.

For serious hifi applications, good circuit design means eliminating the need for large electrolytic capacitors, low power zener diodes and other low grade parts.

DISTORTION

Around 1976/77 many designers were discovering that amplifiers with lower measured harmonic distortion did not always sound better, and some actually sounded worse. The buzzwords used to describe this were Transient Intermodulation Distortion (TID) AND Slew Induced Distortion (SID). Transient Intermodulation Distortion occurs when input or driver stages of an amplifier clip because the signal is so fast that the negative feedback cannot reach the other input quickly enough to reduce the gain. To prevent TID, many manufacturers have produced amplifiers with low negative feedback and this feature is sometimes highlighted in promotional literature.

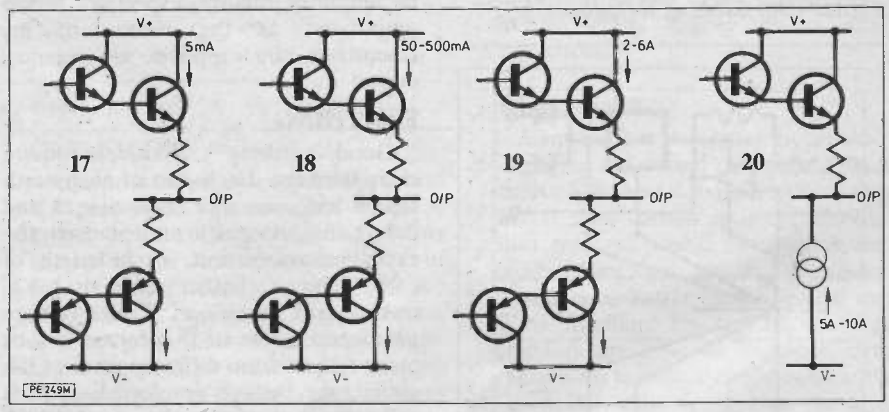


Fig.17. *Class B output* **Fig.18.** *Class AB output* **Fig.19.** *Class A output* **Fig.20.** *Constant current Class A*

Slew induced distortion occurs when a stage of an amplifier runs out of current to charge a capacitor (this includes capacitance within the transistors) due to a large high frequency voltage swing. The slew rate is measured in volts per microsecond. Research work carried out showed that amplifiers with low slew rates had distorted sound. As a result, some manufacturers produced amplifiers with extremely high slew rates in excess of 100V per μs, but there was little evidence that they sounded much better as a direct result. In practical terms a 25W/8Ω amplifier needs a slew rate of abou 10V per μs and a 100W amp twice that. Put another way, an amplifier that can deliver full output into a load at 75kHz is not likely to be audibly degraded by slew rate limiting. But although these areas of design have been extensively discussed in the audio world, they are of comparatively minor importance in relation to sound quality compared to power supplies, components quality and ripple rejection.

The output stage of an amplifier can affect its sound quality. Transistor amplifiers can be operated in Class B, Class AB or Class A (Figs. 17–20). Many hifi enthusiasts praise the attributes of Class A, but almost all the benefits of a Class A amplifier derive from a large power supply and very generous heat sinking. The linearity of Class A biasing adds a small subtle improvement in the focusing of the sound giving a greater depth. Most power amplifiers advertised as Class A have the output stage shown in Fig. 19 and at very high current levels actually operate in Class B. The circuit in Fig. 20 should give a sonic improvement, but its drive current in one direction is limited to the steady state quiescent current of the constant current source.

Recently a number of circuits have been developed to prevent the transistor which is not driving the speaker from switching off. While these have been favoured by a number of major Japanese manufacturers, I myself have doubts about the sonic advantage, because the voltage added to the bias to keep the transistors on will be a distortion signal added to the output. However I wonder if anyone can prove this viewpoint wrong?

The emitter resistors used to prevent thermal runaway in the output devices affect the sound far more than is realised, both in terms of their value and component quality.

There are several different types of output stage circuits used in amplifiers. For lower output currents two transistors are sufficient. At high currents, the gain of the output device will be rather low and output triple may be used. Three types are shown in Figs. 21–23. Fig. 21 has no negative feedback, and requires more overall feedback in the amplifier to keep the distortion low. However, my experience is that output stages without feedback sound more natural (it is difficult to be more specific) and this also applies to the use of compound emitters in regulated power supplies.

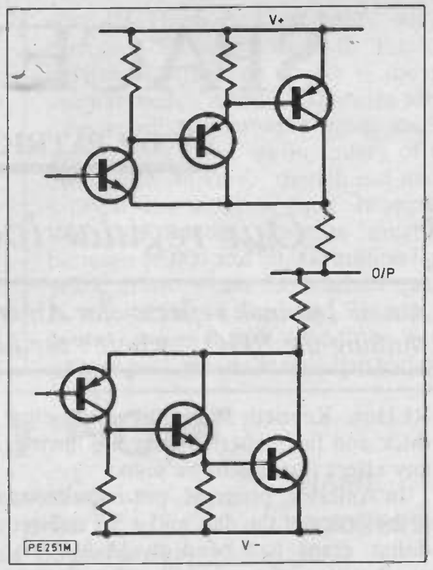


Fig.22. *Output stage example*

Lowering the amount of feedback by resistors in series with the emitters of the transistors may well improve the sonic performance and this is an area which calls for further research.

Radio frequency interference to audio circuits can be divided into two types – the interference you can hear and that you can't. R.f.i. can be heard as annoying clicks and pops from fridges and central heating and even conversations from passing taxis and police cars. You will not hear the other type of r.f.i., but without it, your amplifier will sound a great deal better.

Radio broadcast breakthrough usually occurs in low level input stages. Figs. 24 and 25 show two ways of filtering radio frequency signals to prevent the base emitter junction acting as a demodulator. Radio frequency interference can be minimised by using circuitry with common mode rejection, balanced input signals and passive low pass filters. The use of balanced leads

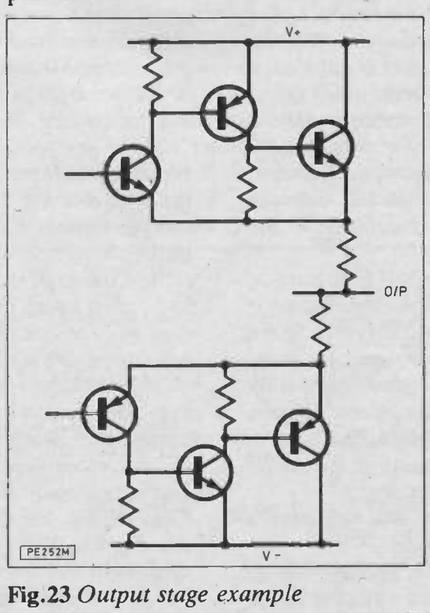


Fig.23 *Output stage example*

from record decks would be particularly sensible, but would make the design of valve preamps particularly difficult.

Twisting and screening loudspeaker leads will reduce the r.f. signals seen at the loudspeaker terminals of the amplifier. However the only problems which this might cause would be high frequency instability.

The mains power supply is by no means a clean 50Hz sine wave. It contains transients caused by the connection and disconnection of equipment and by pulsed loads supplied through transformer-rectifiers and thyristors. It also contains r.f. signals picked up by mains wires acting as aerials. Some voltage spikes can be very high and can be cut down by voltage dependent resistors (v.d.r.s). R.f. signals on the mains can degrade sound quality quite seriously and the design of an r.f.i. filter for audio use has two main requirements:

1. Its low frequency transient performance must not affect sound quality, especially loud bass drum signals which draw large currents from the mains.
2. It must filter all r.f.i. Research by Deltec Precision Audio who manufacture an r.f.i. filter for audio use indicates that frequencies up to 1000MHz need to be filtered for optimum audio performance, but most commercial filters do not extend beyond 100MHz and fail to filter television signals.

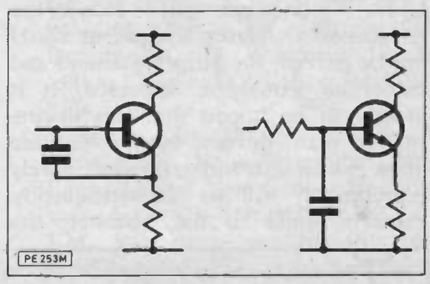


Fig.24, Fig.25. *R.F. supression*

The design of audio amplifiers is a fascinating study, full of challenges and surprises, full of blind alleys and breakthroughs. Although audio design does not appear to challenge the frontiers of technology in the same way as microprocessor research, it will not stand still. Ideas taken very seriously in the past are now known to be of limited relevance to sound quality. Topics of design now considered important were not considered relevant in the past. Many questions are still unanswered. How can a power supply be designed that does not affect the tonal qualities? What type of output triple sound best? etc. In the meantime this article has described developments which hint at improvements in sound quality that can be achieved right now. Let us enjoy them. PE

SPACEWATCH

BY DR PATRICK MOORE OBE

Our regular look at astronomy

A new 140-inch reflector for America while the UK is still considering shutting the RGO – where's the justice?

SADLY, we must record the death of yet another great astronomer: Charles ("Chick") Capen, who was for many years at the Lowell Observatory and who was renowned for his studies of the planets, particularly Mars. He died suddenly and unexpectedly at his home near Cuba in Missouri, where he was in the process of erecting his own observatory. Chick Capen was a pioneer Mars mapper, and also a pioneer in the use of colour astrophotography. He will be greatly missed by his many friends.

At the time of writing (October) the fate of the Royal Greenwich Observatory still hangs in the balance. Under pressure, the Science and Engineering Research Council, which plans to move the RGO to Cambridge – thereby, in effect, destroying it – has had to admit that the move would cost the taxpayer over £6,000,000. Cambridge University does not want the RGO, and Sussex University does not want to lose it; the telescopes and laser equipment could not be moved; the library, archives and exhibition would be dispersed. It is greatly to be hoped that this ill-considered plan, devised by a committee upon which astronomers were barely represented, will be shelved quickly. Protests made to the Minister, the Rt.Hon. Kenneth Baker, have come in thick and fast; whether they are having any effect remains to be seen.

In America, progress, not regression, is the order of the day, and a 3.7 million dollar grant has been made for the construction of a new 140-inch reflector to be set up at Apache Point, New Mexico, at an altitude of 9200 feet. It will have an altazimuth mounting, and is expected to be completed by the end of 1988.

This star is an obscure variable in the constellation of Monoceros, the Unicorn, adjoining Orion. It is an X-ray source, and data obtained by astronomers at Kitt Peak now show that it is a binary system, with a K-type dwarf primary and a more massive but invisibile companion. The mass of the companion is over three times that of the Sun, so that it cannot be a white dwarf or a neutron star; it is more likely to be a black hole — possibly the most convincing of all candidates apart from the famous Cygnus X-1.

Each year the BAA organizes a public lecture. This year it is to be delivered at the London Planetarium, on the evening of 15 December, by Ian Nicholson. Full details may be obtained from the BAA at Burlington House, Piccadilly, London

The first quasar was identified as long ago as 1963. We now know that these objects are very remote and super-luminous; a single quasar may shine as brilliantly as hundreds of whole galaxies combined. Yet they are relatively small, and we have to ask how so much energy can be packed into an area which is probably no larger than the orbit of Neptune. No doubt gravitational forces are involved, and there is every reason to suppose that a quasar is essentially the nucleus of a highly active galaxy.

Because quasars are so powerful, they can be detected out to great distances, and can be used to probe the universe to a range beyond that of galaxies. Up to now the holder of the record has been PKS 2000-330, which seems to have a distance of at least 12,000 million light-years. It was detected at the Parkes Radio Astronomy Observatory in New South Wales, and confirmed optically at the Anglo-Australian Observatory at Siding Spring. Now this record has been shattered. Using plates taken by the UK Schmidt, also at Siding Spring, Stephen Warren and Paul Hewitt have identified a quasar in the constellation of Sculptor which is even further away. It seems to be receding at between 92 and 94 per cent of the velocity of light, which at a

THE MOST conspicuous of the planets this month is Venus, which dominates the south-eastern sky for several hours before dawn. On the 11th it reaches its greatest brilliancy, at magnitude -.4.7. Locating Venus in daylight is quite easy, and there will be a good oportunity on the 28th, when Venus will pass within ten degrees of the old crescent Moon. (Remember, however, never to sweep for Venus with binoculars or a telescope when the Sun is above the horizon, as there is the ever-present danger that the Sun will enter the field of view by mistake, causing serious damage to the observer's eyesight.)

Mercury is also a morning object for the first part of December, low above the south-eastern horizon. Saturn is out of view, but Mars and Jupiter are close together in the Pisces-Aquarius region, and are above the horizon for some time after darkness. On the 19th the two planets are only half a degree apart (a good opportunity for celestial photographers). Jupiter is now much the brighter of the two, though when Mars was at opposition last summer it actually took precedence for a brief period.

The Moon is new on the 1st and 31st, and full on the 16th. Winter solstice occurs on December 22.

Halley's Comet remains in the Crater region, but is inconveniently close to the Sun, and has in any case faded to below magnitude 17, so that it has been lost to amateur observers. A new non-periodical comet, Wilson's, is expected to reach the third magnitude next spring, and has already a considerable tail. But unfortunately, when it is at its best it will be too far south to be seen from Britain; the declination will be around -70 degrees.

There are two major meteor showers in December: the Geminids between the 9th and 14th, and the Ursids between the 17th and the 24th. The Geminids are much the richer, and may attain a ZHR or Zenithal Hourly Rate of as high as 60, though this year the Moon will interfere. (The ZHR is the number of naked-eye meteors which would be expected to be seen by an observer under ideal conditions, per hour, with the radiant at the zenith; in practice, of course, these conditions are virtually never attained.)

The brilliant winter constellations have now come into view, dominated by Orion with its two brilliant leaders, the orange-red Betelgeux and the pure white Rigel. Sirius rises in the late evening; Capella is not far from the zenith; Cassiopeia, with its characteric W of stars, is high up, while Ursa Major, the Great Bear, is at its lowest in the north. The Square of Pegasus is descending in the west, and much of the low southern sky is occupied by the large, sprawling but faint constellations of Cetus and Eridanus.

reasonable estimate puts its distance at around 14,000 million light-years.

The visual magnitude is only 20, so that the quasar is a very dim object indeed, yet it was identified optically. It has not yet been detected at radio wavelengths, though a team at Jodrell Bank, led by the Astronomer Royal (Sir Francis Graham-Smith) is making a major effort to pick up radio emissions from it.

There seems little doubt that the new quasar really is the most remote object ever found, and of course it raises once more the question of 'How far we can see?' If Hubble's Law holds out to extreme distances, we will reach a barrier at which an object is moving away at the full velocity of light, in which case we will be unable to see it, and we will have reached the boundary of the observable universe, though not necessarily of the universe itself. It appears that this limiting distance must be between 15,000 and 20,000 million light-years, in which case the Sculptor quasar is nine-tenths of the way. We are, of course, seeing it as it used to be in the remote past, when the universe had only one-tenth of its present age.

Can we detect any quasars at still greater distances? The success of Warren and Hewitt may indicate that we can; on the other hand, as has been pointed out by the Astronomer Royal, it may be that we are already very close to the limit. Perhaps the 94-inch Hubble Space Telescope will help when it is finally launched – before the end of the decade, we hope. Meanwhile, we have at least the satisfaction of knowing that we have probed forth into the universe to a distance greater than ever before. PE

PE BAZAAR

Wanted: Address information of systematics international Micro systems or employee/owner of their invoice package. Will pay. Peter Stein, Wang Walk Road, Dyers Crossing, NSW 2429, Australia. Tel: 6115 502254.

Wanted: Chromatheque 5000 Lighting unit preferred un-cased board but anything considered W.H.Y.? B. Taylor, 189 Hawes Side Lane, Blackpool FY4 4AJ. Tel: (0253) 695778.

Thandor TF200 Freq counter TP600 prescaler case Ser/man B/New Swap or Sell for Trio TH41E H/Port. Tel: 04738526.

Itron FG13D1 4 light Fluorescent display data £4 two CA DD Red led display £2 each. Adrian Bhagat, 10 Meynell Walk, Netherton, Peterborough, Cambs PE3 6RR.

Kikusui 538A portable scope 10mV/on to 5MHz still in box £75. Tel: Disley (06632) 5705. Mr R. Flitcroft, 6 Chantry Fold, Disley, Cheshire.

Video Projector and screen proclar R.G.B. optical units electronics need rebuild £65. Tel: Disley 2582. Mr J.K. Potts, 42 Keswick Road, High Lane, Stockport, Cheshire SK6 8AP.

Wanted: Practical Electronics July and August 1984 simple logic analyser 1 & 2. Mr S. Fungtammasan, 21 Soi sai;sime, Taksin Road, Tanburi, Bangkok 10600, Thailand.

Texas T199/4A cartridges TI invaders game £10 extended basic with manual £30. O.J.Tait. Tel: 0582 83 3701 any time.

Wanted: Circuit and data for case 428 Modem Unit. J. Hughes, 28 Stephen Road, Prestatyn LL19 7EH.

For Sale: Practical Electronics first five volumes 1964 to 1968. Offers. Mr A Dennington, 17 Boldmere Gardens, Sutton Coldfield D73 5LN. Tel: 021 382 8276.

Wanted: 240/6000 V @ 20 MA Transformer (Neon Sign Type). Mr M. Lang, 24 Pye Nest Grove, Halifax, W. Yorks HX2 7JY. Tel: 0422 66350.

F.M. Bug super sensitive fits inside matchbox with battery microphone and switch. Very long range tuneable 80–120MHZ £12.50. P.G. Margry, 9 Queens Road, Eastbourne.

New PP3 Ni-Cad battery Charger fits 13AMP socket £4.93 plus p&p. E.G. Pristley, FBIS, 6 Lynden Avenue, Windhill, Shipley, West Yorkshire BD18 1HF. Tel: Bed 593382.

PE BAZAAR

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DEAF ALARM

BY TERRY PINNELL

Rise and shine sleepy Joe!

If you have problems waking up in the morning this might provide the answer. It's a novel approach to alarm clock modification and its simple to construct and use!

CHATTING to a colleague, we got onto the topic of early rising and he mentioned the morning chore of waking his young daughter, who was deaf and could not rely on a clock or radio. I was sure electronics could come to the rescue and was soon engrossed in exploring the possibilities.

There were two basic decisions needed: method of waking and method of triggering the device.

Ruling out sound, the options I considered first were:

Light. How pleasant it would be to make a virtue out of necessity and wake her by simulating the sun beaming onto

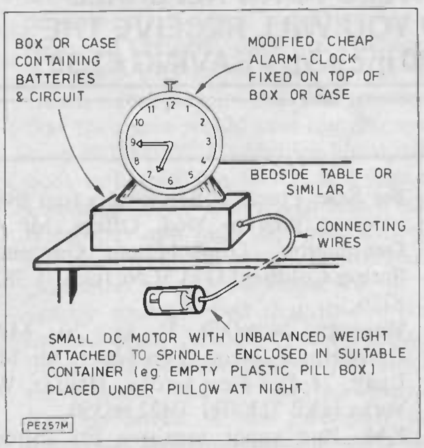


Fig.2. *Schematic diagram*

her face . . . a bright spotlamp perhaps, or even an infra-red lamp. The latter was quickly dismissed because I didn't know enough about infra-red lamps to be sure that prolonged exposure would be safe or effective. I still don't if it comes to that.

I did try a few experiments with a normal 100W spotlamp, and came rapidly to the conclusion that even flashing a couple of feet away it could not be confidently expected to wake someone up.

(Pity really, because I'd been quietly looking forward to messing around with triacs; I'd bought a pack of these from a mail order supplier years beforehand, and I still hadn't got round to doing anything with them.)

Fan. So how about a breeze from a bedside fan? The only fan I had was a little novelty affair with self-extending vanes, driven by a 1½V battery. When

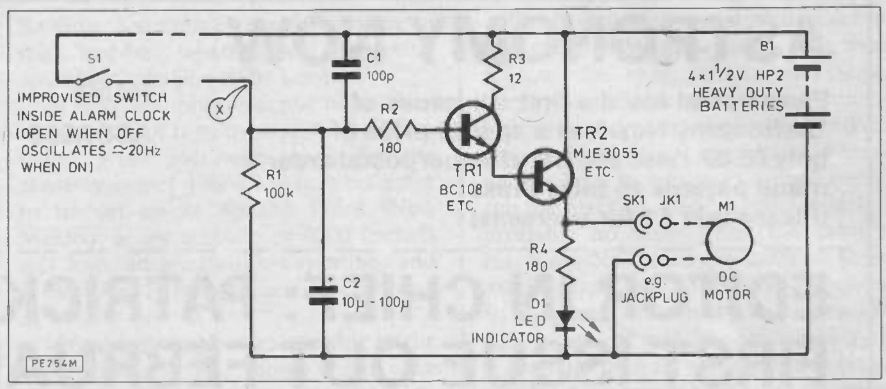


Fig.1. *Complete circuit diagram*

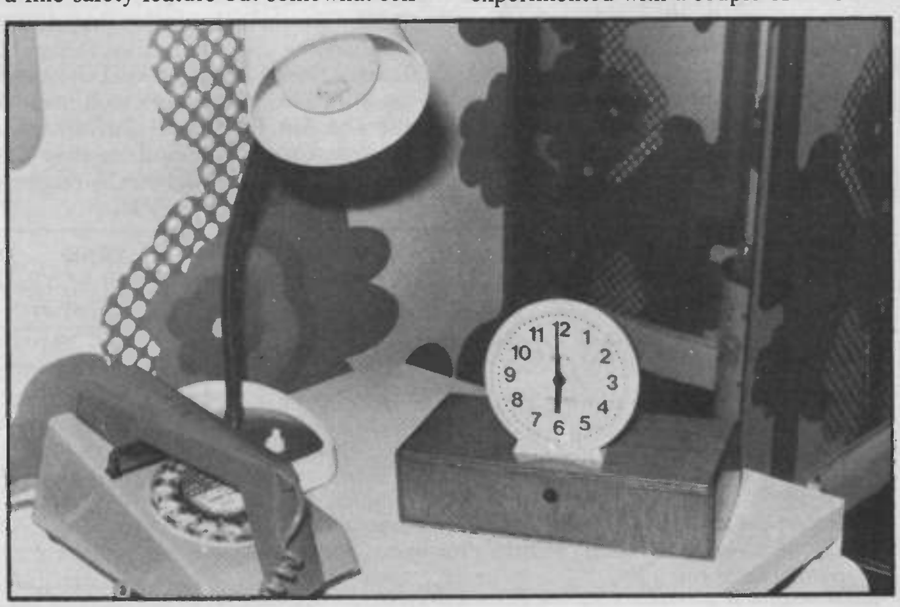
holding it a couple of inches from one ear I could convince myself it might wake me up, but I could not think of any reliable way of ensuring it *stayed* a couple of inches from one ear.

This clearly did not do justice to this approach, so I rigged up a fan with a mains driven motor and some blades. That was easy enough, but it took a lot longer to find some way of mounting it. Eventually I secured it inside a large coffee tin and deployed myself with it to the test bed, so to speak.

Concentrating very hard I could just detect the output at a couple of feet. The problem lay in the mounting; my fan blades were virtually completely enclosed by the cylindrical container – a fine safety feature but somewhat self-defeating. I abandoned this option with reluctance, having spent at least an hour building the fan.

Electric shock. I have to confess that I did fleetingly toy with the idea of a (battery operated!) wrist strap of some sort, the contacts of which would deliver a modest a.c. voltage (40 or 50V?) But it really was fleeting!

Vibration. Which brings me to the final choice, improvising something which would vibrate sufficiently if placed under the pillow or mattress. A small d.c. motor with a lead weight secured to its spindle, all enclosed in a sturdy plastic cylindrical container proved surprisingly effective. I tried various d.c. voltages from my home-built bench supply and experimented with a couple of different



motors. I settled on a powerful and current hungry specimen, which produced a strong vibration using 3 to 4.5V with a current consumption of about 1 to 2A, so I was clearly going to need HP2 or equivalent batteries.

I did not pursue the thought of nicads, because of their initial cost.

Having selected the 'output', the next decision was the method of triggering. I dismissed the absurdly expensive (but potentially reliable) method of extracting a signal from a clock/radio. I also discarded methods dependent on a long duration timer circuit. Analogue versions based on r.c. times would be inexact. Digital types would be too expensive or, if made out of the TTL or CMOS i.c.s which I had at hand, probably require starting the device at precisely 2-to-the-power-N seconds before wake up time.

So the choice was a cheap clockwork alarm clock . . . which I just happened to have in the loft!

But how could this trigger power to the motor? I jumped to the conclusion that some form of sound detector was required, and spent several days building a veritable plethora of circuits. My loose leaf circuit binder is six pages thicker as a result. Sometimes the further back I can push the finishing point of a project, and the more options I can find to explore en-route, the more satisfaction I get out of it. So what looks in retrospect like a real waste of time was actually fun. Who can define a 'waste of time' anyway?

STRIKING CONCLUSION

Sanity soon prevailed (I expect the glimmer of another project had arisen) and I abandoned the sound detecting approach. Instead, I made a simple modification to the striker mechanism so that it repeatedly opened and closed an electric contact, using a few pieces of wire and a little epoxy glue. This became a crude electronic switch, operating at about 20Hz, which then drove the d.c. motor via a pair of n.p.n. transistors. The duly modified clockwork alarm was bolted on top of a home made wooden box which housed four HP2 batteries and the very simple electronics. A jack plug and socket allowed connection of the vibrator via a pair of wires about a metre long.

An l.e.d. in parallel with the socket provided a supplementary indication, and was useful for testing.

If the striker contacts remained closed when the alarm was switched off or when the spring ran down, then the motor would continue to vibrate . . . definitely not a desirable design feature. But in practice this somehow proved mechanically impossible.

Detailed improvisation of the electrical contacts will vary with the particular type of clock used. In my case

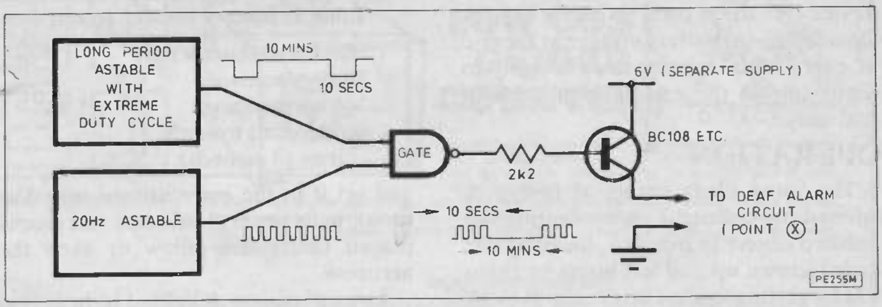


Fig.3. *Simulator block diagram*

it was a matter of epoxy gluing a strip of tin inside the casing, isolated electrically by the glue, so that the hammer could strike it without hindrance, thus making a crude switch operating at 15 or 20Hz when the alarm goes off.

A wire was soldered to the tin and the other switch contact was taken from the case itself, which in this clock was common with the hammer.

The circuit is very simple. When the alarm goes off the newly installed contacts open and close at a rate of 10 or 20 times per second. When they are closed a brief positive pulse is delivered to the first base of the Darlington pair arranged as an emitter follower. If the plug is in place then the motor will vibrate. In any case an l.e.d. will be illuminated, making testing easy (and economical on the four 1½V heavy duty HP2s or similar batteries).

Trial and error with a breadboard gave the component values shown, but all are far from critical. The electrolytic capacitor value was a compromise. The motor must receive large enough current pulses to give adequate vibration, even when the battery voltage has fallen to say 4.5V. (Note that after allowing for the total of the two base-emitter drops this means a little over 3V to the motor.) But the motor must also stop quickly when the alarm clock OFF button is pressed. The low value capacitor was added to remove v.h.f. oscillation apparent on switch-off, detected with my 'scope, but motors aren't exactly electronically quiet, so this was probably redundant.

Quiescent current was negligible, so clearly no ON/OFF switch was necessary. Note that if the contacts were to stay closed then the full current would flow, definitely not a desirable result of switching off. In practice this was mechanically impossible on the prototype, the contacts always being left open, but it would be worth checking on a different type of clock.

Had I been making this for my own family's use I would have had no compunction about powering it from the mains. However in this case the question arose as to what life I could expect from the batteries. I wanted to avoid the embarrassment of the thing running out of steam at the end of a week, with my colleague returning it ingloriously to me, spending a small fortune on batteries or relegating it to a dark cupboard.

This was good for a day's diversion!

What I did was rig up a simulator on breadboard. This produced ten seconds of motor operation every ten minutes, assuming this was a reasonable recovery time between calling on the batteries to deliver all their power. Clearly these were more demanding conditions than expected in practice (ten seconds or less every 24 hours). So assuming that the

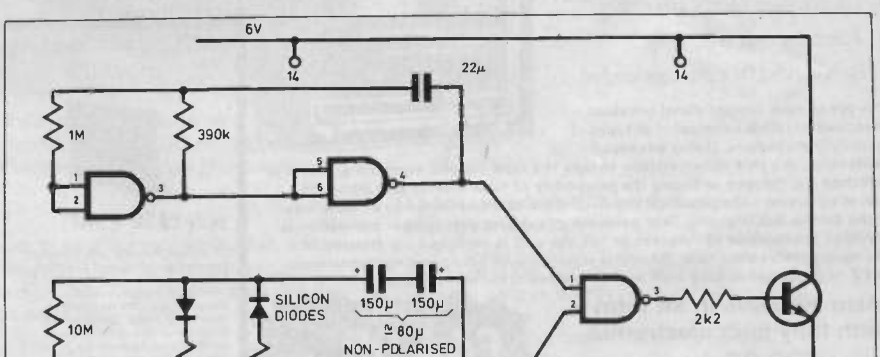


Fig.4. *Simulator circuit diagram*

device was to be used six times a week (Sunday lie-in) battery voltage at the end of every hour corresponded roughly to their state at the end of each week of real usage.

OPERATION

The most likely cause of failure, I advised my colleague on presenting the finished object to him (no, his daughter hadn't grown up and left home by then) was forgetting to wind up the alarm clock and set it in the conventional way. The motor in its smart plastic case was simply placed under the pillow or even the mattress.

I was of course delighted to hear that it performed well in practice.

The unhappy ending was that about six months later it got dropped from a shelf, disintegrating beyond easy repair. At least, that's what he told me! PE

Table 1. *Battery voltage test figures*

Number of hours of test:	0	1	3	6	8	10	26
Weeks simulated:	0	1	3	6	8	10	26
Voltage measured: (under load towards end of 10 seconds).	5.48	5.47	5.46	5.40	5.34	5.27	4.18

INDUSTRY NOTEBOOK

Opportunities in space and television

REPORT BY TOM IVALL – PE's NEXUS

Can the small British firms in the space industry fend for themselves and how will a European broadcast manufacturer fare in the world market

THE hundred or so UK companies in the space industry could do with a bit of help and encouragement, according to Roy Gibson, head of the recently formed British National Space Centre (BNSC). Speaking at the Institution of Electrical Engineers to explain the purpose of the BNSC, he said it would be a good idea if they could form a trade association. Big concerns like British Aerospace, who make satellites, and Marconi, who make earth stations, were probably strong enough to fend for themselves. But the smaller firms found it difficult and daunting to sell their products to international organizations like the European Space Agency (ESA). They would do better if backed by the single, more powerful voice of a national collective body.

There is in fact a national body in existence called the UK Industrial Space Committee, but according to Mr Gibson this is little more than a debating club. It does a certain amount of real work and decision making, but only on an *ad hoc* basis through casual conversations over lunch.

Britain really lost its chance of becoming a major participant in the world space business when the government cancelled the Blue Streak rocket programme. This left the field wide open for another nation to become the leader in Europe. The French stepped in and produced the Ariane satellite launcher, which has been highly successful, both technologically and commercially, and is a rival to NASA's rocket and shuttle launchers in the USA.

You have to admire the French for their intellectual clarity in planning, their political opportunism and their bold determination to become a leading industrialized nation. They want to be independent of the USA. And they do not suffer from the disdain about working in industry and commerce that still lingers on in the British establishment and educational system.

Manufacturers of broadcast equipment have tended to be either the big companies like Marconi and RCA who make practically everything or small firms working in specialized fields. But now Europe has a new, quite large company which specializes entirely in television and doesn't seem to offer any sound radio products.

Called Broadcast Television Systems GmbH, it is based in Darmstadt, West Germany, and has about 2,400 employees. The firm is actually a combine formed by Bosch of W.Germany, who own 70%, and Philips of the Netherlands, who own 30%.

Philips is well known in the UK but Bosch less so. It was founded in 1886 by one Robert Bosch, whose first product was a magneto for a gas engine. This eventually grew into a whole range of automobile components and accessories including the Blaupunkt car radio. In time the company became a big electrical/electronics group. It was involved in the early days of television broadcasting in Germany through Fernseh AG, which it helped to form in 1929. Today its electronics businesses include telecommunications, mobile radio, navigation, CATV and video systems as well as broadcasting equipment.

To the new BTS combine Bosch has contributed its television systems division at Darmstadt and its video equipment business in Salt Lake City, USA. Philips has put in its camera development and production plant at Breda, Netherlands, and its television sales organizations at Mahwah, New Jersey, USA. Through these established concerns BTS claims to be selling its products in 120 countries – not bad, considering there are 158 countries in the world.

The product range includes all kinds of television studio and station equipment, but the firm also does consultancy, planning and installation work, as well as training customers' operation and maintenance staff.

However, the BNSC might well help to get the UK back into a better position. It was set up in 1985 with the object of co-ordinating Britain's space activities and thereby making them more effective. In the past, individual UK organizations looked at particular international space projects as they arose and decided on their own whether to take part. But now, as Roy Gibson explained, space projects are becoming so interrelated that this go-it-alone approach is not possible. A single, national organization is needed to make decisions from a synoptic view of the whole field.

At the time of writing the BNSC has no funds of its own. It is run by staff from four existing government bodies, the DTI, the Science and Engineering Research Council, the National Environmental Research Council, and the MoD. But the government is now studying a National Space Plan it has produced, and on the basis of this will decide what money will be made available to enable it to go into independent operation.

The term 'booting' is well known in the computer field. Sometimes called 'booting up', it is short for 'bootstrapping', which means running a short program on a computer to start it up. The instructions tell the machine where to look for data and what to do with it. And, of course, bootstrapping is also a long established positive-feedback technique in electronic circuitry. It's really a colourful Americanism expressing the notion of lifting yourself up by pulling on your bootstraps, or shoe-laces, as we might say in Britain.

But now, I see, 'booting' could acquire a new meaning through the software industry: namely, being booted out of your job by a computer. The accountants Robson Rhodes and the software house Expertech have devised an expert system program to help employers sack their workers without risking charges of unfair dismissal. Apparently there are more than a thousand rules governing legal dismissal procedures, and in a particular case every one of them has to be examined to make sure it is not being infringed. So the new software will help the employer to check the legal validity of a proposed sacking or redundancy before making a silly mistake.

For the sake of fairness I think Expertech should also offer their skill to the trade unions, staff associations and the race relations, civil liberties and other such organizations that protect the interests of the individual. Technology should be made available to both sides if it is going to be used for economic expediency within the law. PE

CMOS			
4000	13p	4089	80p
4001	13p	4093	18p
4002	13p	4094	48p
4006	36p	4095	58p
4007	13p	4098	50p
4008	38p	4099	45p
4009	20p	4501	30p
4010	21p	4502	38p
4011	13p	4503	32p
4012	13p	4504	55p
4013	19p	4505	200p
4014	35p	4506	60p
4015	34p	4507	33p
4016	18p	4508	70p
4017	31p	4510	37p
4018	33p	4511	40p
4019	28p	4512	42p
4020	35p	4513	80p
4021	36p	4514	75p
4022	36p	4515	75p
4023	13p	4516	40p
4024	25p	4517	120p
4025	13p	4518	38p
4026	60p	4519	30p
4027	18p	4520	38p
4028	29p	4521	90p
4029	35p	4522	50p
4030	17p	4526	40p
4031	90p	4527	44p
4032	54p	4528	40p
4033	60p	4529	75p
4034	80p	4532	52p
4035	45p	4551	80p
4036	180p	4553	190p
4037	75p	4555	29p
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4041	38p	4584	30p
4042	30p	4585	42p
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4045	72p		
4046	45p		
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4050	20p		
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4067	130p		
4068	13p		
4069	13p		
4070	13p		
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4072	13p		
4073	13p		
4075	13p		
4076	45p		
4077	13p		
4078	13p		
4081	13p		
4082	13p		
4085	40p		
4086	32p		

74LS SERIES	
74LS00	15p
74LS01	15p
74LS02	15p
74LS03	15p
74LS04	15p
74LS05	15p
74LS08	15p
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74LS368	38p
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74LS374	55p
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74LS399	80p
74LS670	72p

COMPUTER IC'S	
2114	200p
27256	400p
2532	330p
2716	200p
2732	280p
2764	240p
27128	250p
4116	75p
4164	110p
6116	160p
6264-15	250p
6502	300p
6802	220p
6809	600p
6821	140p
6840	310p
6850	110p
8080A	400p
8085A	320p
8155	390p
8156	360p
8224	270p
8226	270p
8228	270p
8243	250p
8250	850p
8251	300p
8253	340p
8255	360p
8256A	1200p
8257A	370p
8259	370p
8271	4400p
8272	1300p
8279	650p
8282	400p
8283	400p
8284	500p
8288	1000p
8748	2900p
SP0256AL2	500p
Z80ACPU	180p
Z80BCPU	500p
Z80ADMA	650p
Z80AP10	250p
Z80BP10	600p
Z80ACTC	250p
Z80BCTC	600p
Z80AS10	660p
Z80AS10/1	700p
Z80AS10/2	700p
Z80ADART	680p

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7403	22p
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7409	20p
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74155	45p
74157	45p
74160	50p
74164	50p
74167	35p
74173	50p
74174	70p
74175	65p
74176	45p
74180	50p
74182	45p
74192	40p
74196	40p
74197	45p
74393	70p

LINEAR IC'S			
AN-214P	200p	LM301	26p
AN-240P	150p	LM311	35p
AN-360	120p	LM324	35p
AN-7110	140p	LM325	45p
AN-7114	160p	LM339	40p
AN-7115	160p	LM348	60p
AN-7120	140p	LM380	100p
AY3-1270	680p	LM381	150p
AY3-1350	300p	LM382	130p
AY3-8910	360p	LM387	100p
AY3-8912	400p	LM709 OIL	30p
AY5-3600	570p	LM723	40p
CA270	40p	LM741 DIL	18p
CA3046	60p	LM741 MET	45p
CA3048	190p	LM747	58p
CA3060	280p	LM748	35p
CA3080E	70p	LM1458	33p
CA3086	55p	LM3900	30p
CA3089E	150p	M-51513L	180p
CA3090AQ	300p	M-51515BL	270p
CA3130E	80p	M-51518	280p
CA3130S	100p	M-51517L	280p
CA3140E	38p	MB3712	150p
CA3189E	250p	MB3730	260p
CA3240E	90p	MB3756	260p
HA-1156W	110p	MC1327	70p
HA-1197	150p	NE555	20p
HA-1306W	170p	NE556	40p
HA-1319	250p	SAS560	110p
HA-1339	170p	SAS570	110p
HA-1342	170p	SN76003N	140p
HA-1366WR	160p	SN76110N	70p
HA-1368	160p	SN76115	70p
HA-1377	220p	T2800D	52p
HA-1389	140p	TA-7120	55p
HA-1392	230p	TA-7137P	83p
HA-1397	250p	TA-7146P	400p
HA-1398	240p	TA-7193P	400p
LA-1201	85p	TA-7200	200p
LA-1352	120p	TA-7201	200p
LA-1365	140p	TA-7203	180p
LA-3301	120p	TA-7204	110p
LA-3350	120p	TA-7205	80p
LA-3361	115p	TA-7210	200p
LA-4030	200p	TA-7222AP	120p
LA-4031	140p	TA-7310P	100p
LA-4032	140p	TA-7609	270p
LA-4050	130p	TAA550	16p
LA-4051	160p	TBA120S	45p
LA-4100	120p	TBA395	60p
LA-4101	100p	TBA396	60p
LA-4102SK	140p	TBA520	100p
LA-4112	250p	TBA530	100p
LA-4125	210p	TBA540	100p
LA-4140	70p	TBA560	100p
LA-4201	120p	TBA750	100p
LA-4220	120p	TBA800	35p
LA-4400	190p	TBA810S	80p
LA-4420	140p	TBA820	75p
LA-4422	130p	TBA920	100p
LA-4430	130p	TBA950	100p
LA-4460	170p	TBA990	100p
LA-4461	180p	TCA270	40p
LA-5112	120p	TCA800	200p
		TCA940	100p
		TDA1170	100p

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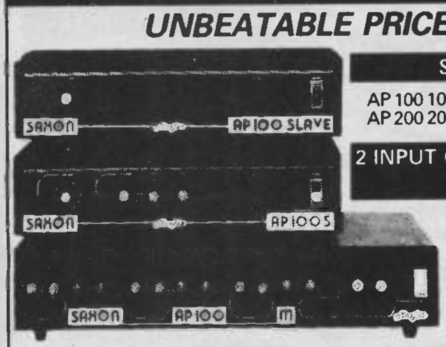

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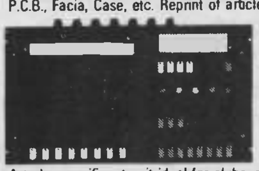

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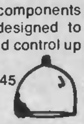

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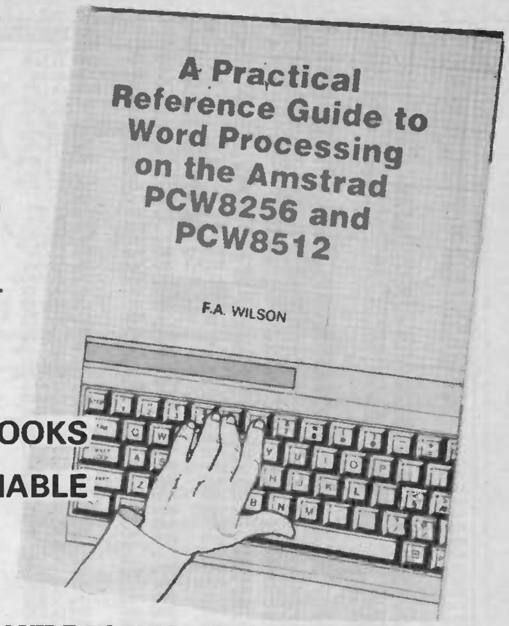

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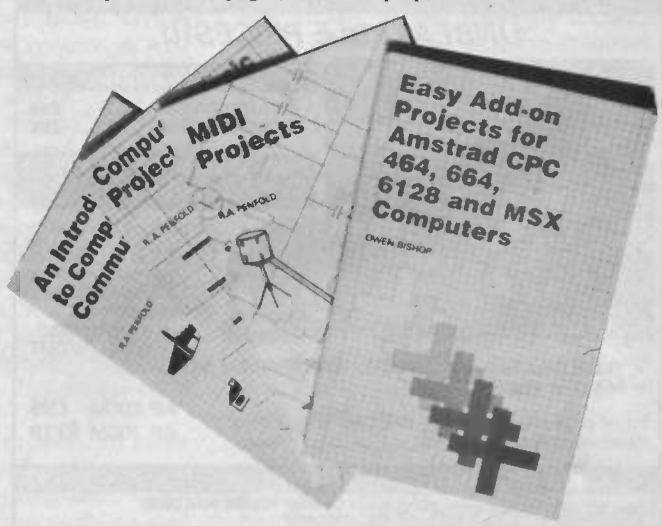

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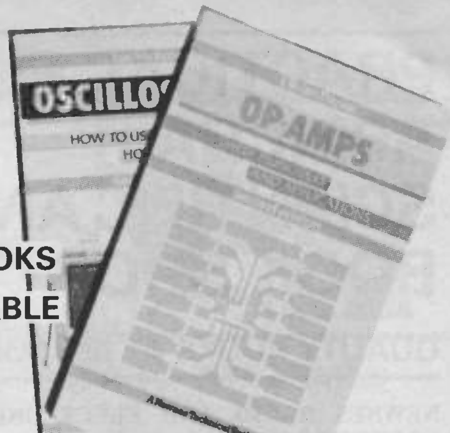

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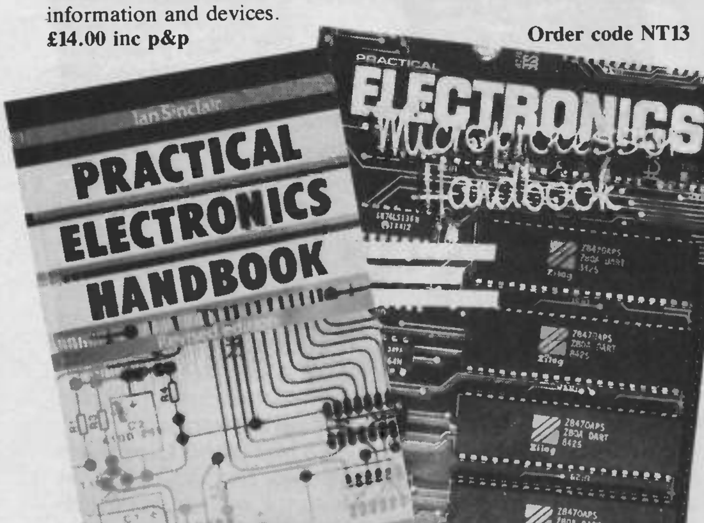

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J. Seidler, Institute of Fundamentals of Informatics, Polish Academy of Sciences, Translation Editor: Richard Deasington, IBM United Kingdom Laboratories Ltd, Southampton, 1983, 567 pages
This unified and systematic analysis of network performance and theory of operation is compatible with the recent trend in computer systems which indicates the growing importance of computer networks. It reflects the technical progress in the field of electronic digital circuits, and describes, classifies and evaluates the quality and optimisation of the rules of computer communication systems operation.

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C.G. Morgan, Lecturer, University of Salford, 1984, 194 pages
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S.J. Cahill, Senior Lecturer, School of Electrical and Electronic Engineering, Ulster Polytechnic, 1981, 513 pages
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INDEPENDENT SCIENTIFIC AND TECHNICAL BOOK REVIEWS

SERVICING PERSONAL COMPUTERS

Michael Tooley
212 pages 234 × 163mm (soft cover) £17.95
Wm. Heinemann Ltd.
ISBN 0 408 01502 0

As yet there are few books to aid would-be computer repairers, and this one is a welcome addition. The first part of the book deals with some microprocessor basics, and this is followed by details of various types of test gear needed for checking microprocessor circuits. The final part of the book is a reference section which covers such things as circuit symbols and TTL integrated circuit details. I can't help feeling that most of the information in these sections is superfluous, as it is the type of thing that anyone contemplating microcomputer servicing should be very familiar with already or they should not be thinking seriously about delving into a computer's innards. It is the middle chapters of the book which are likely to prove most useful, and these cover fault diagnosis, tape and disc drives, and printers and monitors. The treatment is fairly comprehensive, and includes advice on how to replace devices without causing more damage than you repair, as well as the technicalities of fault diagnosis.

Servicing any electronic equipment is a situation where experience counts for more than anything, but this book should get the reader started on the right lines.

DOMESTIC VIDEO CASSETTE RECORDERS – A SERVICING GUIDE

Steve Beeching
162 pages 245 × 190mm (soft cover) £15.95
Newnes Technical Books
ISBN 0 408 01573 X

Although primarily aimed at the professional service engineer, this book comprehensively covers the operation of video recorders and is an interesting read for someone who simply wishes to know more about the inner workings of these machines, with no interest in servicing them. The obsolete Philips N1500 series are used to illustrate the basic techniques utilized in video recorders, but details of modern developments such as high quality stereo sound and digital techniques are included, and this second edition of the book is fully up to date. Taking the original video recorder techniques and then describing modern developments helps to make things understandable, as well as providing a logical way of covering any divergences between different systems, or between various manufacturers of equipment operating to the same system. You are not blinded with details before the basics have been explained. For those who are interested in the book as an aid to servicing rather than for its interest value, the final chapter covers fault patterns for a wide range of machines. There is also an appendix covering A/V socket connections, and a large glossary of video terms.

This book is intended as a primer for someone who will go on to undertake video recorder servicing, and as such it is very good, but it also succeeds as an informative and interesting book for someone with a reasonable grounding in electronics who would like to expand their knowledge of the subject.

BEGINNER'S GUIDE TO INTEGRATED CIRCUITS

Ian R. Sinclair
190 pages 185 × 123mm (soft cover) £4.95
Wm. Heinemann Ltd.
ISBN 0 408 01301 X

The stated aim of this book is to help a comparative newcomer with some knowledge of transistor circuits to understand the principles, construction, and use of integrated circuits. This is the second edition of a book which was first published in 1977, and the concept is perhaps a little out of date, in that most beginners these days learn about some of the simpler integrated circuits before mastering transistors. The first two chapters cover the basics of i.c.s and their production, then subsequent sections deal with amplifiers, digital devices, MOS devices, microprocessors, domestic i.c.s, specialised i.c.s, and practical construction.

There is certainly a lot of useful information in this readable and well written book, but it is not quite the bargain it seems in that some of the information is outdated and some of the devices described are now obsolete. It still justifies the modest cover price though, and is a worthwhile proposition for those of limited experience who would like to know more about the fundamentals of a wide range of integrated circuits.

NEWNES RADIO AND ELECTRONICS ENGINEER'S POCKET BOOK (16th Edition)

Keith Brindley
166 pages 166 × 95mm (hard cover) £5.50
Wm. Heinemann Ltd.
ISBN 0 408 00720 6

First published in 1940 and now in its 16th edition, this has to be a useful and worthwhile book. It is not the usual type of technical book with chapters on various subjects, but is more a collection of lists, tables, etc., with a wide range of topics covered. It would take far too much space to list all the subjects dealt with, but as a few examples taken at random, there are pinout diagrams for a range of CMOS and TTL integrated circuits, reactance charts, amateur radio abbreviations and the "Q" code, BS3939 component symbols, conversion tables, CB and amateur band frequency allocation details, and power supply data.

It is important to realise that this is *not* a teach yourself electronics book, and does not set out to be. What it does set out to do, and largely achieves, is to provide a useful reference source for electronics engineers, or anyone involved in electronics design and servicing. Although it has its origins well back in the valve era, this book has been regularly up-dated, and although in a few places it shows signs of its age, most of the data is modern and relevant to today.

Reviews by R.A.P.1986

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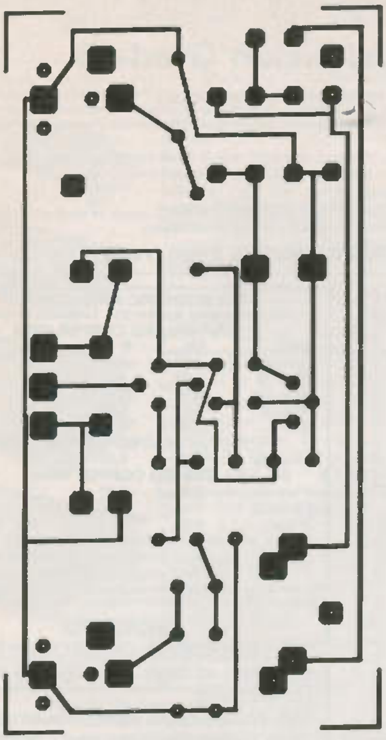

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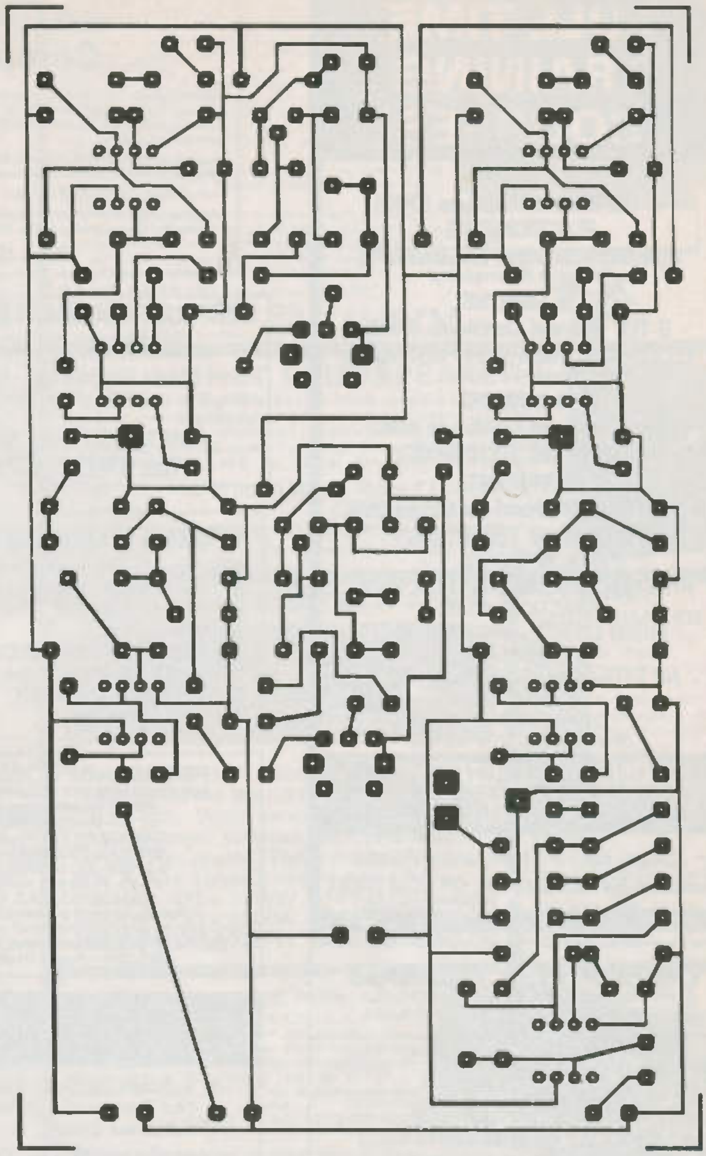

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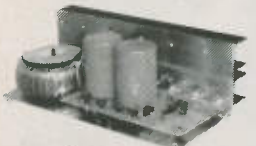

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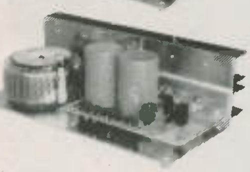

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★ Insulated plastic case
★ Full wave control using 8 amp triac
★ Conforms to BS800
★ Suitable for both resistance and inductive loads. Innumerable applications in industry, the home, and disco's, theatres etc.

PRICE £13.99 + 75p P&P

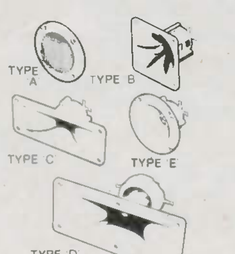
BSR P295 ELECTRONIC TURNTABLE

★ Electronic speed control 45 & 33⅓ r.p.m. ★ Plus/Minus variable pitch control ★ Belt driven ★ Aluminium platter with strobed rim ★ Cue lever ★ Anti-skate (bias device) ★ Adjustable counter balance ★ Manual arm ★ Standard ½" cartrige fixings ★ Supplied complete with cut out template ★ D.C. Operation 9-14v D.C. 65mA
Price £36.99 — £3.00 P&P.

ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p.

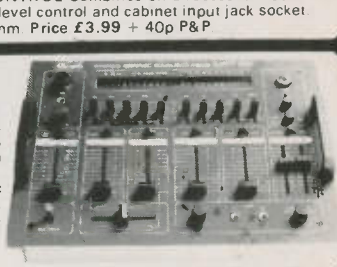
PIEZO ELECTRIC TWEETERS MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. Price £4.90 each + 40p P&P.
TYPE 'B' (KSN1005A) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. Price £5.99 each + 40p P&P.
TYPE 'C' (KSN6016A) 2" × 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. Price £6.99 each + 40p P&P.
TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. Price £9.99 each + 40p P&P.
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. Price £5.99 each + 40p P&P.
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket. 85 × 85 mm. Price £3.99 + 40p P&P.

STEREO DISCO MIXER



STEREO DISCO MIXER with 2 × 5 band L. & R. graphic equalisers and twin 10 segment L.E.D. Vu Meters. Many outstanding features 5 Inputs with individual faders providing a useful combination of the following:—
3 Turntables (Mag), 3 Mics, 4 Line plus Mic with talk over switch. Headphone Monitor. Pan Pot. L. & R. Master Output controls. Output 775mV. Size 360 × 280 × 90mm.
Price £134.99 — £3.00 P&P

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