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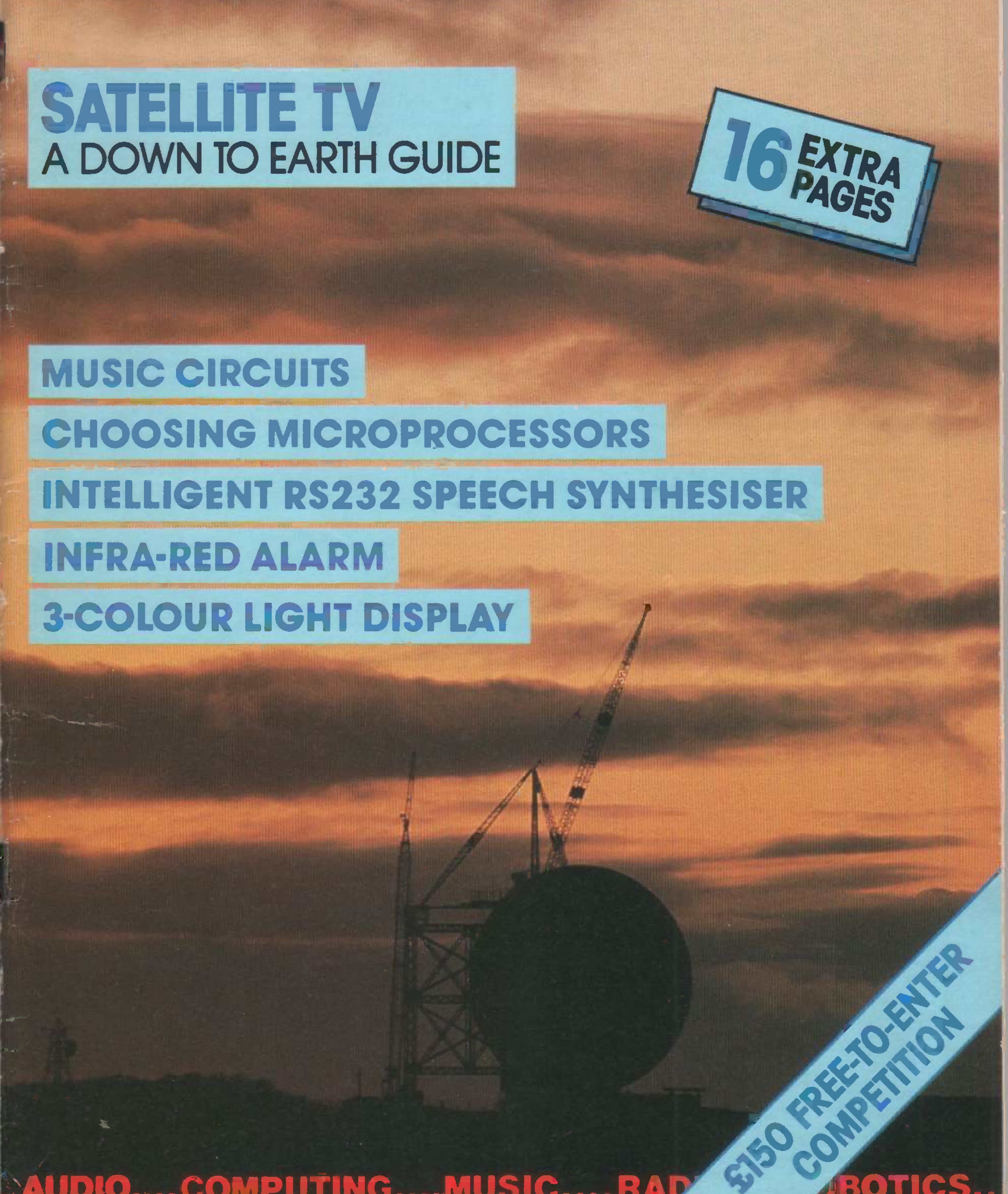

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INTERNATIONAL JAN 1988 VOL 17 No. 1

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ARGUS PRESS GROUP

FEATURES

PROJECTS

REGULARS

Cirkit's winter electronic constructor's catalogue is now out. The catalogue features Cirkit's range of components, kits, tools and books and costs £1.20. Vouchers worth £10 redeemable from orders are included along with a competition to win over £200 of test gear. The catalogue is available from Cirkit, Park Lane, Broxbourne EN10 7NQ. Tel: (0992) 444111.

IQD's annual catalogue is now available and contains details of IQD's range of crystals, quartz resonators, oscillators and SAW filters. The catalogue is available from IQD, North Street, Crewkerne, Somerset TA18 7AR. Tel: (0644) 74433.

Amstrad CPC micro users can now design PCBs from the comfort of their own keyboards with a PCB drafting program from Cadsoft. The program operates on all versions of the micro without the need for expansion RAM and can cope with double sided boards of up to 25in square with 4000 pads and tracks. Foil artwork is produced on a standard dot-matrix printer at 2:1 scale. The program costs £19.99 on cassette or £21.99 on disk from Cadsoft, 18 Ley Crescent, Astley, Tyldesley, M29 7BD.

Making contact with the tiny closely-spaced leads of surface mount components is made easier thanks to a range of purpose-designed test leads from PSP Electronics. The SMD Grabber is a variation on conventional test lead grippers but uses pincer-like contacts instead of the normal hook to grasp the leg of devices such as SOIC, SOJ and PCC packages/ IC clips for SOIC and PCC or PLCC pack- ages are also available in 20, 28, 44, 52 and 68 pin versions. Details and prices from PSP Electronics, 2 Bilton Road, Perivale, Greenford UB6 7DX. Tel: 01-998 9061.

Mitsubishi has launched three monitors for micro users with a yearning for high resolution colour and with a bank balance to suit. They range from the 14in FA3405 at £600 featuring auto scanning of vertical and horizontal frequencies, through the 16in £1900 FG6605, to the 20in £2300 HJ6905 with a 0.31mm dot pitch giving a resolution of 1200×1000. Further details from Mitsubishi, Hertford Place, Denham Way, Maple Cross, Rickmansworth WD3 2BJ. Tel: (0923) 770000.

Take It Away Alan Sugar

Alan Sugar's Amstrad is set to take the micro world by storm yet again. This time it is a portable IBC PC compatible micro he is launching, again for less than most people would consider possible.

The PCC range is fully compatible with the IMV PC and features an 8MHz processor, 512K RAM, 80×25 character LCD screen and 720K disk drives.

Yet the micro weighs just 5½kg and measures 19×9×4 in when the full sized keyboard is folded to the closed position.

Four models will be available in January 1988 starting with the PPC512S with 512K and a single disk drive for £399+VAT and ranging to the PPC640D with 640K, twin drives and a built-in Hayes-compatible model for £599+VAT.

The micro's power is supplied by dry cell batteries (giving eight hours' use), from a car battery, the supplied mains adapter, an Amstrad PC monitor (giving a full colour display) or from a bolt-on expansion slot unit.

To think that just a couple of years ago the display alone would have cost more than the entire PPC512!

Further details are available from Amstrad, Brentwood House, 169 Kings Road, Brentwood CM14 4EF. Tel: (0277) 230222.

Big Signals From A Mini Dish

Salora Luxor claims its 90cm satellite TV dish is as good as the more usual 1.2m and 1.5m dishes thanks to a super low-noise LNB amplifier unit a the focus of the dish. The dish is to be marketed in two systems under the names of both Salora and Luxor. The Salora system offers basic TVRO facilities and costs £549. The Luxor system uses the existing Mark 2 receiver unit found in Luxor's de luxe systems and costs £599. Both systems use a fixed dish mount only and can have a polariser added for around £100 extra. All prices include VAT. Further details from Salora, Bridgemead Close, Westmead, Swindon, Wilts. Tel: (0793) 644223.

Flicker Free Digital TV

Flickering TV screens will be a thing of the past if the latest idea and chips from Siemens take off.

The Siemens system relies on increasing the frame frequency from 50 to 100Hz. This is done by digitising the incoming TV signal and storing it in 256K RAM. The stored picture can then be 'read' and displayed twice in the time usually taken to display a single frame.

The picture shows the (lower) 100Hz screen without the vertical blanking interval bar in this 1/60th second exposure.

The system uses a family of digital video processing chips developed by Siemens including a 13.5MHz ADC (the SDA7509), a digital colour decoder (SDA905n), a DAC (SDA9060) and a memory controller (the SDA9095) running at 27MHz.

The system and the chip set works with PAL, NTSC and SECAM TV standards and lends itself to future TV systems such as D2-MAC. Siemens expects TVs using the digital frame rate increase to be on sale in 1988 or 1989.

Dream Time

If you thought the Dream Machine presented free on the covers of the last two months' ETI is just a pipedream then think again. Researchers at the Medical Physics Department of the Withington Hospital in Manchester are using the Dream Machine's soothing effect for psychotherapy experiments. Just goes to show that just because it's free, it doesn't mean its worthless.

Less Women In Engineering

There are 40% less women employed in the engineering industries now than ten years ago claims a recent report from the Engineeing Industry Training board.

However, the proportion of women to men has risen in the same period. Women still outnumber men in the offices of engineering companies by about three to one.

Engineering management is still very much a male bastion. Although the proportion of female managers has risen over the last ten years, it is still at an atypical 3.8%.

In electrical and electronic engineering the percentage of women workers is currently at a reasonably healthy 32% – well above the overall engineering average of 20%.

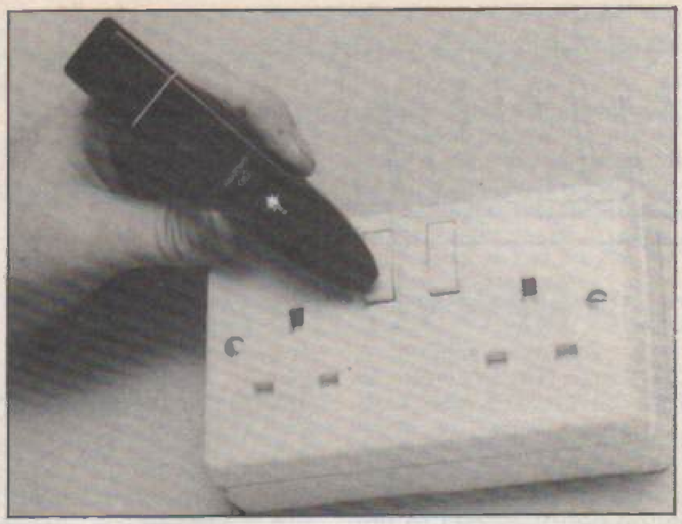
However, the numbers of workers of both sexes in electrical and electronic engineering has fallen since 1978 with a considerably greater drop of women workers.

The prospects for equality in the future look promising. The number of female electrical engineering graduates has more than doubled in the last ten years although the total number of graduations has risen by only a quarter.

The Engineering Industry Training Board report is called 'Women in engineering - trends in employment and training' and costs £10 from EITB Publications, PO Box 75, Stockport, Cheshire SK4 1PH.

Chips To Suit Every Palette

Hitachi has reduced the whole of the video back end of a micro onto a single chip. The HD153108 provides a complete colour palette with three 4-bit DACs, a microprocessor inter- face, and a 260-word 12-bit dual port RAM. Up to 256 colours can be displayed at once from a palette of 4096 at video dot rates of up to 50MHz. 75ohm drivers for the red, green and blue signals are also provided. Prices for the new chip have not yet been finalised but Hitachi expects the HD153108 to cost in the region of £40. Further details from Hitachi, 21 Upton Road, Watford, Herts WD1 7TB. Tel: (0923) 246488.

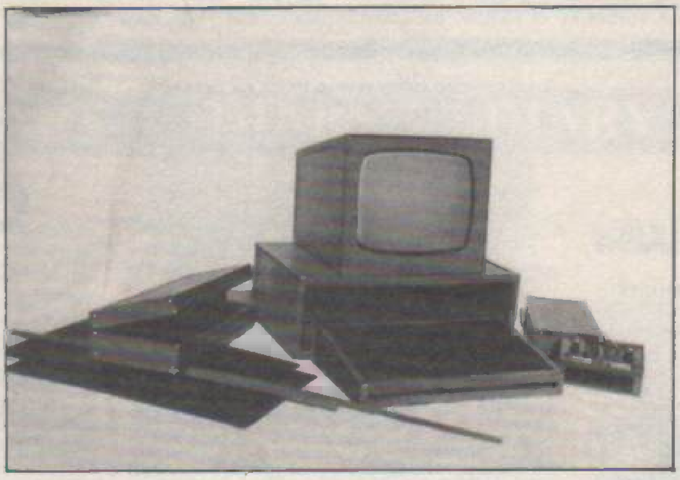


Detection Without Connection

The pocket voltage detector from Subtronic is a mains tester that doesn't need to be touched to the test cable! The pocket unit needs only to be placed near suspected area to register the presence of mains voltage.

The detector is battery powered and indicates mains voltage in the vicinity with an LED. It is voltage which is detected and not current, so the unit is ideal for plumbers, electricians and other workers dealing with mains wiring.

The pocket voltage detector costs £19.50 + VAT and it is available from Subtronic Ltd, High Street, Hillmorton, Rugby, Warwickshire CV2 4HD. Tel: (0788) 70241.



A Case Of Good Design

Encore Enclosures' DIY case system allows any size and shape of case to be custom made for difficult projects.

The system is based around plastic sheeting and a range of plastic extrusions form the edges of the case and join side panels cut from the sheeting. All panel edges are concealed by the edge extrusions and so considerable neatness and margin for error is achieved even with unprofessional assembly.

A range of corner fittings and front panel edge trims are also available.

Encore claims the DIY system provides cheaper cases than the ready-made variety as a project can be cased in the bare minimum sized box required for the job rather than in the next largest standard size.

Typical costs are £11 to make up a 19in racking case and £8 for a slope front computer keyboard.

The Encore DIY system was originally developed after complaints from Bath University that students were having difficulty finding suitable enclosures for their course projects.

Further details and prices from Encore Enclosures, Unit 3, Willand Industrial Estate, Cullompton, Devon EX15 2QW. Tel: (0884) 820955.

- *City and Guilds is promoting itself with a 12-minute video. Available free to employers, training agencies and educational establishments, the video highlights the various aspects opf the City & Guilds' work in engineering, computing, catering, tourism and chemical engineering. For a free copy write to The Publicity Officer, City & Guilds, 46 Britannia Street, London WC1X 9RG.*

- **Low power PAL devices are now available from Monolithic Memories. The PAL C20R8Z-35/45 ZPAL devices are manufactured in CMOS and consume less than 10uA in standby mode and 3mA/MHz in operating mode. The low power PALs are offered in 24 pin 'Skinny-dip' packages or 28 pin PLCC. Further details from MMI, Monolythic House, Queens Road, Farnborough GU14 6 DJ. Tel: (0252) 517431.**

- *Greenweld's 1988 component catalogue is now available at a price of £1. The 88-page catalogue contains details of all Greenweld's range from single resistors to music keyboards. A free continuity tester is offered to the first 1000 customers. Greenweld, 443a Millbrook Road, Southampton SO1 0HX. Tel: (0703) 772501.*

- A directory of 'ex-government' software is available from Microinfo. Over 1,700 programs developed for US Federal Agencies are listed in 21 subject areas in the Directory of Computer Software and most are available from Microinfo for purchase but without installation or support. Further details from Microinfo, PO Box 3, Omega Park, Alton, GU34 2PG. Tel: (0420) 86848.

- **Peculiar custom keypads are easily made up using Highland Electronics' DNC DT series of DIY keypad kits. The kits are available in 4, 12, 16, 40, 80 and 102 key configurations and include the basic switch unit, graphic overlay, colour pad, connector, bezel, and face plate. Dry transfer lettering is also available in a number of styles for labelling the keys. The switches have a steel dome to provide tactile feedback and can be cut up from the seven standard layouts for custom designs. Further information is available from Highland Electronics, Albert Drive, Burgess Hill, West Sussex RH15 9TN.**

NEXT MONTH

electronics today INTERNATIONAL

YOUR NEW YEAR'S RESOLUTION

MORE SATELLITE TV

Keith Brindley knows when he's onto a good thing and next month he looks at 55 satellite TV reception systems (that's TVROs to you if you've read this month's article). Don't miss the February ETI to find which is dish of the day.

TRANSISTOR TESTER

It's been a while since we published one of these. This high tech version tests transistors and diodes in or out of circuit and displays the results on an LCD. Definitely a flashy addition to your workshop.

SPECTRUM CO-PROCESSOR

If you thought 128K Spectrum Plus 17 was the last word in updating the Spectrum architecture then think again. This wondrous add-a-micro unit provides 256K and a second Z80 processor for your Spectrum for truly complex home computing or system development.

NOT FORGETTING . . .

. . . all the rest that go to make ETI the best electronics magazine on the shelves of your local newsagent. There's news, reviews, projects, features and much, much more in next months ETI.

February ETI – Out 1st January 1988

All these articles are in preparation but circumstances may prevent publication.

One Good Turn Deserves Another

An ingenious hand held tachometer is available from Electronic Temperature Instruments (a company with a strangely familiar abbreviated name). The PFM120 digital tachometer uses a modulated beam of infra-red light reflected once every revolution from a piece of reflective tape onto the rotating object to determine the rotational speed without contact.

An optional 'contact adapter' is also supplied. This plugs into the end of the tachometer and the conical head is touched to the end of a rotating shaft to measure rotational speed or a rubber covered disc is placed in contact with conveyor belts, roller surfaces and the like for measuring linear speeds.

The tachometer can measure rotational speeds from 1-100000rpm with four digit accuracy. The PFM costs £125 +VAT from ETI, PO Box 81, Worthing, West Sussex BN13 3PW. Tel: (0903) 202151.

European Rocket Finally Leaves The Ground

Ariane has finally managed a successful launch. On 16th September, after a delay caused by fueling telemetry problems on the third stage, the joint European rocket left the launch pad just after midnight to deposit two communications satellites in geostationary orbit.

The previous Ariane was blown up early in its flight in 1986 because of fuel problems preventing the third stage from igniting.

Now that Ariane is back on stream we can expect a launch every month or so. The next cargo scheduled is the West German RT SAT A3. This heavy 200W satellite will provide Germany with its full DBS service receivable on dishes of less than 60cm.

The US Space Shuttle has also been having some luck. The recent tests of the solid fuel rocket boosters have shown no leakage of gas through the redesigned o-ring seals (the cause of 1986's shuttle disaster). Many more tests are still to be performed but if these all go well, the shuttle is expected to resume launches in June 1988.

CD ROMs Are Here

The first CD ROM package for personal computers is about to hit the electronic streets. Bookshelf from Microsoft provides ten reference works for writers using an IBM PC compatible micro.

On the read-only optical disc is stored information amounting to 1500 floppy disks, claims Microsoft Amongst the reference works stored at a comprehensive dictionary, a thesaurus, a business information listing and literary style manual.

The CD ROM runs on a Hitachi drive connected to an IBM PC compatible and can be accessed while using other programs, such as a word processor.

Microsoft hopes to release further CD ROM packages of other reference information soon and claims that optical storage will soon be commonplace amongst office micros.

Bookshelf costs £195 +VAT and includes the CD ROM MS-DOS extensions. A separate CD ROM drive is required. Further details from Microsoft, Excel House, 49 De Monfort Road, Reading RG1 8LP. Tel: (0734) 500741.

DIARY ... DIARY ... DIARY ... DIARY ... DIARY ...

The UK Space Programme - December 7th
The IEE, London. Lecture by R. Gibson of the British National Space Centre. Contact IEE on 01-240 1871.

Mathematical Modelling of Semiconductor Devices - January 7-8th
University of Technology, Loughborough. Contact IEE on 01-240 1871 or The Institute of Mathematics and its Applications on (0702) 612177

Early Days Of Electric Lighting - January 11th
IEE, London. Lecture by C. N. Brown of the Science Museum. Contact IEE on 01-240 1871

Corporate Computer Security '88 - January 12-14th
Metropole Exhibition Centre, Brighton. Contact PLF Communications on (0733) 60535

Gallium Arsenide: A New Generation Of Devices - January 14th
IEE, London. Lecture by Prof. D. V. Morgan (UWIST). Contact IEE on 01-240 1871

The Illusion Of Colour - January 14th
Lecture by M. B. Halstead (Thort EMI) at the Gonville Hotel, Gonville Place, Cambridge. Contact Eastern Region IEEIE on (0603) 628321

British Engineering Supplies & Technology - January 18-21st
Olympia, London. Contact Mack-Brooks Exhibitions on (07072) 75641

The Which? Computer Show — January 19-22nd
NEC, Birmingham. Contact Cahners Exhibitions on 01-891 5051

Role Of Highly Elliptical Orbits In Satellite Communications - January 28th
IEE, London. Lecture by G. Beretta of the European Space Agency. Contact IEE on 01-240 1871

Electromagnetic Compatibility And Microprocessor Based Systems - February 2nd
Heathrow Penta Hotel, London. Contact ERA Seminars and Exhibitions on (0372) 374151

European Seminar On Neural Computing - February 8-9th
Royal Garden Hotel, London. Contact IBC Technical Services on 01-236 4080

Energy '88 - February 10-12th
Garrogate Exhibition Centre. Contact Emap Maclaren Exhibitions on 01-686 9200

Cable And Satellite '88 - February 25-28th
Wembley Exhibition and Conference Centre, London. Contact Montbuild Exhibitions on 01-485 1951

Offshore Computer Show - March 22-24th
Aberdeen Exhibition and Conference Centre. Contact Offshore Conferences and Exhibitions on 01-549 5831

Electro-Optics & Laser UK — March 22-24th
NEC, Birmingham. Exhibition running alongside the Optics-Ecoosa '88 conference at the Birmingham Metropole Hotel. Contact Cahners Exhibitions on 01-891 5051

Computing In The Next Generation - March 25-27th
Annual conference of the British Computer Society's Young Professionals Group. Contact Julia Allen on 01-637 0471 for the venue.

Computers In Retail & Retail Technology Exhibition - March 29-31st
Metropole Exhibition Centre, Brighton. Contact Focus Events on 01-834 1717

HF Radio Systems And Techniques - April 11-13th
The IEE, London. Conference organised by the IEE and The Institute of Mathematics and its Applications. Contact IEE on 01-240 1871

COMPETITION

Win one of two prizes worth £150 in our free-to-enter competition

ETI has two £75 vouchers redeemable against ETI project kits from Specialist Semiconductors just waiting to be given away to two lucky readers. You can use the vouchers in part or total payment against any ETI project kit available from Specialist Semiconductors. See the ad in this issue for a taster of the range available.

What do you have to do to win these precious prizes? Well it couldn't be simpler and we're not asking for you to be superhumanly intelligent in electronics either.

Below you will see two panels. One contains a wordsearch square and the other a simple resistor network. The wordsearch is the really easy one so let's look at that first.

Hidden in that 400-letter mass are more than 30 words (between three and ten letters long) you are likely to find in the pages of ETI. All you have to do is find them. The words are written horizontally, vertically and diagonally and they're not necessarily the right way around. As that's so easy, we're not going to tell you how many there are there – it's more than 30 and a lot less than 452! Ring the letters of each word as you find it, as shown with the word 'KEYPAD'.

The resistor network is even simpler. Here's your chance to put that *Circuit Theory* to the test. All you have to do is to work out the current (I) flowing through the central resistor, to the nearest milliamp. Couldn't be simpler!

When you've found all the words you're going to, list them out in the space provided (now that gives you some idea how many there are . . .) and write the total where indicated. Write the current you've calculated to be flowing through the central resistor in the space provided for that and send the whole coupon (or a photocopy) to:

ETI SS Competition
1 Golden Square
London W1R 3AB.

All entries must be clearly marked for the SS Competition and must arrive at the ETI offices by 12 midnight on 31st December, 1987. The results will be announced in a future issue. Needless to say, the judges decision will be the last word.

D	H	T	O	O	T	W	A	S	V	V	U	R	E	D	I	L	S	X	E
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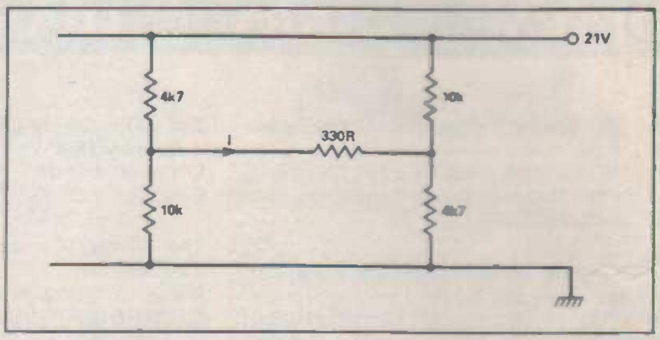

The current, I, is:

Total number of words found:

The words I have found are:

READ/WRITE

Dead Clever

Here I was, on my (late) summer hols (better late than never) when I received my September issue of ETI (late, on account of my being (a) overseas and (b) on holiday previously as well).

The little paragraph at the end of Read/Write inspired me to write to you. As a matter of fact I *was* in Torremolinos but I had to catch a bus and so I couldn't fulfil your request to the letter. However, I'm sending you a postcard from Puerto Banus which is much more distinguished anyway.

Now to electronics: I think the ETI EEG Monitor is a brilliant idea! I shall relate to you an experience I have with a similar device.

I used two well-screened, balanced differential amps feeding a third (as in your Bio-amp) then a buffer, a further amp and the whole thing was connected to a scope.

I used three proper electrodes in saline gel and, having created the proper atmosphere (cauldron, candles, etc) connected it up to a human skull my father has at home.

Lo and behold — alpha-waves! We couldn't believe our eyes (my father is a psychiatrist) so to see if it was just noise we disconnected the skull — nothing. We tried the electrodes on ourselves — alpha!

At this point we ripped the whole thing to bits and tried to forget all about it!

So, a warning to all who build the EEG Monitor: Watch out, watch out, there are alpha waves about!

Ilya Eigenbrot
A train somewhere in Portugal (usually Heidelberg, West Germany)

PS By the way, what's happened to Tech Tips?

What can we say. A postcard — how touching. So there are readers who care!

It's well known that EEG really stands for Eerie Electric Ghost so what did you expect!

Seriously though, folks, as was explained in the last part of the EEG Monitor project (November 1987) it is not a good idea to directly connect up such a device to any mains powered equipment (such as a scope). That is why the opto-isolated output was provided on the ETI device.

As to Tech Tips: Although generalised Tech Tips have been a bit short on the ground recently, there has been an abundance of circuit ideas on specific areas (CB, music, cars and so on) over the last year or so. We will try to fit more of both into the mag in future.

At Last!

I've always wondered what I was supposed to do with ECL logic chips. The *Hardware Design Concepts* in the November ETI has now told me.

Can we have more such articles please.

Neil Sinclair
Gunnerside, North Yorkshire

Mike Barwise's excellent *Hardware Design Concepts* series has now run its course. However, Mike is starting a new series to look at specific ICs and families in this very issue. We hope you find this useful in the coming months.

Who Needs Software?

Thanks for Robert Stevenson's *Concept* controller project. As you said, many controllers have been published before but this has to be the ultimate. I'm now well on the way to finishing mine.

I am a little puzzled, however, by the whole page of EPROM hex dump that you published in the November issue. Given that Robert is selling pre-programmed EPROMs, why take up so much space (which you are always bemoaning as short) in the magazine with a listing which few, if any, readers would attempt to type into a programmer?

Hugh Young
Congleton, Cheshire

Many ETI projects these days are microcomputers in one guise or another and so a great deal of magazine room is taken up by publishing the software. However, we feel this is essential for those readers who do not wish to pay out for intangibles and for those reading the mag in years to come, after the project's author has moved on.

Next On BBC1 . . .

It is a well known fact that only very weird people ever write in to *Points of View* at the Beeb. You know the kind of thing: "I was disgusted to hear the word 'elbow' mentioned on BBC2 last night before nine o'clock" or "I would gladly give my right arm and several toes for the chance to see the closing credits of last night's six o'clock news again".

Anyway, I am not (very) weird and so I am not going to write to *Points of View*. Instead, I am writing to you to say how glad I am that *Doctor Who* is back on the box (pity about Bonnie Langford, though).

Ever thought of changing your postcode to W12 8QT?

Roger Thomson
Crewkerne, Sommerset

It's nice to know that ETI is held in higher esteem than *Points of View*. Quite agree about Doctor Who (and about Bonnie Langford).

It's a bit of a silly selection in this month's postbag but who are we to complain. Even a crazy letter is much better than no letter at all. So, with that as your motto, scribble us off a note while this month's controversy is still fresh in your mind.
Write to: Electronics Today International
1 Golden Square
London W1R 3AB

ETI

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Radio Modeller	£14.40
Sea Classic International	£11.70
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THE SKY'S THE LIMIT

Keith Brindley has scanned the heavens for this low-down on Satellite TV equipment

There's a lot of trash talked about satellite television, not the least by some specialist journalists so the first thing we need to do here is get back down to earth and define a few terms.

The term *satellite television* covers any system where television pictures are transmitted from an *earth station* to a satellite in orbit around the earth. Generally, though not specifically, the transmitted pictures on the *uplink* (from the earth station to the satellite) are retransmitted from the satellite back to another earth station on a *down-link* at a different frequency.

On the satellite, the devices which receive and retransmit satellite communications are known as *transponders*. At the earth station, an antenna (if satellite communications had been pioneered in Britain we'd have called this an aerial!) does the transmission and reception.

Satellite transmissions are typically in microwave frequencies – more specifically in Band VI in the super-high frequency range (between about 11GHz and 13GHz). The antennae are parabolic reflecting dishes which concentrate the signal onto a receiving device at the focal point, much like a concave mirror. The parabolic dish must be accurately pointed at the satellite within only a fraction of a degree, to satisfactorily focus the microwave signals onto the receiving device.

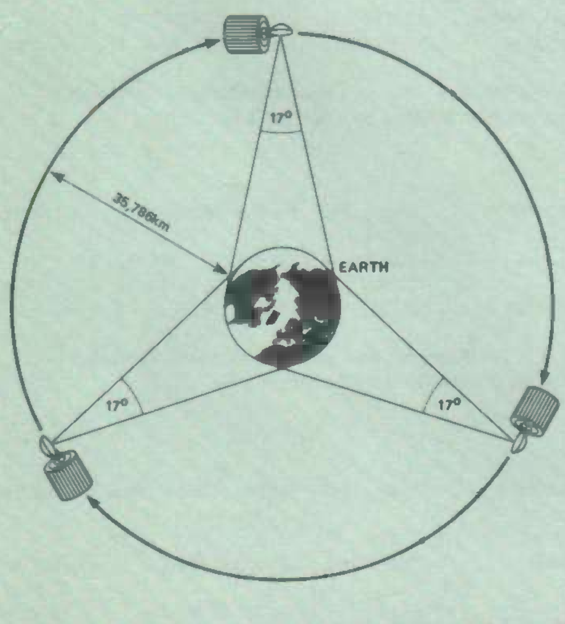


Fig. 1 Three satellites can cover the whole of the earth's surface with transmissions if they are positioned in the geo-stationary orbit

All the satellites of interest to us are in a geo-stationary orbit (GSO) around the earth, sometimes known as the *Clarke belt* after the science fiction writer Arthur C Clarke who, in an article in the October 1945 issue of 'Wireless World' showed how a satellite positioned 35,786km (give or take a centimetre) above the earth's equator would rotate with exactly the same period of revolution (24 hours) as the earth itself.

The GSO is quite a long way out from the earth – about five times the earth's radius from its surface or one tenth of the way to the moon – and at this distance any one satellite can have an extremely wide coverage (known as a *footprint*) of the earth's surface. As few as three satellites (Fig. 1) can cover the whole of the earth.

To do this, the *beamwidth* of the transponder's transmission only needs to be about 17°. Generally, though, satellites with restricted footprints are used (Fig. 2) where the beamwidth is reduced. These *spot beams*, are then used to transmit only to selected areas.

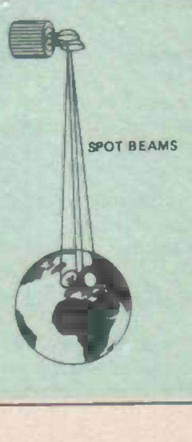


Fig. 2 Restricting the beamwidth of the satellite's antenna reduces the earth coverage. The reduced beamwidths are called spot beams

Beamwidth in degrees	Diameter of spot beam on earth (in miles)
10	3900
5.7	2200
2.8	1100
1	390
0.57	220

Table 1. Relationships of spot beam coverage to satellite transponder beamwidth.

Fig. 3 Multiple spot beams, used to exactly cover a specific area of the earth

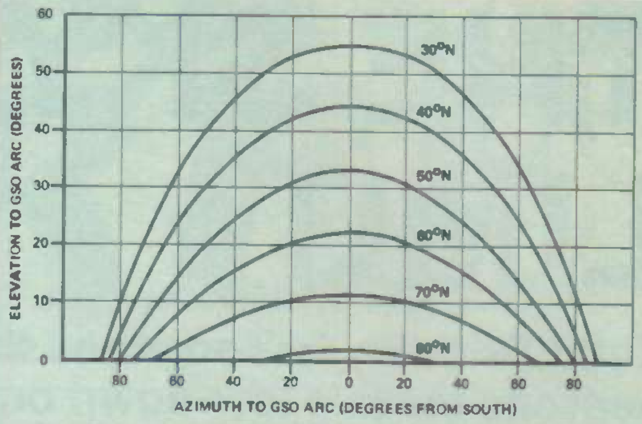


Fig. 4 Showing how the GSO is viewed at different latitudes of north

Naturally enough, the beamwidth defines the area selected and approximate area sizes are as listed in Table 1. Sometimes, a number of beams are used close together, as *multiple spot beams*, to cover an area (Fig. 3).

The GSO does not, of course, form the only orbit of consequence, many others exist but none are useful for television picture reception in the same way as the GSO because of one vital fact. From a stationary viewpoint on the earth, any chosen satellite in the Clarke belt appears stationary – a factor which greatly eases the requirements of pointing an antenna directly at it. In terms of reception here in Britain, it also means that the satellite must also be within just a few degrees or so either side of south (otherwise it will be over the horizon and invisible in terms of microwave transmissions!) and the antenna must have a clear unobstructed view of the southern aspect, on an arc to 30° or so east and west of due south.

On the equator, the GSO is directly overhead, swinging from directly east to directly west. At more northerly latitudes like Britain, the GSO forms more of an arc, peaking over the south and dropping away towards east and west. How high the actual peak is depends purely on the observer's latitude. The further north the observer, the lower the peak.

Figure 4 shows a view of the GSO arc from a number of latitudes. In Britain the arc varies from about 29° at latitude 50° north (Land's End) to 21° at 59° north (John O'Groats). The exact arc seen by the observer at any particular latitude is of direct relevance when installing an antenna.

Sometimes, the earth station both transmits and receives transmissions but in the case of satellite television systems, the earth station is more likely just to receive. For this reason, such systems (the sort you may have in your home) are called *television receive-only* (TVRO) systems. Sometimes, the reception of television pictures is not meant for an individual home but for, say, a cable network to a

Channel	Freq.	Pol	Audio	Video	Hrs.	Scramble
Anglovision	11.515	V	6.6	PAL	6	–
Arts Channel	11.135	H	6.6	PAL	3	–
BBC1/2	11.175	H	6.65	PAL	8	Sat-Tel SAVE
Children's Channel	11.015	H	6.6	PAL	10	–
CNN	11.155	V	6.65	PAL	24	–
Lifestyle	11.135	H	6.6	PAL	4	–
MTV	10.975	H	6.65	PAL	24	–
Premiere	11.015	H	6.6	PAL	9	–
Satellite Information	11.575	H	Digital	B-MAC	4	SAB-MAC
Screensport	11.135	H	6.6	PAL	6	–

Table 2. Frequencies and specifications of television channels transmitted by Intelsat VA F11.

Channel	Freq.	Pol	Audio	Video	Hrs.	Scramble
3Sat	11.175	H	6.65	PAL	8	–
Filmnet	11.140	V	6.6	PAL	24	Matsushita
RAI Uno	11.007	H	6.6	PAL	18	–
RTL-Plus	11.091	V	6.65	PAL	5	–
SAT1	11.507	V	6.65	PAL	10	–
Skychannel	11.650	H	6.65	PAL	19	OakOrion
Superchannel	10.674	V	6.65	PAL	24	–
Teleclub	11.987	V	6.5	PAL	8	–
TV5	11.472	H	6.65	PAL	8	–
Worldnet	11.512	H	6.65	PAL	4	–

Table 3. Frequencies and specifications of television channels transmitted by Eutelsat 1 F1.

Channel	Freq.	Pol	Audio	Video	Hrs.	Scramble
Norsk Rikskringkasti	11.644	H	Digital	C-MAC	9	–
Worldnet	11.591	H	6.6	SECAM	4	–

Table 4. Frequencies and specifications of television channels transmitted by Eutelsat 1 F2.

Channel	Freq.	Pol	Audio	Video	Hrs.	Scramble
CanalJ	12.564	V	5.8	PAL	10	–
La Cinq	12.606	V	5.8	SECAM	17	–
M6	12.648	V	5.8	SECAM	10	–
Worldnet	12.732	V	5.8	NTSC	4	–

Table 5. Frequencies and specifications of television channels transmitted by Telecom 1 F2.

Channel	Freq.	Pol	Audio	Video	Hrs.	Scramble
Infofilm & Video	11.015	H	6.6	PAL	3	–
SVT-2	11.178	H	Digital	C-MAC	7	Tanberg C-MAC
SVT-1	11.133	H	Digital	C-MAC	7	Tanberg C-MAC

Table 6. Frequencies and specifications of television channels transmitted by Intelsat F2.

group of homes. Such systems are called *satellite master antenna television* (SMATV) systems and don't concern us here.

The most well-publicised TVRO satellite system is the proposed *direct broadcast by satellite* (DBS) service due to start within the next year or so, with five or less channels. DBS will use quite high powered satellite transponders and so receiving antennae will be around 0.9m in diameter or less, so being little more obtrusive than some existing terrestrial television system aerials.

Waiting for Godot

Waiting for DBS to appear has become a bit of a joke in Britain and although plans seem to have been finalised, it's still a long way off and it will only provide a maximum of five channels (that's all we've been allocated). On the other hand, existing communications satellites (with lower-powered transponders) are already in use by British programme providers to transmit television signals to SMATV systems.

A growing number of suppliers now market antennae and equipment capable of receiving the signals and displaying them on an ordinary television set, in such a way that the systems have been coined as *quasi-DBS* satellite receivers by some observers.

These systems are at a price which may tempt the individual, particularly when it's considered that around ten channels of English-spoken television programmes are currently broadcast from two satellites (Intelsat BA F11, and Eutelsat 1 F1). Other satellites transmit foreign programmes. Around sixteen more could be transmitted from another satellite (Astra) due to come on stream this year. Compare that lot with the five channels of DBS!

Tables 2 to 6 list channels, various technical specifications and number of hours (approximately) broadcast per day, transmitted from the satellites Intelsat VA F11, Eutelsat 1 F1, Eutelsat 1 F2, Telecom 1 F2 and Intelsat V F2. Still other satellites exist and transmit television signals which may be received in Britain – for example Russian Gorizont satellites.

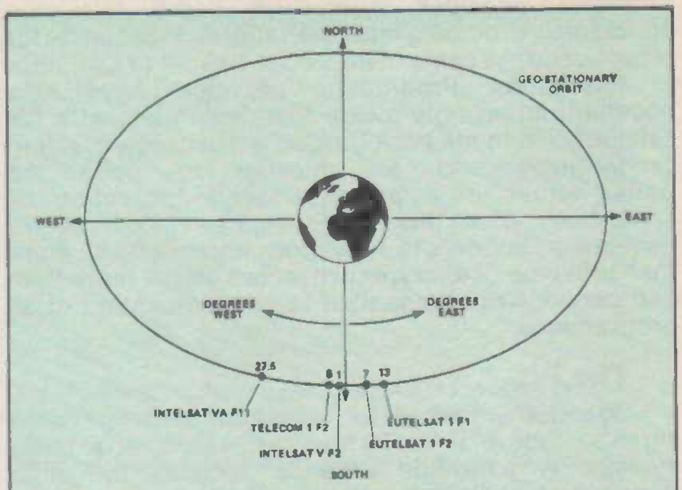


Fig. 5 Positions in the GSO of the main television transmitting satellites relevant to the UK

Some other satellites are so far away from true south they would be impossible to locate with an antenna unless it's on a steeply-sloping south-easterly or south-westerly facing high hilltop. Best of luck if that's what you want!

Figure 5 shows positions of the main satellites in the GSO as far as Britain is concerned. Figure 6 shows a similar view of the world-wide proposed DBS satellites listed with the various countries satellite positions. Also shown is the Astra satellite due to start operations shortly – although not actually a DBS satellite by strict classification, it's going to provide a similar (if not better) function.

Antennae for low-powered communications satellites need to be a lot bigger than DBS antennae (generally, between about 1.2 metre and 1.8 metre) depending on situation and Astra is a higher-powered satellite and so will allow antennae of around the DBS size to be used.

Up to now, most signals can be received and displayed on ordinary television receivers without problem using satellite reception equipment. The reason for this is mainly because most programme

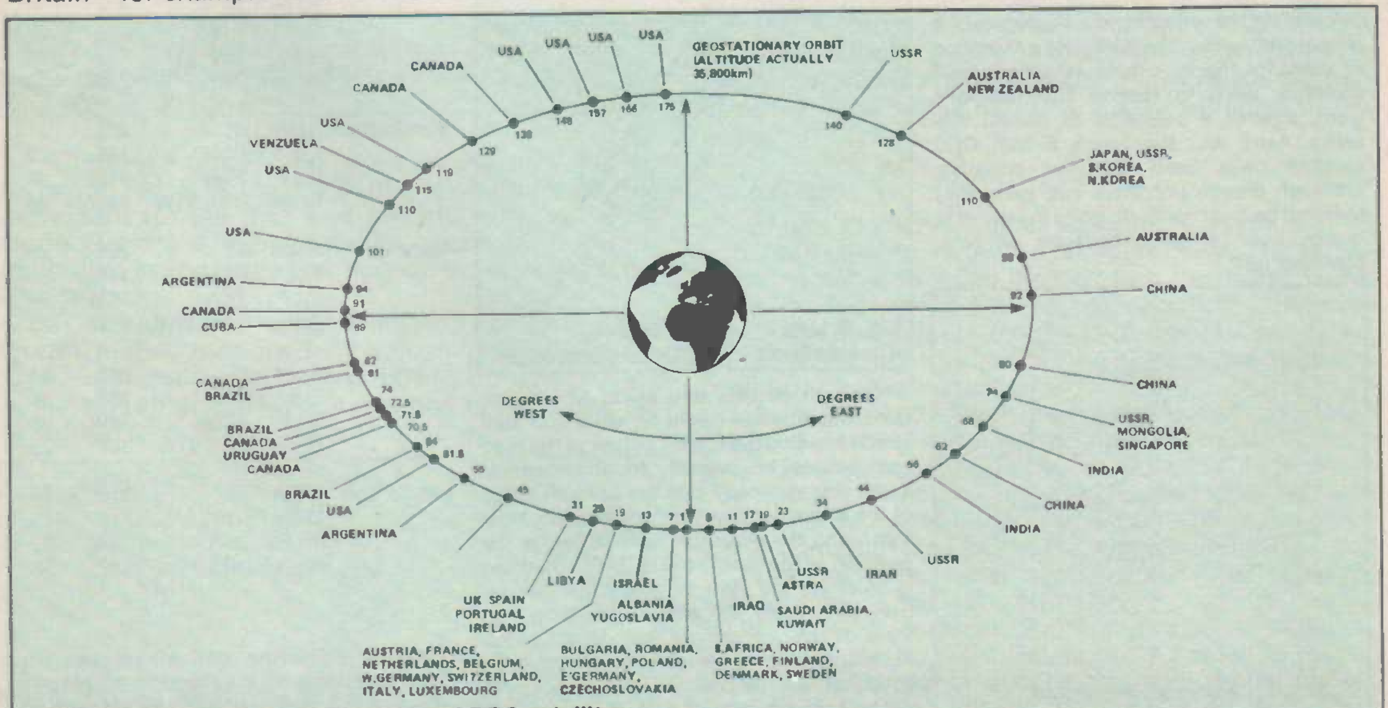


Fig. 6 GSO positions of all proposed DBS satellites. Although not an official DBS satellite, Astras (due to come on-stream in 1988) is shown at 19° east of south

providers consider themselves cable television companies, providing television signals via satellite for reception at the cable head-end to be split to a number of televisions. Programme providers have now become increasingly aware that Joe Public with his satellite dish in his back garden is effectively stealing programmes and are moving to code the transmissions in a process called *encryption* or *scrambling*. When this is the case, viewers will require necessary decoders to view programmes and as more than one type of encryption process exists, more than one decoder will be needed to allow reception of all programmes.

The Biz

So, what's needed to receive satellite television signals? Figure 7 shows the main parts of a basic system. A parabolic antenna focuses the high frequency signals, a *low noise converter* – sometimes called a *low noise block converter* or *low noise blockdown converter* (LNC or LNB) – receives the high frequency signals transmitted from a satellite and reflected from the antenna, amplifying and converting them to a lower frequency between 950MHz and 700MHz, coaxial cable carries the signals indoors and a receiver provides an output suitable for an ordinary television set.

In essence, that's it. A system like this would

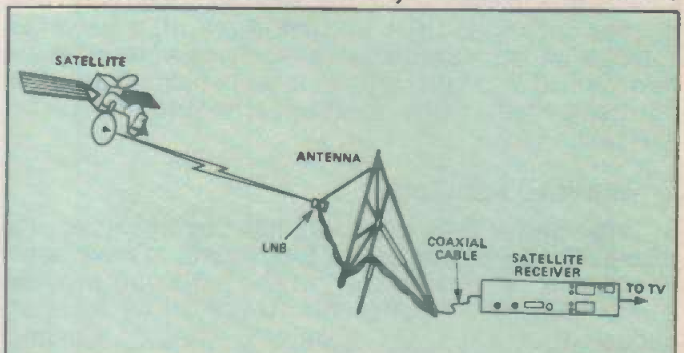


Fig. 7 Main parts of a basic satellite television reception system

Site Survey

Surveying the system site is a matter of locating a suitable position for the antenna to stand. If you're going to buy a system from a dealer, he'll probably do a brief site survey, checking that all desired satellites can be 'seen' by the antenna. This involves nothing short of trudging around the area armed with a good compass. You can do it yourself if you want to do a preliminary check and yours will probably be every bit as accurate as the dealer's.

So, you need a compass. Helpful, too, is a sheet of thick card, marked in angles up to about 45° and folded to provide a platform to stand the compass on, as shown in Fig. A. You should now mark the card with the various elevation and azimuth angles of every satellite you wish to receive transmissions from.

Satellite elevations and azimuths depend on whereabouts the antenna is to be located. There are accurate methods of calculating these but for the purposes of a simple site survey, the table lists a selection of them for the four main satellites you'll probably want to receive transmissions from, against a selection of salient site areas. Astra and the future British DBS satellite have been included because, although they're not there yet, eventually they will be and there's no point in having to re-site your antenna because of poor planning now.

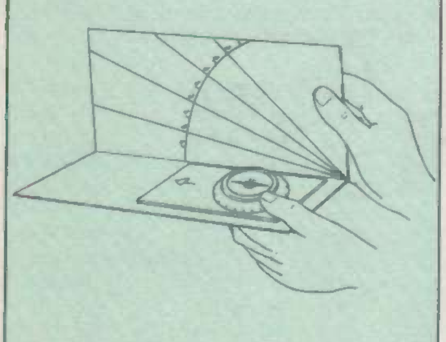


Fig. A An aid to surveying a potential antenna site

You need to bear in mind that all azimuths are with respect to true south but your compass will only give you a reading for magnetic south. Again, there are methods for accurately calculating the angle between magnetic north and true north but an Ordnance Survey map of the area will give more than enough detail for the survey. Say the approximate difference between magnetic north and true north is 5°, accurate enough for most purposes then simply subtract 5° from all east of southerly satellite azimuths and add 5° to all west of southerly satellite azimuths. Mark both elevations and adjusted azimuths down on the card, so you don't have to keep referring back to the list.

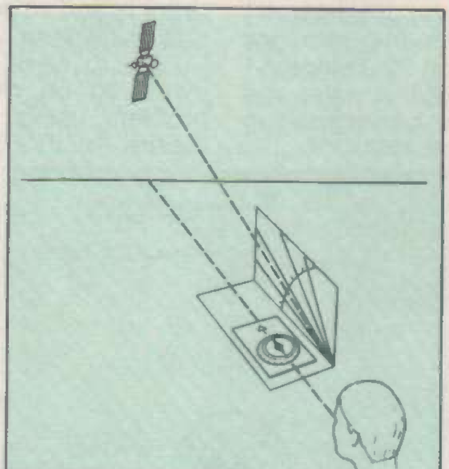


Fig. B Use the aid to locate the satellite's azimuth and elevation

Now, go outside and stand where you think the antenna might be sited and face south. Holding the folded botton of the card and compass horizontally and the elevation angle side vertically, aim the azimuth angle of the first satellite with the compass. Now aim along the elevation lines to locate the position of the satellite (Fig. B). If anything is blocking the view to a satellite (house, tree, wall, fence, the missus) you'll have to try a different location. Step through the azimuths and elevations of all chosen satellites until a position is found where nothing obstructs your view of any satellite – *that* is where the antenna can be sited.

Area	Satellite	Az	El
John O'Groats	Astra 19E	25E	21
	Eut 1 F1 13E	19E	22
	Int F11 28W	28W	20
	British DBS 31W	32W	19
Aberdeen	Astra 19E	25E	23
	Eut 1 F1 13E	18E	24
	Int F11 28W	30W	21
	British DBS 31W	34W	20
Newcastle	Astra 19E	25E	25
	Eut 1 F1 13E	18E	26
	Int F11 28W	31W	23
	British DBS 31W	35W	22
Liverpool	Astra 19E	27E	26
	Eut 1 F1 13E	20E	27
	Int F11 28W	30W	25
	British DBS 31W	34W	24
Dublin	Astra 19E	30E	25
	Eut 1 F1 13E	24E	27
	Int F11 28W	26W	26
	British DBS 31W	29W	25
Birmingham	Astra 19E	26E	27
	Eut 1 F1 13E	19E	29
	Int F11 28W	31W	26
	British DBS 31W	35W	24
Norwich	Astra 19E	22E	28
	Eut 1 F1 13E	14E	29
	Int F11 28W	35W	24
	British DBS 31W	39W	23
London	Astra 19E	24E	29
	Eut 1 F13E	16E	30
	Int F11 28W	34W	26
	British DBS 31W	38W	25
Land's End	Astra 19E	31E	28
	Eut 1 F1 13E	24E	30
	Int F11 28W	28W	29
	British DBS 31W	32W	28

Satellite azimuths and elevations for four satellites at a selection of places around the British Isles. All angles to the nearest degree.

receive *some* signals from a *single* satellite and allow viewing. But there are problems. First, satellite signals are polarised, either horizontally or vertically and the basic system of Fig. 7 can only receive signals of one polarisation. To receive signals of the other polarisation, either the LNB needs to be turned through 90° or a second LNB mounted at right angles needs to be fitted.

The viewer may wish to receive signals from a second, or subsequent satellite. So, two or more antennae are needed (expensive and unsightly) or the antenna needs to be turned to point at whichever satellite is required.

More complex satellite reception systems control these functions with motor-driven polarising and positioning equipment which, in turn, have to be controlled by internal equipment – either as part of the receiver itself or as a separate piece of equipment. Usually the motor-controlled polarising equipment is known as a *polarator* or *polariser*, while dish-positioning equipment is called an *actuator* or simply *dish positioning equipment*.

A Dish Fit For A King

The dish itself is generally of one of three types – prime focus, offset feed or Cassegrain feed type (Fig. 8). Parabolic dishes are used because the parallel (well, as near as damnit!) transmissions from the satellite are focused onto a single point where the LNB is situated. They are also decidedly unidirectional so transmissions focused on the focal point will only be from one direction – the satellite.

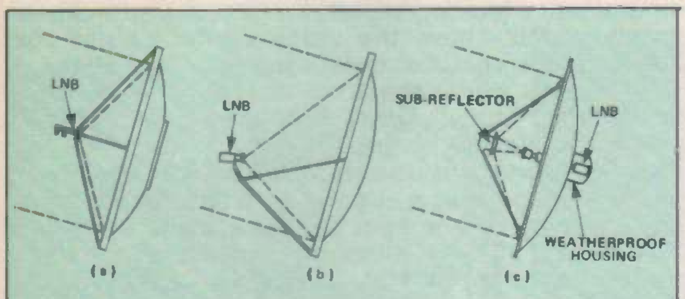


Fig. 8 The three main types of antenna dish (a) prime focus (b) offset feed (c) Cassegrain feed

There are three main types of antenna mounts, shown in Fig. 9. A fixed mount allows no freedom of movement for the dish and repositioning to receive signals from a different satellite means, quite simply, unbolting everything, pointing in the new direction and re-fixing.

The *el/az* (elevation/azimuth also known as az/el) mount allows independent adjustments along two axes – left and right, up and down. So by adjusting both azimuth and elevation settings the antenna can be moved from one satellite to another.

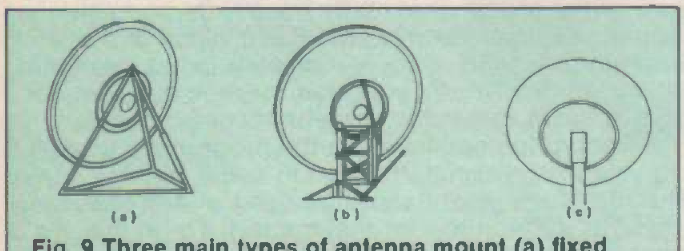


Fig. 9 Three main types of antenna mount (a) fixed mount (b) el/az mount (c) polar mount

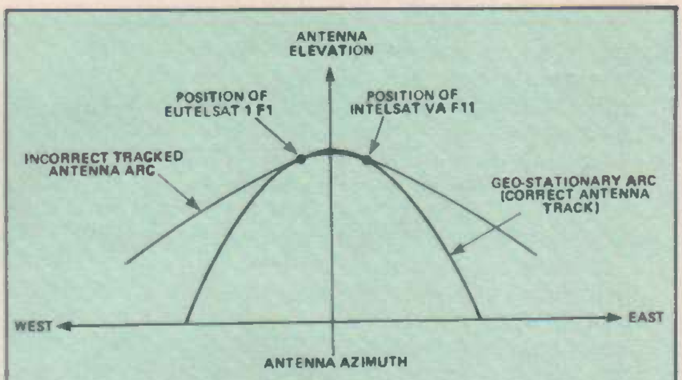


Fig. 10 Showing how a polar mount, if incorrectly installed, can track an arc on which two satellites will be viewed. However, as the arc is not the GSO arc, transmissions from other satellites can not be picked up

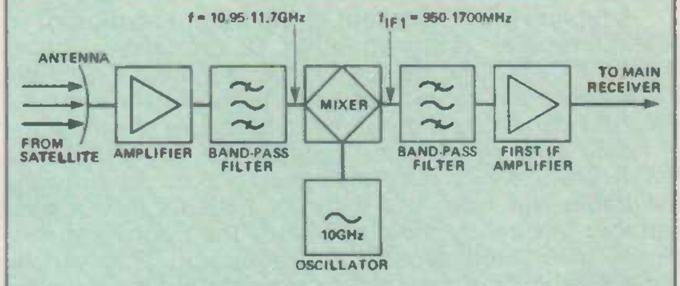


Fig. 11 Block diagram of an LNB

For easiest maneouvering between satellites, a polar mount is best as it has only one axis to follow and so can be made to track continuously along the GSO arc. Setting up the polar mounted antenna is an involved job, mind you, because the arc has to be followed precisely. The polar mount will always track an arc – any old arc – purely because of its nature. On this arc you might just find two satellites (Fig. 10) but unless the tracked arc truly is the GSO, no further satellites will be found.

The enormous advantage of the polar mount (however difficult it may be to set up) is that it may be easily motorised. A single actuator only needs to push or pull it in its single axis to track all satellites in the visible GSO arc.

LNBs

Figure 11 shows a block diagram of a typical LNB and it can be seen it's quite a complex beast, The signal from the antenna is fed directly to a low-noise GaAs amplifier followed by an image rejection bandpass filter. The noise figure for the LNA must be as low as possible because this defines the basic signal-to-noise ratio for the whole system.

A mixer and fixed frequency local oscillator (10GHz) convert the received satellite transmissions to an IF frequency band of 950-1700MHz (block down conversion) which is then bandpass filtered and amplified by a first IF amplifier. From there, co-axial cable connects the LNB to the receiver indoors.

Yes, the IF frequency band is 950-1700MHz which means the LNB is effectively 'looking' at a 10.95-11.7GHz transmission band from a satellite. Transmissions from the Telecom 1 F2 satellite (listed in Table 5) cannot be received as their transmission frequencies are all around 12.5GHz. A different LNB will be required to do that.

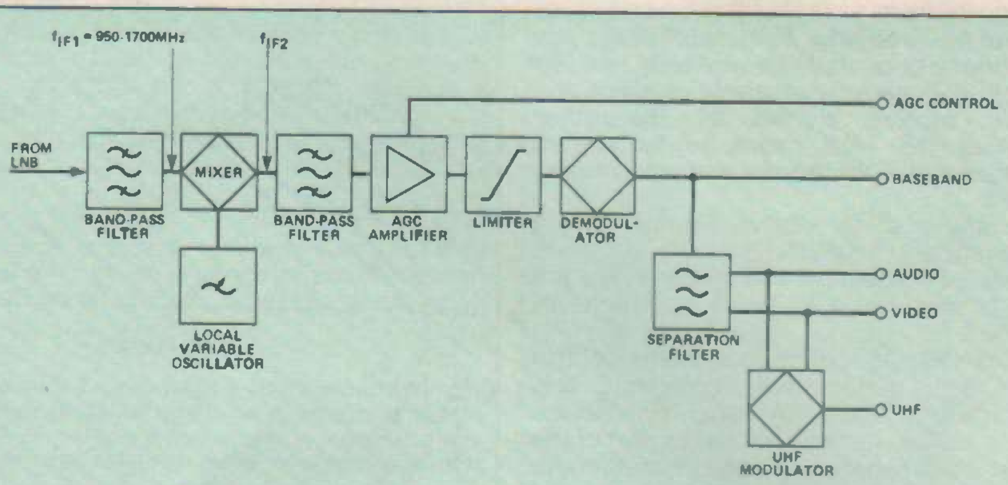


Fig. 12 Block diagram of the main receiver

A typical block diagram of the tuning section of a satellite receiver is shown in Fig. 12. Effectively, there is little more to the device than a reasonable-quality FM tuner, such as you may use in your hi-fi system. The first bandpass filter allows a measure of rejection of noise and interference outside the 950-1700MHz first IF band, which may have been picked up through the cable run from the external LNB. A mixer and variable frequency local oscillator then converts the signal to a fixed second IF frequency. This varies considerably from receiver to receiver but is typically between 100-600MHz.

A second IF bandpass filter – usually a SAW (surface acoustic wave) filter – limits the second IF bandwidth to about 27MHz whereupon the signal is amplified by an AGC amplifier and limited. Often a DC control output is taken from the AGC voltage for signal strength display.

From there the signal is demodulated down to a composite *baseband* television signal. In cheaper receivers this is done by a single demodulator but for optimum sound and vision, two demodulators are used. However separation is performed, audio demodulation must allow for different audio sub-carrier frequencies (which we'll come to in a minute).

Separate audio and video signals, although usable by, say, a video cassette recorder or some monitors (composite input monitors with audio, not your Beeb RGB monitor) aren't really suitable for use by a bog-standard telly. So an integral part of the satellite receiver is a modulator which converts the signal up to a UHF channel (typically channel 39) for display via the television receiver's conventional aerial socket.

Often, just before this stage, a receiver might have a loop-through facility to allow an encryption decoder, nicknamed a *descrambler*, to be added to the system to allow display of the signal, in the same way that, say, a graphic equaliser can be added to a hi-fi system via the tape monitor outputs and inputs of an amplifier.

Generally, the complete satellite receiver is more than just a tuner and other parts (notably a polarising circuit and an actuator drive circuit) will be included. More often than not, the actuator drive circuit will be housed separately from the receiver as there are some high currents associated with driving the actuators, which may cause interference to the tuner. In most current systems the actuator drive – as well as being housed separately – is a remote device, in the sense that to watch channels on different satellites the user has to first change antenna position via the actuator drive circuit, then change the tuned frequency/ polarity/audio sub-carrier via the tuner.

However, some of the latest satellite receivers have reduced this to a single change. The tuner automatically controls the actuator driving circuit at the same time as changing frequency and so forth.

Scrambled Egg

To understand encryption we've first got to look at the baseband signal, which in most cases is similar to the standard British 625-line terrestrial broadcast television signal – a PAL encoded composite video/ audio signal, a spectrum of which is shown in Fig. 13. A vision carrier carries luminance (black and white) and chrominance (colour) signals and a sound sub-carrier spaced 6MHz above the vision carrier carries the sound signal. Total bandwidth is just under 8MHz.

The PAL signal spectrum in Fig. 13 is that of a British PAL signal. Other European countries use variants, which differ usually only in terms of the spacing between vision and sound carriers. However, North America uses a slightly different signal format (NTSC) and the original French colour television system used SECAM. Although France itself has since started to adopt a PAL derivative, much of the remainder of the world's television systems still use SECAM. So there's a range of available television signal standards in use.

The fact that different satellite transmissions use different audio sub-carrier frequencies is the reason why a receiver must have the capability of adjusting the audio sub-carrier frequency when demodulating the signal. Also, there is the possibility that the transmission may have more than one sub-carrier – different languages could be broadcast on each.

Where the total 8MHz channel is modulated onto a carrier in the region of about 450-900MHz for terrestrial television, satellite television signals are modulated onto a carrier in the region of 11-12GHz. so, the basis of a satellite television receiver is a tuner, capable of demodulating the microwave signal back down to the original 8MHz channel. In fact, as we've seen, what the tuner actually does is demodulate the signal right back down to the basic vision and sound baseband signals and for display on a standard television receiver they are put through a modulator. This is much as a video cassette recorder.

Encryption occurs when the programme provider adjusts the transmitted signal in some way such that the received signal cannot be used by the television receiver (or monitor, for that matter). To do this, it's a simple matter of, say, swapping the order of the lines which make up the picture on the television tube's screen or even cutting lines in two and reversing their order. Other encryption methods break up the sound into parts and scramble them. As far as the satellite tuner and the television receiver are concerned, they've done their job but to the viewer the picture is broken up and totally unwatchable or the sound is garbled.

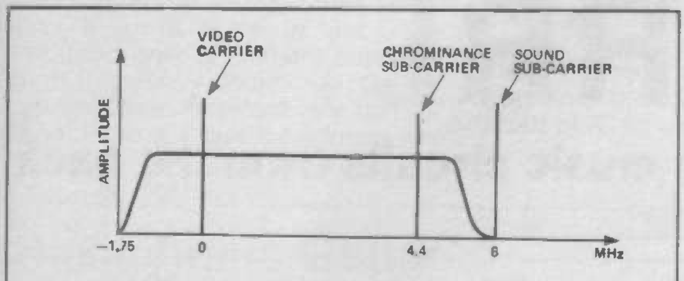


Fig. 13 PAL encoded composite video signal

If, on the other hand, a decoder is included in the satellite receiving system, capable of reorganising the lines back to their correct order, the picture is OK. The chosen encryption process merely defines the way and the extent to which the lines are disorganised. This, in turn, defines the necessary complexity and price of the decoder. However, as far as the TVRO viewer is concerned, the decoder generally goes between the satellite receiver and the television or, in the case of a receiver with loop-through facility, between the receiver's baseband output and UHF modulator input.

The complexity of the encryption process depends totally on the enthusiasm of the programme provider to prevent unauthorised people from watching the programmes. In many instances signals aren't encrypted severely and so decoders are simple – the likes of ETI readers would be able to build a descrambler as easily as falling off a log.

However, if the programme provider wants almost total prevention of unauthorised viewing, the scrambling will be severe, generated by random binary sequence techniques in extremely complex ways. Descrambling is equally complex, perhaps requiring the user's personal identification number and/or authorisation codes which may change regularly. Whatever the complexity, encryption can *never* be totally secure. There may always be a bright spark who comes along a builds a descrambler. In the case of complex encryption, this is just less likely – particularly if LSI devices are used to build the circuits.

Most programme providers, aware that they either have to go to the expense of developing and running a complex system or stick to simple methods, choose the latter option. Then they provide cheap decoders to authorised users, usually as part of the subscription process. Although the risk is taken that unauthorised users may go to the lengths of building or buying a descrambler, the risk *is* pretty small.

Next month, we'll be looking at a selection of available satellite television reception systems, comparing features and prices like for like.

ETI

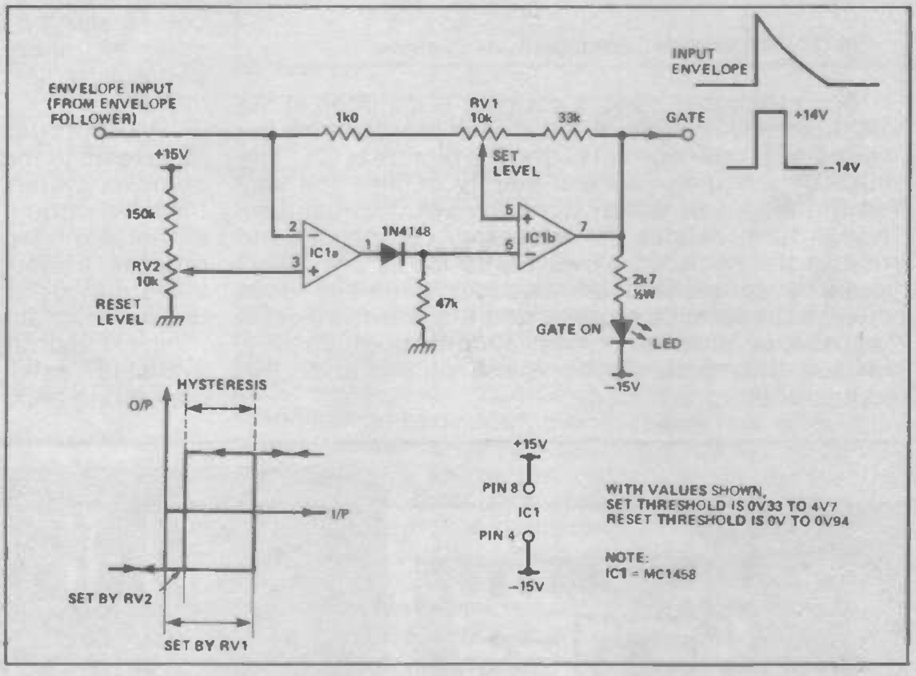
MUSIC CIRCUIT POTPOURRI

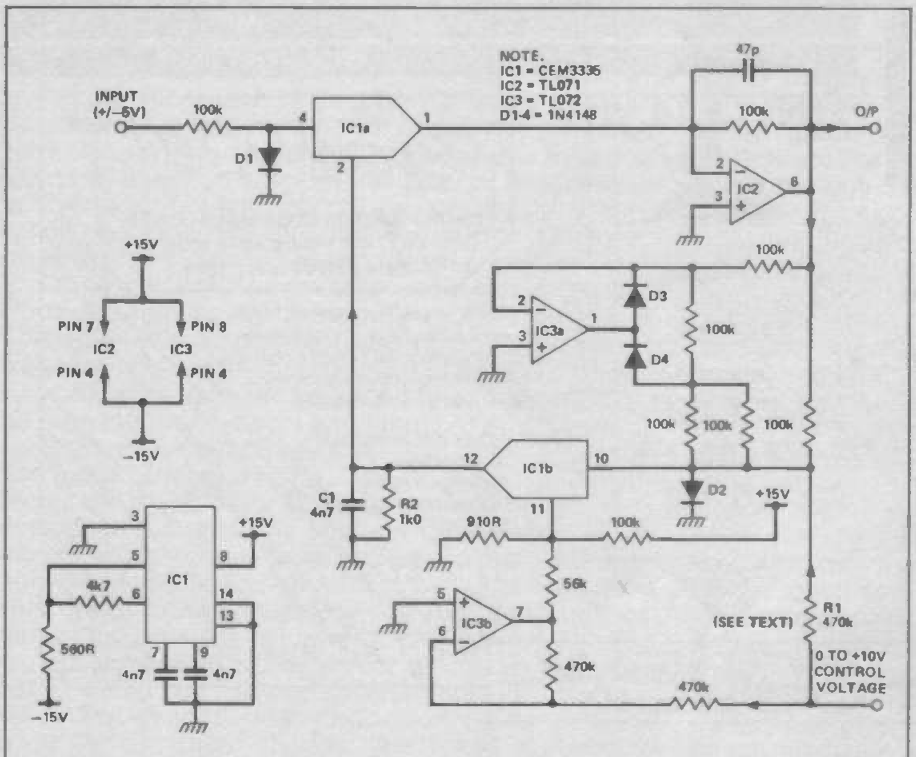
Bruno Hewitt reveals ingenious music circuits from the back of a multitude of envelopes.

Gates From Envelopes

Analogue synths often allow (or can easily be modified to allow) the input of an external signal from perhaps a guitar or microphone. One of the hardest parts of such a conversion is to control the envelope generators from the envelope of the original signal.

The best way of achieving this is the use of an envelope follower (full wave rectifier with output smoothing) followed by a comparator with hysteresis, to generate a gate voltage with which to control the ADSRs. The circuit shown is such a comparator and possesses the advantage that set and reset levels can be adjusted independently of each other.





Voltage Controlled Overdrive

No claim is being made here to emulate the elusive 'valve sound', (which is perhaps still best left to valve amps themselves) since there is a great deal more involved than merely a nonlinear transfer function. Nevertheless, one can easily improve on the harmonic carnage generated by mindless diodes hacking pieces off waveforms with a butcher's precision. This circuit provides an unusual way of doing so.

The configuration is strangely reminiscent of an AGC or compressor circuit – for a good reason. The input signal passes through a VCA and output buffer and is then fed into a feedback side chain comprising a full wave rectifier (IC3a,D3,D4 and so on), a second VCA (which controls the degree of compression) and a smoothing filter (C1,R2).

The filter feeds the (exponential) control input of the first VCA, thus completing a negative feedback loop which acts in such a way as to decrease the VCA gain when input signal level is high. The difference lies in the value of C1, which is about 10,000 times lower than it ought to be. In fact C1 is included only to prevent spurious high frequency oscillation. So the compression is effectively instantaneous and input waveforms are flattened out progressively and smoothly, to a degree of sharpness determined by he external control input to IC1b.

Controlling the gain of the feedback path in this way results in a 15dB drop in output at maximum distortion setting (+10V control input). This can be corrected or even reversed by adding a proportion of the control voltage to the input of IC1b via R1.

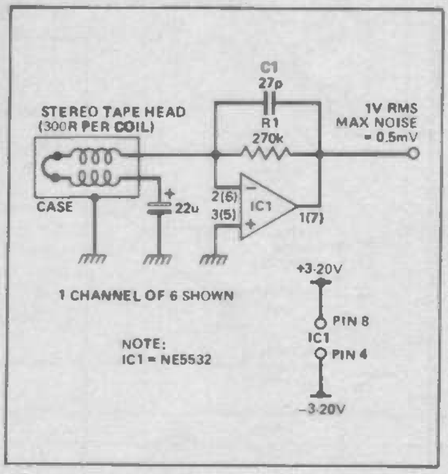
The value of 470K actually corresponds to a drop of around 6db, which gives a subjective impression of equal loudness due to the interactive perception of sound intensity and spectral content that goes on in the brain. Of course, this effect depends to some extent on the brightness and shape of the input waveform, so experimentation is necessary. Decreasing the value of R1 increases the signal output at high distortion settings.

Hexaphonic Guitar Pickup

Polyphonic guitar synths require that signals corresponding to the vibrations of individual strings be kept separate. In practice this is not easily achieved and initial attempts at making a hexaphonic pickup with low noise and good string-to-string separation are likely to be disappointing.

Cassette tape heads are well suited for use as string pickups because of their small size and their highly localised sensitivity, meaning that signal output is negligible for a string-to-pickup spacing of only 2.55mm. Thus, if six heads are mounted near the bridge saddles with a clearance of 0.5 - 1mm, then 50 - 55db of separation between adjacent strings can be achieved.

Stereo tape heads can be used with their coils connected back to back in the standard 'humbucking' configuration, which significantly improves signal-to-noise ratio due to cancellation of the effects of non-local ambient magnetic fields, such as those caused by mains transformers and wiring.



Tape heads do not contain magnets (fortunately for tape users) and an external magnetic field must be provided by a strong magnet in close proximity to both the strings and heads. The stronger the magnet, the better the signal-to-noise ratio and with a good magnet you can expect 70dB.

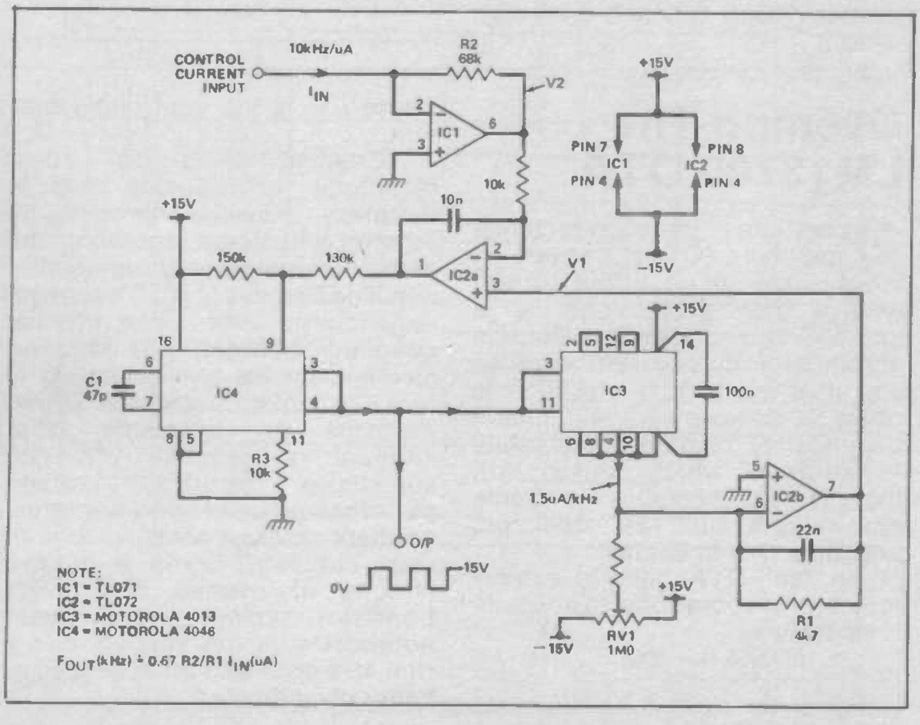
Output from the heads is very low, normally in the region of several millivolts peak. The circuit shows a suitable low noise amplifier, which had a gain of 450 with the heads used. Gain is given approximately by the ratio of R1 to the head resistance and should be adjusted according to measured output. C1 limits bandwidth to 22kHz and helps to reduce spurious pick-up of radio signals but the strings and head cases should be earthed to solve this problem entirely.

A very useful feature of the NE5532 op-amp is its ability to drive loads of as little as 470R which can be placed at the receiving end of long multicore guitar leads in order to minimize hum pick-up and crosstalk between channels caused by capacitive coupling.

High Frequency Current-Controlled Oscillator

This ICO achieves linearity of 0.1% over the frequency range 0.7KHz-1.5MHz (a span of 10 octaves). VCOs and ICOs usually rely on some form of current-switching arrangement around a capacitor with the charge/discharge cycle sensed and controlled by a Schmitt trigger. A switching delay of only 10ns causes an error of 1% at 1MHz in the case of a sawtooth oscillator, 2% in the triangle case since two transitions are required per cycle.

This effect can in principle be compensated by the judicious use of a resistor in series with that timing capacitor but the snag is that switching delay is generally not constant, tending to increase



at the higher current levels that correspond to higher frequencies.

The ICO shown here cheats its way round the problem by employing a highly linear frequency to voltage convertor (IC3,IC2b) and a feedback loop (IC2a) controlling a cheap and fairly dodgy VCO (IC4).

The FV converter exploits the dependence of CMOS supply current on clock frequency which for the 4013 dual flip flop (connected as shown) is a consistent 1.5uA/kHz up to at least 1.5MHz. RV1 corrects for the op-amp offsets and 4013 quiescent current (nominally 1uA maximum but nearer to 10nA in practice).

Scaling is controlled by the ratio of R2 to R1, provided that V1 and V2 do not exceed −12V. If the frequency range is to be extended up or down, C1 and/or R3 should be changed accordingly. Regarding the output of the 4046, the mark/space ratio varies with frequency so if a true squarewave is required then a divide-by-two flip flop or counter stage should be added to the output.

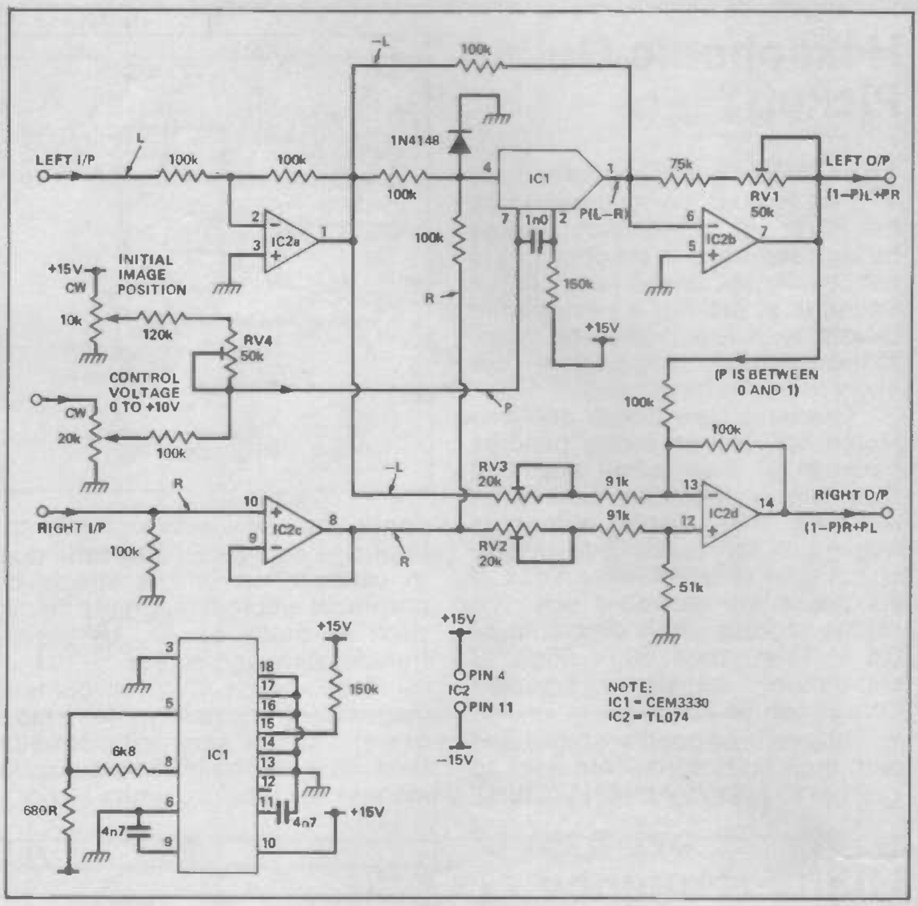
High frequency ICO/VCOs are useful for controlling the clock rate in samplers, switched capacity filters and waveform generators based on EPROM look-up tables.

Voltage Controlled Stereo Cross-Pan

It can all be done with just one VCA! Follow the L and R signals through the top half of the circuit and you will arrive at a left output expression L+P(R−L), which simplified to (1−P)L+PR, as shown. The three signals R,L and −(L+P(R−L)) are summed (with equal weight) in the differential amplifier IC2, giving R+L−L−PR+PL. The two L's cancel out and rearrangement gives (1−P)R+PL, the right output.

Calibration procedure is as follows. Connect a signal to the right input, turn the image position pot fully clockwise and adjust RV4 so that there is no output from the right output. Adjust RV1 for unity gain from the right input to the left output. Set the image position pot down to zero and adjust RV2 such that there is now no signal at the left output. Finally, swap the signal to the left input and adjust RV3 for no signal at the right output.

The VCA used is one half of a dual CEM3330 device, which has a claimed 100dB S/N and 0.1% distortion.



Ovening The LM13700 OTA

Operational transconductance amplifiers (OTAs) convert an input voltage to an output current with a gain proportional to a controlling current. Circuits abound for these useful devices and it is a pity that precision is often let down by the significant dependence of gain on absolute temperature, which causes drift that is unacceptable in some applications such as oscillators and Q control in filters.

In fact OTA gain is exactly inversely proporational to absolute temperature:

$$I_O = \frac{5802.4\ I_{ABC}\ V_{IN}}{T}$$

where I_{ABC} is the controlling current.

'Ovening' is a well-known technique for reducing drift in thermally sensitive circuits by sensing and finely regulating the device temperature thermostatically. The success of such a scheme depends on very close thermal coupling between the heating element, device and sensor. It is best to integrate these three elements on a single chip, although in practice this can sometimes actually worsen performance by placing a thermal gradient across a sensitive area of chip circuitry. Some published circuits of ovened 3046 NPN transistor arrays have been noteworthy in this respect and a trial and error design approach is generally indicated.

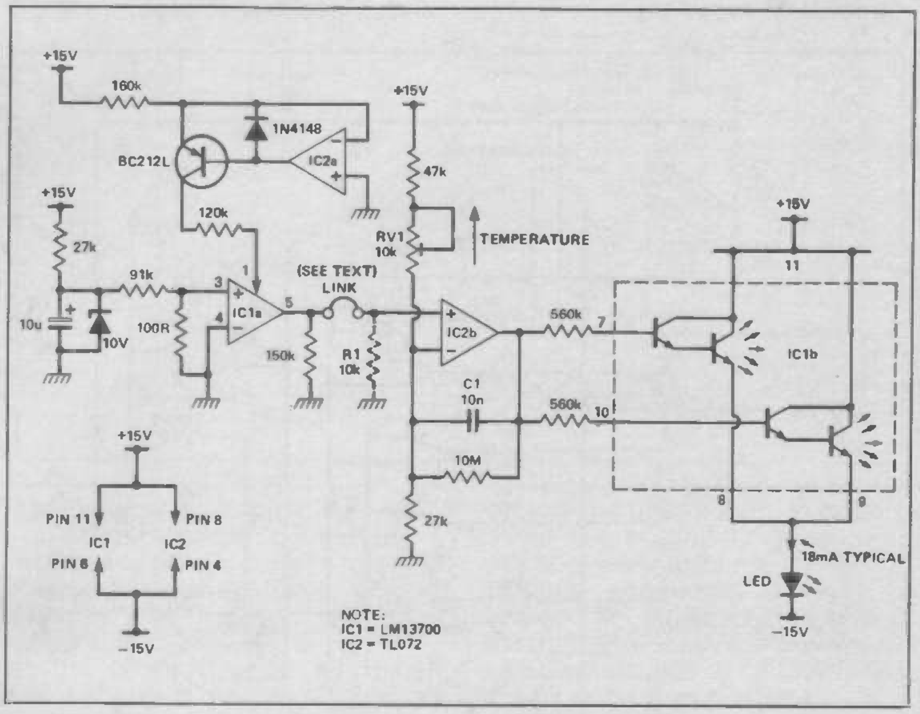
The LM13700 dual OTA seems to lend itself well to ovening, achieving a measured temperature regulation of ±0.0018%. Warm-up time at switch-on is less than one second. One of the two OTAs in the device is used as a thermal sensor, generating a voltage of around 5.6V at 25°C, which drops by 10% to 5.04V at 58°C.

The difference between this voltage and the reference voltage at the inverting input of op-amp IC2b is amplified by a factor of 560 and used to control the heating current flowing through both of the uncommitted darlingtons on the chip. The LED is used primarily to generate a 2.2V voltage drop which keeps the output of IC2b 3-4V away from the negative rail but additionally serves as a visual indication of correct operation and even acts as a fuse if all goes wrong.

C1 in the feedback path of the error amplifier imparts a 70ms time constant which matches the thermal time constant of the system and optimizes stability. Temperature regulation is independent of positive supply fluctuations since both sensor and reference voltages track this supply. A 45mV increase of the −15V rail (to −13.959V) will cause the reference voltage to increase very slightly, resulting in a 0.0006°C drop but provided that a regulated negative supply is used this problem is not likely to be significant.

Calibration procedure is as follows. First (before power-up) disconnect the link shown joining IC1 to IC2b and ensure that R1 is connected. Now power up the circuit and measure V_T. Adjust RV1 so that V_{REF} is 10% lower than V_T. Remove the power, remove R1 and reconnect the IC1/IC2b link. Following his procedure will avoid overcooking the circuit.

Note that the LM13600 has an internal connection between its current control inputs and darlingtons, which renders it unsuitable for use in lieu of the LM13700 in this application.



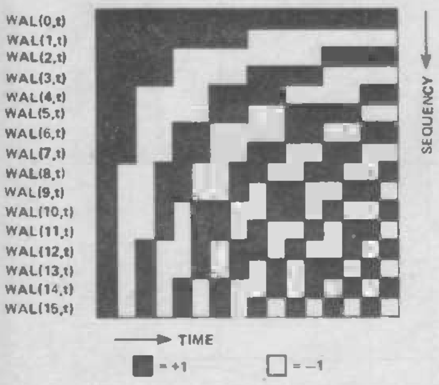
Additive Synthesis Using Walsh Functions

Sine waves are not the only set of functions possessing the magical property of orthogonality which allows any signal to be expressed in terms of a spectrum of components. Square waves are just as orthogonal but do not on their own constitute a complete set of building blocks and therefore cannot be used to represent any arbitrary signal.

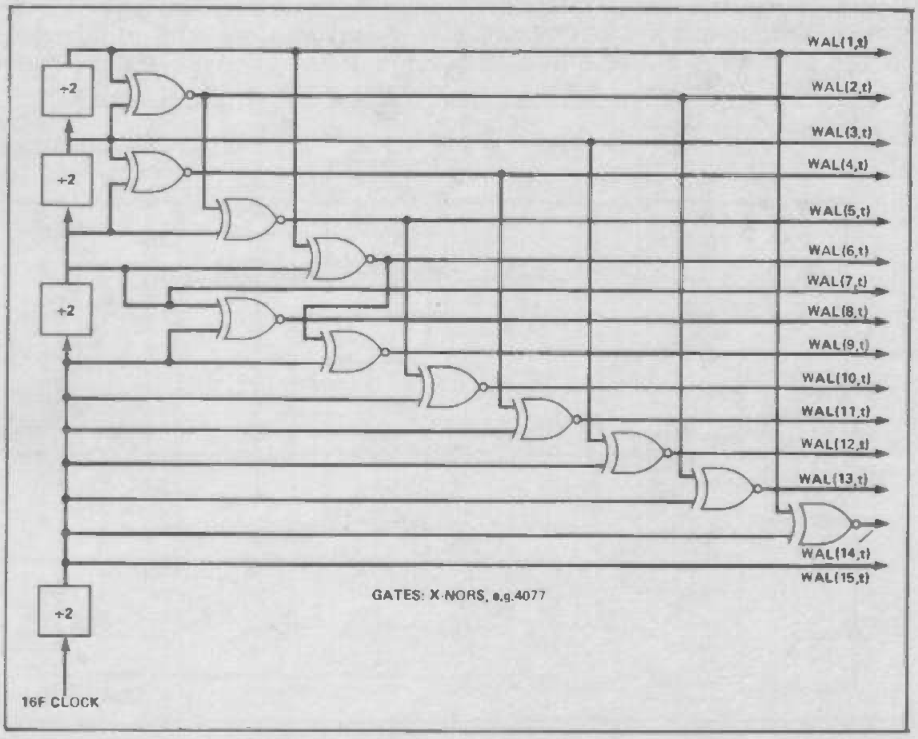
This problem can be overcome by including in the set some additional pulse waveforms which are systematically derived from square waves (by a recursive process of modulo-2 additions) thus generating a complete set known as the Walsh functions.

Then were invented by mathematician J. L. Walsh in 1923 and have not hitherto received the attention they deserve. Sine waves always seem to steal the limelight, perhaps in much the same way that analogue technology dominated before the arrival of digital.

The figure shows one cycle of the first 16 Walsh functions, using an unconventional format which helps to make their pattern and symmetry clearer than is possible with an ordinary timing diagram. Note that Walsh functions are AC, alternating between +1 and −1 like sines. Note also that, unlike sines, phase is built into the series. For

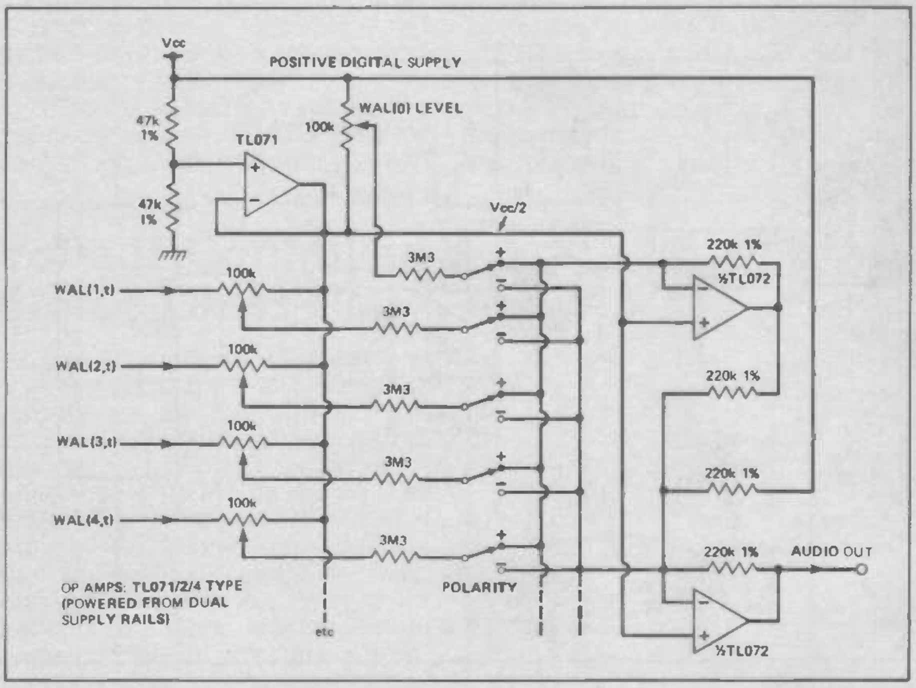


ADDITIVE SYNTHESIS USING WALSH FUNCTIONS



example, WAL(2,t) is simply WAL(1,t) time-shifted. The notion of frequency also goes out the window and is replaced by the concept of *'sequency.'*

The circuit shows a Walsh function synthesiser which can easily be expanded if desired. The digital supply rails should be earth and a positive voltage - +15V if 4000 series CMOS is used. Exclusive- NOR gates are shown in order to match up the outputs with the timing diagram in the figure which has in fact been time-shifted by half a cycle for clarity. Exclusive-OR gates (modulo2 adders) can be used instead with no circuit modifications. Logical 1 is interpreted as +1, logical 0 as -1. The pulses are mixed and centred about earth by the op-amp circuitry.



The Walsh coefficients for a sine wave start off as follows:

0.663 WAL(1,t)
0.063 WAL 92,t)
−0.263 WAL 95,t)
0.025 WAL (6,t)
−0.052 WAL (0,t)
−0.006 WAL (10,t)
−0.126 WAL (13,6)
0.013 WAL (14,t)

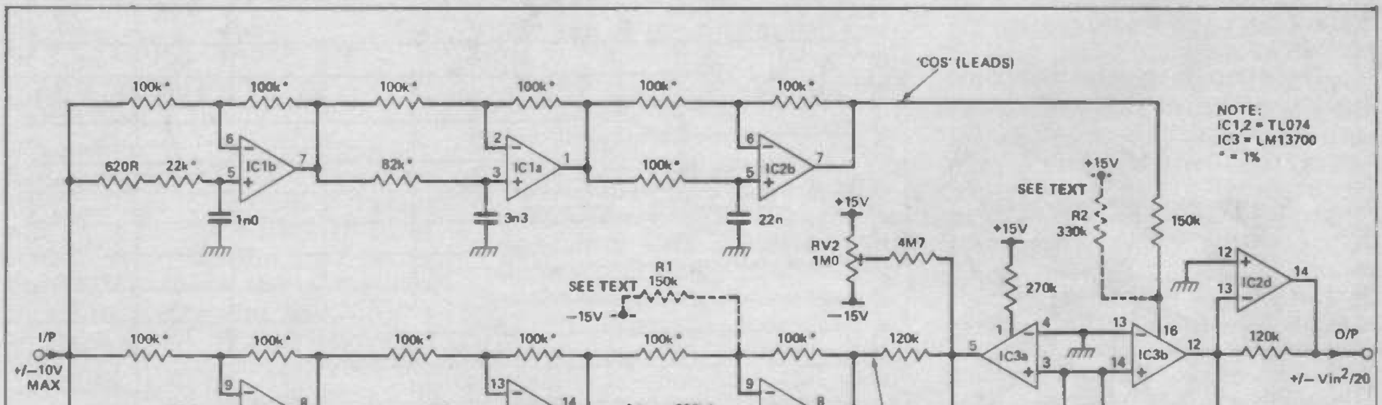
Anyone seriously interested in the subject is urged to get hold of *Applications of Walsh and Related Functions* by K. G. Beauchamp (Academic Press, 1984). Price is around £30.

Improved Frequency Doubler

When two sine waves are multiplied together the result is two new sine waves with frequencies given by the *difference between* and *sum of* the original two frequencies. The figure shows the exact relations. This phenomenon has been used in the past as a guitar effect, in which the signal is multiplied by itself with a ring modulator (four-quadrant VCA) to produce a frequency-doubled output (and also an annoying DC click or thump).

However, observation of the third equation reveals that if one of the multiplier inputs is shifted by 90° in relation to the other, then the difference component, which has zero frequency, is a sine rather than cosine wave. The sine of zero is zero and so the difference component conveniently loses itself.

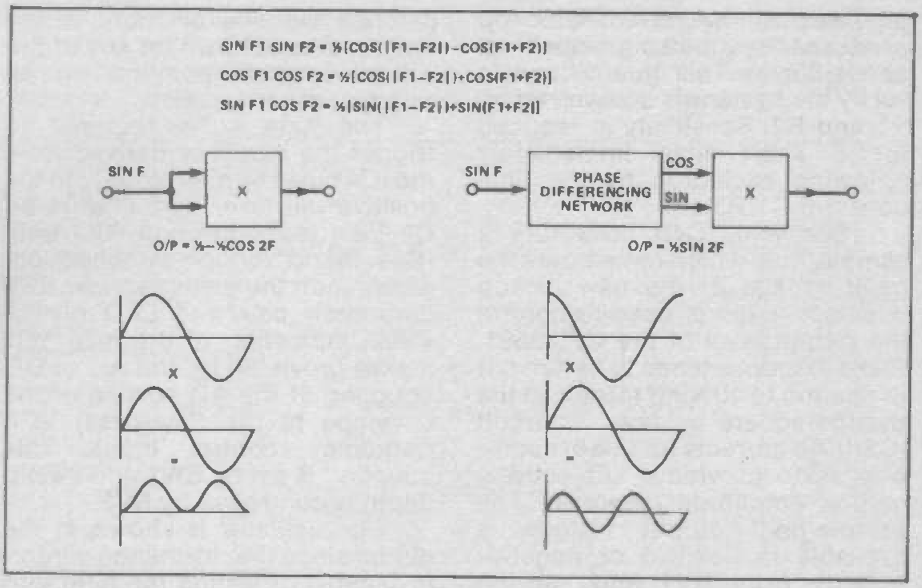
The hardest part is to achieve a consistent 90° phase difference over a wide frequency range. In practice this condition can only be approximated by means of two cascades of phase shifters (all-pass filters) with judiciously staggered time constants. The calculation of time constant values is actually rather tricky, so it is best to stick to the component values shown. Six phase shift stages are used to get a 90° complementary output with a phase error of less



than a few degrees over a frequency range of 35Hz to 4kHz. Multiplication is performed by IC2a/IC2d/IC3. RV1 and RV2 can be used to trim the feedthrough of 'sin' and 'cos' multiplier inputs respectively, if required.

Note that, because the input is being multiplied with itself, albeit with a phase difference, the output amplitude is the square of the input amplitude, which is equivalent to a 2:1 expansion on the decibel scale. It is therefore desirable to precede the input with a compressor or sustain unit.

Note also that intermodulation occurs when the input is a composite of sine waves – the device is not a harmoniser but is well-suited to guitar sounds

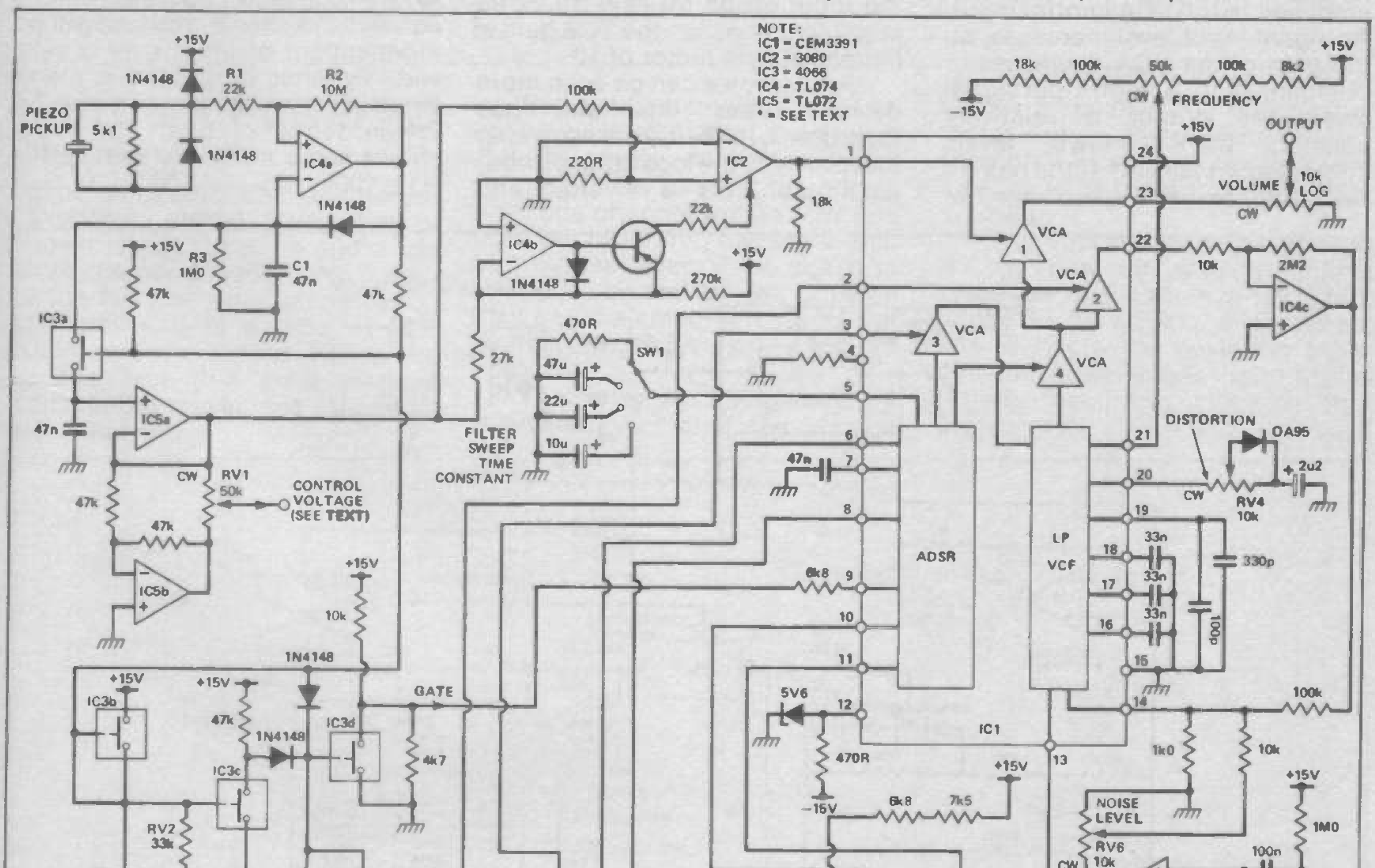


Electronic Percussion Synth

This percussion/effects unit is based on an all-singing, all-dancing synthesiser chip, providing fourteen controllable parameters with only five ICs. Sound is initiated by striking a wooden or plastic surface to which the piezoelectric pickup (Maplin QY13P) is glued on the underside.

It is advisable to damp resonances of the striking surface with rubber sheet, preferably both on top and underneath, in order to avoid the possibility of spurious multiple retriggering. The 5k1 resistor connected across the pickup is adjusted to give a maximum output of 10V from the sample/hold IC5 when the unit is struck as hard as possible.

Op-amp IC4a produces a brief



positive pulse whenever the pickup produces an impulse greater than about 30mV. This guard-band is set by the hysteresis determined by R1 and R2. Sensitivity is reduced for a short time immediately following excitation by the time constant C1/R3.

IC3a and IC4b constitute a sample/hold which remembers the peak voltage of the new pickup impulse, which is used to control the output level of the CEM3391. Piezo response tends to flatten out in relation to striking force and the pseudo-square law circuit IC2/IC4b corrects for this in such a way as to provide a subjectively natural amplitude response. The sample/hold output voltage is available in positive or negative polarity from RV1 and can be patched via one or more rotary switches (not shown) to any of the voltage-control points marked with asterisks.

The gate pulse required to trigger the ADSR is derived from the IC4 pulse by charging C2 to the positive rail level. The charge on C2 then leaks through RV2 until IC3c is no longer switched on, whereupon the gate goes low. The darlington pair and LED give a visual indication of the gate. IC1 makes provision for the AC or DC coupling of the AD portion of the envelope to the (low-pass) VCF frequency control input. This coupling is set by SW1 and sweep depth is controlled by RV3.

No oscillator is shown in the circuit since the resonance control is capable of setting the filter into oscillation. This oscillation is a sine wave with a distortion of only a few per cent, which can be made considerably raunchier by means of the germanium diode and RV4.

There is a second resonance control called 'feedback' (RV5) which uses the second VCA output (pin 22) of IC1. The resonance caused by feedback is dependent on the ADSR envelope. With short envelopes the filter impulse response that results from heavy use of this feedback becomes very rich and interesting, indeed almost acoustic.

Noise input to the filter is provided by zener diode D1 and IC4d under the control of RV6, allowing good snare, whip-lash, gun shot and explosion sounds to be produced.

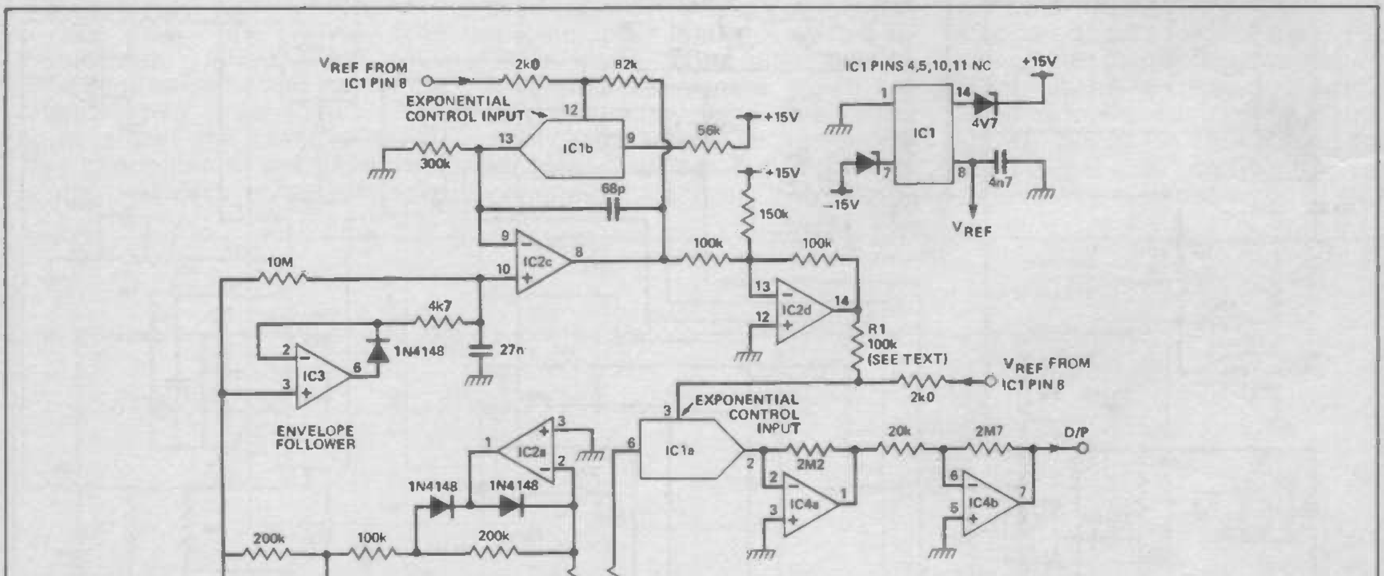
Feed-Forward AGC

Automatic gain control circuits are usually configured as a VCA with a feedback loop, via an envelope follower and inverting amplifier, to the VCA control input. As signal input level increases, so the gain of the VCA decreases in compensation. At high input signal levels the output is relatively constant but at lower levels compression falls off. If the gain in the feedback path is increased to counteract this effect, instability usually arises.

The answer is to avoid feedback by controlling VCA gain from the signal input raher than output. To do this we can use a reciprocal (1/x) function, so that if the input drops to, say, 0.1 of its previous value then the VCA gain is increased by a factor of 10.

Actually, we can be even more devious than this and use logarithms. IC1b/IC2c is a log amp that provides the logarithm of input amplitude. This is inverted and added to a constant by IC2d then fed via R1 to the exponential control input of the VCA IC1a.

The value of R1 then determines the compression slope on the decibel scale. If it is less than 82k then larger inputs will result in *smaller* outputs. It it is equal to 82k then the output will be independent of input over a very wide dynamic range. If it is made twice 82k then compression will be 2:1 in terms of dBs. The table shows some measured results for R1 = 100k.



INPUT (RMS)	OUTPUT (RMS)
30mV	1V19
100mV	1V78
300mV	2V08
1V0	2V30
2V5	2V45

MEASURED PERFORMANCE (FOR R1 = 100k)

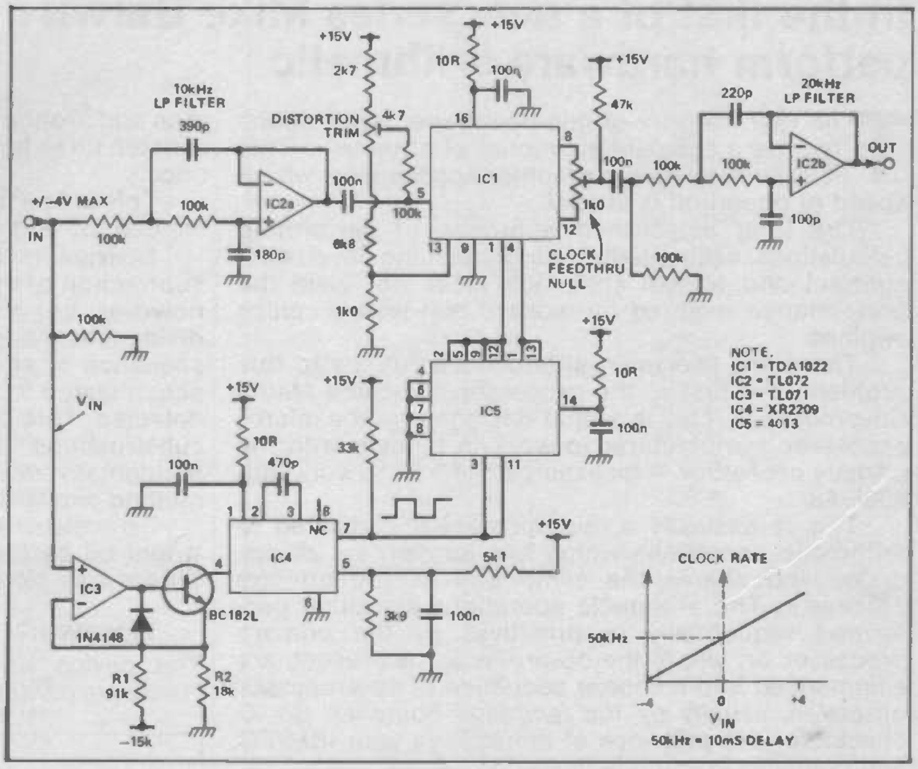
Self Modulation

Signals can be persuaded to frequency modulate themselves by using them to control their own rate of propagation through a delay line, in this case a TDA1022 BBD (which has certain advantages over the more popular MN3000 types).

When the input is zero, clock rate at the output of the linear VCO comprising IC3 and IC4 is about 50kHz, which corresponds to a delay time of 10ms. Clock rate drops to zero for an input of −4V and increases to 100kHz at +4V. R1 sets the quiescent clock rate and R2 sets the sensitivity to input voltage.

Note that the peak input to the TDA1022, pin 5, should not exceed ±4V if distortion is to be avoided. IC5 generates a clean antiphase squarewave pair for the delay line. IC2 is a second order unity gain Butterworth low pass filter which helps to keep aliasing effects down, while IC2b is a similar filter, which helps to keep Britain tidy!

Strong harmonics and sum/difference frequency components can be generated in practice but not to the same degree as in a digital FM synth, since a delay line is incapable of providing a negative delay, necessary to 'modulate through zero'. However, by the same token an FM synth is incapable of modulating an existing audio signal.



Constant Power Pan Pot

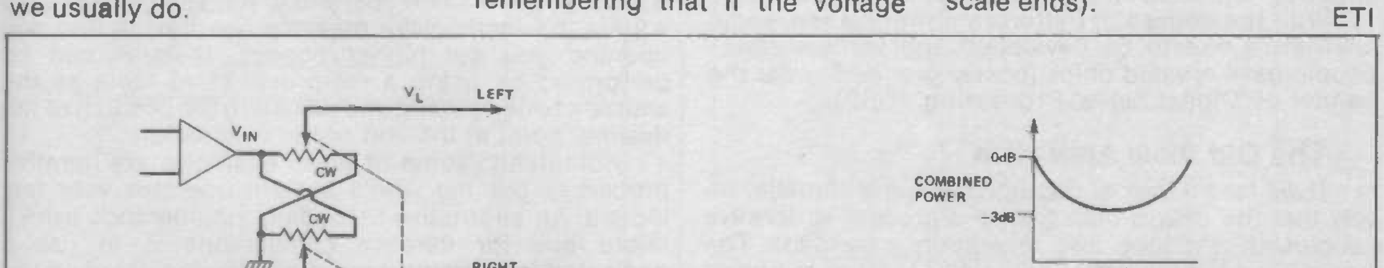
The apparently common sense, simple stereo pan control shown is not suited to audio use since the combined power output of the left and right amplification channels suffers a drop of 3dB when the pot is central. This is due to the fact that here we are considering power, not voltage as we usually do.

Say a stereo amplifier gives an output power of 10W for an input voltage of 1V. At the end-stop settings of the pan pot the output from one channel will be 10W and from the other 0W, making a total of 10W. However, if the pot is at midpoint, V_L and V_R will both be 0.5V and the amplifier outputs will be delivering 2.5W each, a total of opnly 5W.

This is easily understood by remembering that if the voltage across a speaker coil drops by a factor or two, the current flowing through it will consequently halve also, causing a net four-fold drop in power.

The improved scheme shown is not new (it was originally proposed by R. Orban in 1971) but handy to be reminded of. When $R = R_V/1.414$ the deviation from constant power is less than 1.6% or 0.14db (occurring close to the scale ends).

ETI



ARTFUL ARITHMETI

In the first of a new series Mike Barwise looks at devices to perform hardware arithmetic

The vast majority of microcomputer applications require a substantial amount of arithmetic. This is especially true in graphics applications, where speed of operation is crucial.

The long established approach of performing calculations sequentially using machine level add, subtract and logical shifts just does not yield the performance required by modern real-time graphics engines.

There are two main alternative solutions to this problem: the first is the processor-dedicated *Maths Co-processor.* This is a chip designed by the microprocessor manufacturer to work in tandem with the primary processor — for example the 8087 to work with 8086/88.

This is basically a microprocessor dedicated to arithmetic operations which has its own set of opcodes and shares the same bus as the primary processor. The arithmetic operations are either performed sequentially in primitives by the primary processor or, where the co-processor is present, are summarised into a shorter sequence of co-processor op-codes, *usually by the language compiler.* So, C checks for the presence of the 8087 in your IBM/PC and compiles your code accordingly.

The co-processor solution is flexible. You can perform almost any calculation using the same hardware and the hardware is a totally standard package but it does not represent the maximum in attainable performance.

The very fastest arithmetic is performed by *Function Dedicated Arithmetic Circuits.*

These are one-job black boxes which are hardwired implementations of specific mathematical algorithms (formulae, functions). The speed of operation attainable by this approach is phenomenal but until recently the circuits have been difficult to design and required a circuit board the size of a football field strapped to Battersea power station to operate.

With the demise of Battersea power station, some alternative had to be developed and various clever people have created chips loosely grouped under the banner of 'Digital Signal Processing' (DSP).

The Old Slow Approach

If we take a look at microprocessor arithmetic, we see that the delays occur when a process is iterative (enclosed in a loop and repeatedly executed). The conventional Arithmetic/logic unit (ALU) at the heart of a microprocessor is capable of addition, subtraction and shift/rotate operations on digital bit sets of the system bus width.

Real maths, on the other hand, also requires multiplication, division and their derivative, exponentiation (powers and roots) and needs a precision several orders greater than 8 or 16 or 32 bits.

Let us leave roots for the moment for simplicity (because I forget how to work them out!) and look at powers, multiplication and division.

Multiplication has been traditionally performed by micros as a sequence of left shifts (multiply by two) and additions or subtractions of the multiplicand. So, to multiply X by five, you shift left twice (multiply by four) then add X once to finish off. To multiply by seven you shift left three times (multiply by eight) then subtract X once.

This is fine for small numbers but it gets quite long winded for fiddly values such as 129 x 51.

Division is performed most simply by repetitive subtraction of the divisor from the dividend. There is, however an alternative method. The divisor and dividend are aligned and the operation consists of a sequence of shifts and bitwise comparisons. One is accumulated to the quotient every time a carry flag is detected. This is actually a little faster than repetitive substructions of the divisor from the dividend. Incidentally, multiplication can also be performed by a method similar to this.

To calculate a power, multiple multiplications would be performed, resulting in two levels of loop. This is very slow.

Hardware Multipliers

The device which will save all this hassle is the *Hardware parallel multiplier* (Fig. 1). This has two input

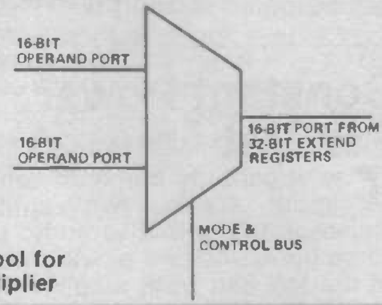


Fig. 1 Schematic symbol for hardware parallel multiplier

ports of operand width and an output port of double width. The operands are loaded and a start signal is given. The output appears in typically less than 100n. By applying the same operand to both inputs you get a square. By feeding the previous result back into one operand you get higher powers. Division can be performed by using a reciprocal (1/n) table as the source of one operand and adjusting the position of the decimal point at the end of the calculation.

Admittedly, some of these examples are iterative processes but the whole system operates very fast indeed. An alternative to loading the operands from a micro bus for iterative calculations is to use a dedicated logic sequencer. A totally dedicated power generator could trap the output of the multiplier in a register and feed it back to one operand input in time for a subsequent multiply cycle for a number of iterations set by a user loadable counter (holding the index).

Typical of these devices is the IDT7217 (Fig. 2) an improved second source for AMD AM29517. This is a 16-bit parallel multiplier in a 64-pin package and it is capable of producing a 32-bit result in 70-185n depending on the device suffix. This device has several acceptable data formats, including:

- fractional twos-complement
- fractional unsigned
- integer twos-complement

C

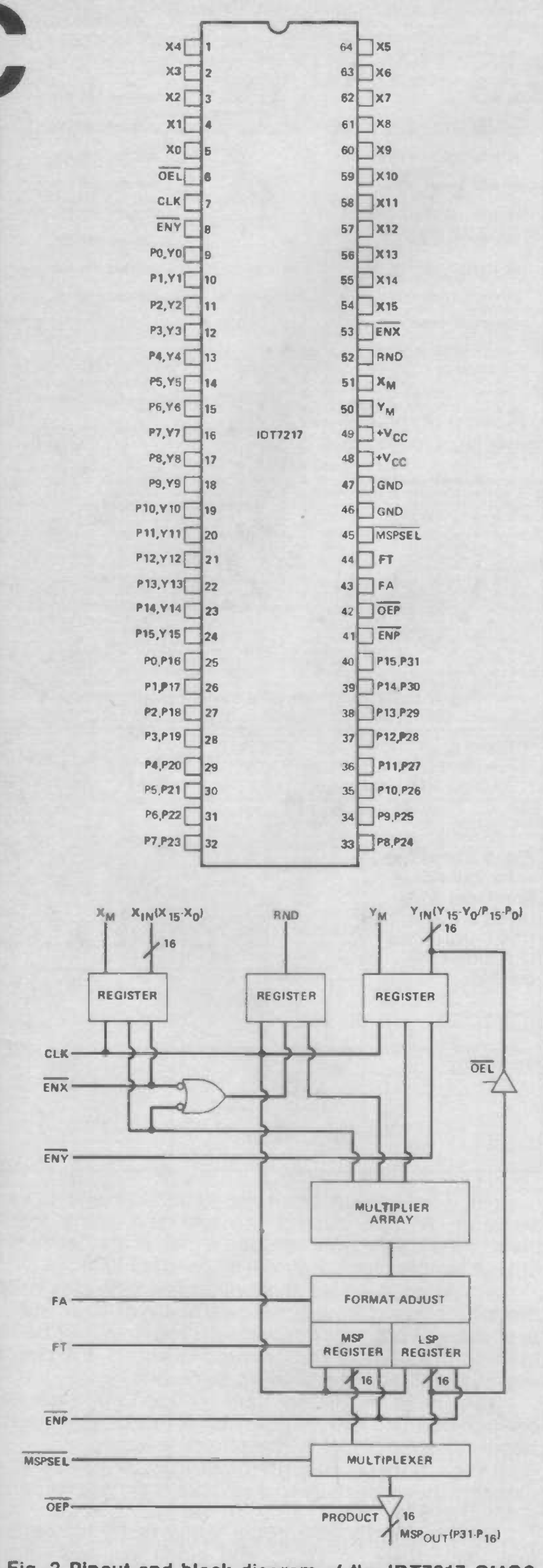


Fig. 2 Pinout and block diagram of the IDT7217 CMOS multiplier

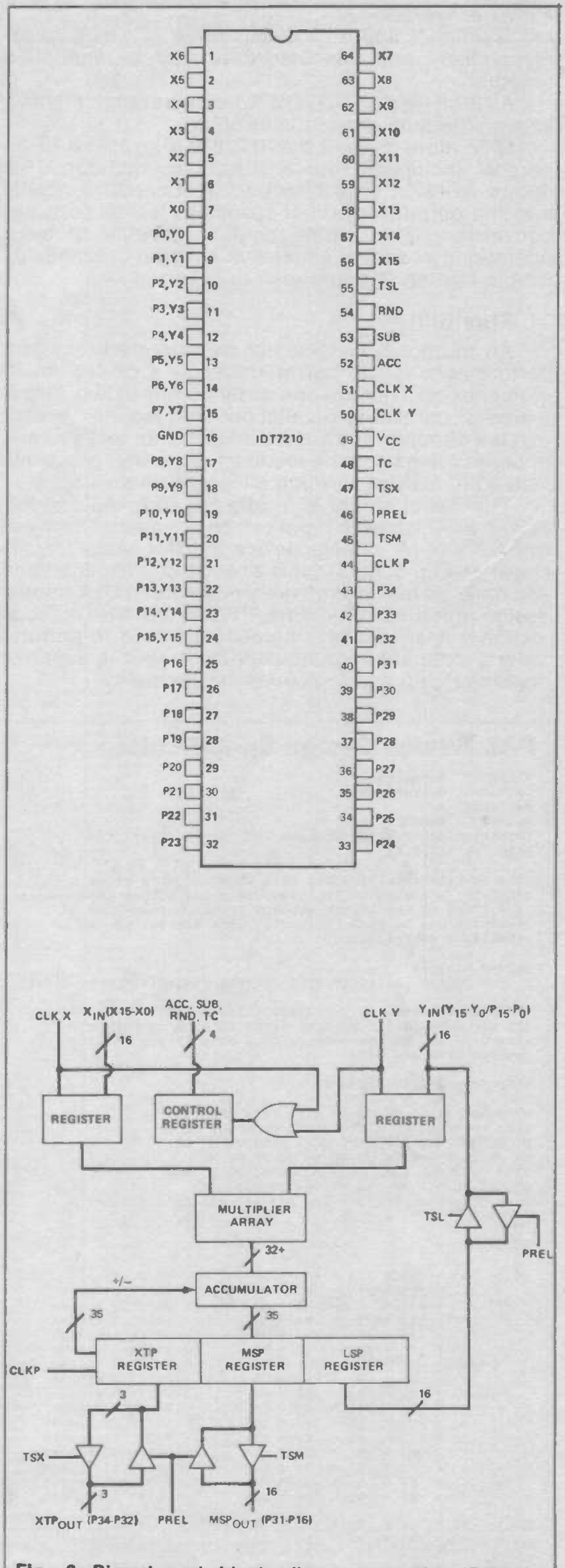


Fig. 3 Pinout and block diagram for the IDT7210 multiplier-accumulator

- integer unsigned
- a fractional and an integer mode in which twos-complement and unsigned data may be multiplied together.

A 12-bit version (IDT7213L) is also available, with a conversion time of as little as 55ns.

Even more clever is the IDT7210 (Fig. 3) — a 16-bit parallel multiplier with a result accumulator. This allows addition or subtraction of successive results into the output register at speeds as fast as 65ns per conversion. This single chip is capable of such operations as sum of squares of all input operands by simple routing of operands.

Flexibility

An additional device which can improve the system performance is the barrel shifter — a device which multiplies or divides in one go by powers of two. This is a kind of parallel-in/parallel out shift register, except that the direction and number of shifts are set by a bank of control lines and the result appears after *one* clock instead of shifting through all intermediate states.

The barrel shifter is in effect a compound multiplexer, in which each input can be connected to any of the outputs. A sample device in MMI Mega-PAL is shown in Fig. 4. Add to this a twos-complementer and you have the makings of a very powerful ALU. A sample design (this time in MMI PRE/PROM) is shown in Fig. 5.

OK I hear you say, supposing I need to perform several different calculations. Do I need a separate multiplier chip and logic network for each?

PAL Device Design Specification

```
Title      Barrel_Shifter
Pattern    Barrel.pds
Revision   A
Author     Mehrnaz Hada
Company    Monolithic Memories Inc. Santa Clara, CA
Date       1/15/85

;The 16-bit barrel shifter will shift 16 bits of data
;(D15-D0) a number of locations into the output pins, as
;specified by the binary encoded input. A compacted
;equation can be used to specify this design. It can be
;specified as following:
;
;Q[J=0..15] :=
;      OR[K=0..15](D[(J+K)-((J+K)/16)*16]*BIN(K,I=3..0]S(I))
;
;Inputs are shown by D. Si are shift amount inputs and
;Qj are outputs. 16 product terms in each output pair
;are directed to one output; thus only 16 out of 32
;output pins are used.

CHIP BarrelShift PAL64R32

D7 D6 D5 D4 D3 D2 D1 D0 /PL1 /PS1 GND CLK1
/OC1 Q0 NC Q1 NC Q2 NC Q3 NC Q4 NC Q5 NC Q6
NC Q7 NC /OC2 CLK2 VCC /PS2 /PL2 NC NC NC
NC NC S0 S1 S2 S3 NC NC NC NC NC NC NC
/PL3 /PS3 GND CLK3 /OC3 NC Q8 NC Q9 NC Q10
NC Q11 NC Q12 NC Q13 NC Q14 NC Q15 /OC4
CLK4 VCC /PS4 /PL4 D15 D14 D13 D12 D11 D10
D9 D8

EQUATIONS

Q0 := /S3 * /S2 * /S1 * /S0 * D0        ; No shift
    + /S3 * /S2 * /S1 *  S0 * D1        ; Shift 1 space
    + /S3 * /S2 *  S1 * /S0 * D2        ; Shift 2 spaces
    + /S3 * /S2 *  S1 *  S0 * D3        ; Shift 3 spaces
    + /S3 *  S2 * /S1 * /S0 * D4        ; Shift 4 spaces
    + /S3 *  S2 * /S1 *  S0 * D5        ; Shift 5 spaces
    + /S3 *  S2 *  S1 * /S0 * D6        ; Shift 6 spaces
    + /S3 *  S2 *  S1 *  S0 * D7        ; Shift 7 spaces
    +  S3 * /S2 * /S1 * /S0 * D8        ; Shift 8 spaces
    +  S3 * /S2 * /S1 *  S0 * D9        ; Shift 9 spaces
    +  S3 * /S2 *  S1 * /S0 * D10       ; Shift 10 spaces
    +  S3 * /S2 *  S1 *  S0 * D11       ; Shift 11 spaces
    +  S3 *  S2 * /S1 * /S0 * D12       ; Shift 12 spaces
    +  S3 *  S2 * /S1 *  S0 * D13       ; Shift 13 spaces
    +  S3 *  S2 *  S1 * /S0 * D14       ; Shift 14 spaces
    -  S3 *  S2 *  S1 *  S0 * D15       ; Shift 15 spaces

Q1 := /S3 * /S2 * /S1 * /S0 * D1        ; No shift
    + /S3 * /S2 * /S1 *  S0 * D2        ; Shift 1 space
    + /S3 * /S2 *  S1 * /S0 * D3        ; Shift 2 spaces
    + /S3 * /S2 *  S1 *  S0 * D4        ; Shift 3 spaces
```

Fig. 4 PAL specification of a Barrel shifter

```
PLE8P8                              PLE CIRCUIT DESIGN SPECIFICATION
P5015                                          MIKE VOGEL 11/28/83
8-BIT TWO'S COMPLEMENT CONVERSION
MMI BREA, CALIFORNIA
.ADD D0 D1 D2 D3 D4 D5 D6 D7
.DAT Y0 Y1 Y2 Y3 Y4 Y5 Y6 Y7
Y0 = D0                                       ; CONVERT 1ST BIT (LSB)

Y1 = D1 :+: D0                                ; CONVERT 2ND BIT

Y2 = D2 :+: D0 + D1                           ; CONVERT 3RD BIT

Y3 = D3 :+: D0 + D1 + D2                      ; CONVERT 4TH BIT

Y4 = D4 :+: D0 + D1 + D2 + D3                 ; CONVERT 5TH BIT

Y5 = D5 :+: D0 + D1 + D2 + D3 + D4            ; CONVERT 6TH BIT

Y6 = D6 :+: D0 + D1 + D2 + D3 + D4 + D5       ; CONVERT 7TH BIT

Y7 = D7 :+: D0 + D1 + D2 + D3 + D4 + D5 + D6  ; CONVERT 8TH BIT (MSB)
```

FUNCTION TABLE

D7	D6	D5	D4	D3	D2	D1	D0	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	;DECIMAL
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	0
L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	1
L	L	L	L	L	L	H	H	H	H	H	H	H	H	L	H	3
L	L	L	L	L	H	H	H	H	H	H	H	H	L	L	H	7
L	L	L	L	H	H	H	H	H	H	H	H	L	L	L	H	15
L	L	L	H	H	H	H	H	H	H	H	L	L	L	L	H	31
L	L	H	H	H	H	H	H	H	H	L	L	L	L	L	H	63
L	H	H	H	H	H	H	H	H	L	L	L	L	L	L	H	127
H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	255
H	H	H	H	H	H	H	L	L	L	L	L	L	L	H	L	254
H	H	H	H	H	H	L	L	L	L	L	L	L	H	L	L	252
H	H	H	H	H	L	L	L	L	L	L	L	H	L	L	L	248
H	H	H	H	L	L	L	L	L	L	L	H	L	L	L	L	240
H	H	H	L	L	L	L	L	L	L	H	L	L	L	L	L	224
H	H	L	L	L	L	L	L	L	H	L	L	L	L	L	L	192
H	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	128

Fig. 5 Specifications of a twos-complementer

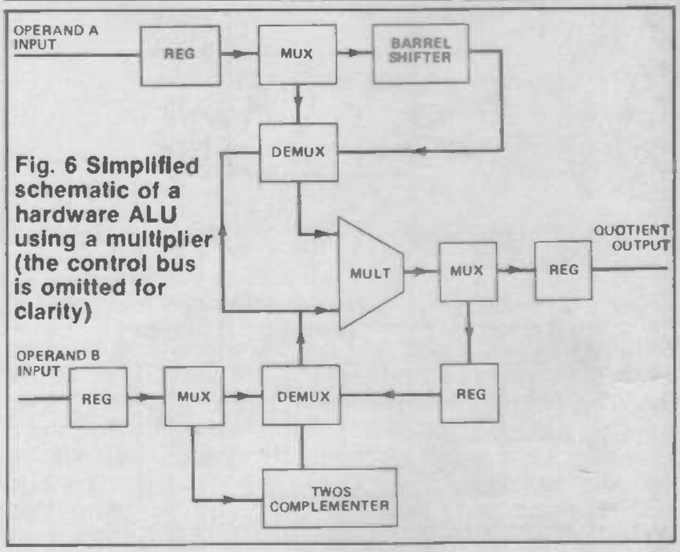


Fig. 6 Simplified schematic of a hardware ALU using a multiplier (the control bus is omitted for clarity)

No! That would get quite expensive and is very wasteful. A little careful thought and some multiplexers yield a flexible solution which is in effect a fast ALU. A simple block diagram is given is Fig. 6.

A system such as this will alllow complex arithmetic to be performed independently of your microprocessor. The only intervention required will be the loading of function and operand registers, the checking of status and the reading of results.

You need not stop here, though. If there are enough pennies in your piggy bank this can be just the beginning of parallel arithmetic processing.

I reckon this is enough to get you started. Detailed data on these devices is available from Microlog on (04862) 29551.

I am currently examining some really interesting new departures in video and electro-optics among other things, so next month I will probably have some surprises for you. **ETI**

IMAGINARY TIMES

Paul Chappell takes his life in his hands with an explanation of complex numbers.

For many people the thought of complex numbers seems to induce reactions of panic and mental numbness out of all proportion to the difficulty of actually doing the calculations.

I have a suspicion this is partly a balking at interference with anything so familiar and 'obvious' as the ordinary number system. After all, we've been using numbers since primary school days for counting and measuring. They are safe, predictable, easy to understand.

Then along come these new numbers which do odd things, are not easy to interpret and are utterly useless for counting and measuring!

If you have doubts about the meaning and value of complex numbers, you're in good company. At the beginning of the last century they were generally held to be meaningless and 'imaginary' and their study a waste of time. The main reason for this was that they had no obvious interpretation. Allowing them into algebraic equations gave solutions of a sort, but what could be understood by an answer such as 7+j9, where j is to be interpreted as $\sqrt{-1}$?

It may as well have been 'hickory dickory dock' for all the sense it made.

Why Complex Numbers?

The study of complex numbers arose from dissatisfaction that perfectly reasonable looking equations and expressions have no solution within the ordinary number system. The quadratic equation $x^2+5x+6=0$ has roots (values of x which make it 'true') of -2 and -3. If you substitute either of these values for x in the equation, the left hand side does indeed add up to zero. Yet, try as you might, you won't find a value of x to make $x^2+5x+7=0$ come out 'true'.

At an even simpler level, there seems to be no candidate within the ordinary number system for the value of, say, $\sqrt{-4}$. It can't be negative (since any negative number multiplied by itself will give a positive result) and it can't be positive for the same reason. It's certainly not zero, which is the only remaining possibility.

If we return to the awkward quadratic equation and try to use the well worn formula:

$$x = \frac{-6 \pm \sqrt{6^2-4ac}}{2a}$$

to find the roots, we hit a similar problem. All goes well until we try to evaluate $\sqrt{b^2-4ac}$, which in this case will be $\sqrt{-3}$. The square root of a negative number again!

What if we allow negative numbers to have square roots — what then?

One thing we won't be able to do, as we've already seen, is to find a place for these new numbers within the realm of the ordinary counting and measuring numbers. Whatever solution *is* found will have to be given a new meaning. Let's just put this into perspective.

Cracked It!

The process for solving quadratic equations by completing the square (the basis of the formula given above) was known to the Babylonians. Yet the range of things they would accept as proper answers was even more restricted than those accepted by 19th century mathematicians. They only liked positive solutions.

When it came to subtracting one number from a smaller one, they had no way to cope with it. To their practical, commonsense minds you either had something or you had nothing. To talk about having less than nothing was just plain nonsense. They had a point — didn't they?

From the viewpoint of our familiarity with the arithmetic of negative numbers, we can find all kinds of interpretations which would have seemed the epitome of abstract philosophical twaddle to the Babylonians.

Instead of thinking of an overdraft as owing a positive amount of money, we can think of it as *owning* a negative amount. If a current goes one way in a circuit, we might call it positive. If it goes the other way it's negative, although there's no real difference between the two. We might consider a hole in the ground as having negative height, sadness as negative happiness — once we've caught on to a pattern, there's no end to the ways we can apply it.

To get a firm grasp of complex numbers, we'll see what kind of pattern they make when we put them through their paces and then try to match it up with something familiar. This being ETI, there are no prizes for guessing what that familiar subject will be!

The Basic Properties

I don't intend to go too deeply into the mechanics of manipulating complex numbers this month but there are two things to consider before we go any further. First, since -n can be written as -1 x n for any number n, it is reasonable to write $\sqrt{-n}$ as $\sqrt{n} \times \sqrt{-1}$. This means that the square root of any negative number can be looked on as a multiple of $\sqrt{-1}$.

If we use the symbol j to represent $\sqrt{-1}$, we have a neat way to write down these new numbers: $\sqrt{-16}$ will be j4, for instance.

Second, all text books I've ever come across begin with the assumption that complex numbers are of the form a+jb. I've no objection to this (I'll be doing the same myself) but I think it's worth considering for a moment why this assumption can be made.

If you give j the status of a number and allow it to run amok through your equations, there's no knowing what might come out. One thing to notice about j is that it has certain 'self-simplifying' properties. For instance, j^2 is (obviously) −1, j^3 is −j, j^4 is 1, and higher powers of j just trudge eternally around the loop j, −1, −j, 1, so at j^5 we're back to j again, j^{19} will be −j, and so on.

Similarly, something of the form $(c+jd)^n$ will also reduce to a+jb. Tug it! Expand it out, replace all the powers of j by j,−1,+j or 1, then gather together all the ordinary numbers and all the multiples of j and you're there!

To follow this bottom-up approach to the bitter end would mean anticipating every single combination that could emerge from an equation and showing that they all reduce to the form a+b. There would always be the possibility that one had been overlooked.

The alternative is to take a top-down view. Assume that all complex numbers are of the form a+jb, then show that numbers of this form can provide solutions to all possible equations. This is also a tall order if you include every conceivable equation, but a simple proof is possible for the case of algebraic equations. Other equations can be considered on their own merits and we'll be looking at one example in particular next month.

Two-Dimensional Numbers

The first step towards providing an interpretation for the square roots of negative numbers was taken by Jean Robert Argand in 1806. He developed a geometric representation which placed them along a line at right angles to the ordinary number line (Fig. 1). This construction would probably have had a much greater impact for generations brought up on Euclid's 'Elements' than it does for us but at least it gives a way of visualising the situation.

Gauss later extended Argand's idea to incorporate numbers of the form a+jb as points on the plane. 2+j3, for instance, would be represented by a point two units to the right of zero and three units upwards — rather like a map reference showing where the number can be found.

That's as far as I intend to go for this month, but before I leave, does anyone have any questions?

I've seen all this before – Argand diagrams and all that kind of stuff. But I still don't see what complex numbers are. For example, if an answer comes out to 4+j6, is that more than 4? Or the same (if so, why the j6?), or less?

You're looking down the wrong end of the telescope! You can't take complex numbers and try to crush them into the structure of ordinary numbers. The best way of looking at the situation I can give at the moment is this:

Suppose you were a master chef with a fine appreciation of the subtle variations in flavour you can obtain by adding different kinds of salt to your dishes — sea salt, table salt, and so on.

One day a chemist comes to eat at your restaurant. You fall to talking about salt and he tells you that from his point of view the word covers a whole class of chemical compounds. As a chef, you might be excited at the prospect of the culinary masterpieces you will be able to prepare when you come to terms with all these new types of salt. Chicken à la ferric chloride, perhaps. The chemist explains that salts in general are not really much good for flavouring food and to think that all salts must have the properties of the familiar one is a mistake.

With complex numbers, you've got to take the chemist's-eye view — that numbers are really of the form a+jb and they don't necessarily have the properties of the familiar type. The only ones which are

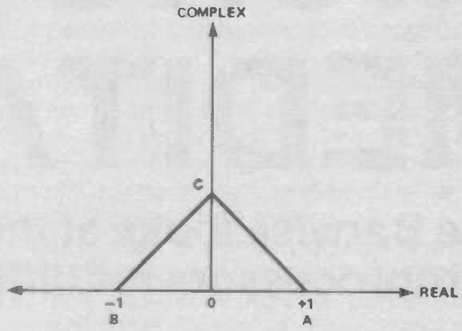


Fig. 1 Argand's geometric construction for $\sqrt{-1}$. OC is constructed to be the same length as OA and OB. OC/OA = OB/OC so OC^2=OA.OB=1.-1=1-1. Therefore OC=$\sqrt{-1}$. This demonstration has the same flavour as the theorems of Euclid's 'Elements' which would have been familiar to all 19th Century mathematicians.

any good for counting and measuring are those in which b=0. The others have different uses, which become evident when you start experimenting with them.

Ordinary numbers can only be compared with each other because they 'lie in a straight line'. We then adopt the convention that any number on the line is greater than all numbers to its left and less than any number of its right. This isn't so easy to do when the numbers are spread out over a plane (although there is a more restricted sense in which their 'sizes' can be compared).

You promised these numbers would have some kind of a pattern which would make it clear how to interpret them. I haven't seen much of a pattern yet!

I agree. I promised to make you a number naturalist and so far I've only shown you a stuffed otter in a glass case. The pattern of complex numbers only becomes apparent when you study the habits of live ones.

The particular pattern we will be interested in is how closely the behaviour of complex numbers matches that of electronic components and circuits. That must wait until next month.

OK, so we've got a way of showing the square roots of negative numbers. That's no big deal. What about all the other things that have no answer, like the logs of negative numbers? Are we going to have negative-log numbers next? And how about things like e^j or $\sqrt{-j}$, or even j^j? Are we going to need hyper-complex numbers to give answers to this kind of thing? Where will it all end?

The interesting thing about complex numbers is that the expansion of the number system has ended already. All the problems you pose (and more!) can be given solutions of the form a+jb. For algebraic equations, this is known as the fundamental theorem of algebra. Functions like e^j (which we will be looking at next month — it's important for electronics calculations) also have a place within the realm of complex numbers.

The value of j^j, by the way, is 0.2078795 . . . which is just the kind of thing you need to know if you're a mathematical 'Trivial Pursuits' player!

ETI

MICRO MEDITATIONS

Mike Barwise looks at the pros and cons of different microprocessors for different uses

Amid the plethora of alternative microprocessors currently available, it is sometimes difficult to come to a rational decision on the best choice of processor for a given task.

There are two mutually opposed common misapprehensions on this subject:

The first is that certain CPUs are generally 'better' than others. The second, that there is little to choose between devices and any CPU will perform any task equally well given the right software.

The truth lies somewhere between these two poles. The choice of processor for a given task depends primarily on the application designer's criteria in a given design situation.

Alternative factors which could guide or dictate choice are:

- system chip count in a low cost commercial application
- system throughput as an absolute parameter
- system efficiency as an absolute parameter
- system cost effectively represented as throughput per pound or dollar cost
- system adaptability for non-standard implementations
- system reliability or the capacity of the system for self-maintenance
- designer familiarity with the system.

The list could go on indefinitely but this sample shows just how diverse are the factors which seem significant in varying design situations.

What I would like to do in this resumé is to give my personal overview of the current mainstream CPUs and support devices and to outline some of the criteria I consider most important in different areas of application.

Bus Width, Speed And Map Size

Sadly, these three parameters are inextricably intertwined. Early 8-bit CPUs with low clock rates and 64K maps have given way to apparently much faster 16 and 32-bit CPUs with maps in excess of 1Mb, without any transitional devices.

This is probably a major influence on the 'generally better' theory. Faster is better, faster is 16 or 32-bit, 16 or 32-bit has a larger map and so on.

In practice, the three parameters should ideally be considered quite separately. It may not hurt to have a 16-bit bus width when you need a large map or it may be no problem to have a large map when you need a high throughput, but in either case it may be no advantage either.

To take a typical example: if you are building a microprocessor driven printer buffer you may need a data buffer expandable to about 512K bytes (quite a few word processor files on my IBM compatible are in this order of size). You will not, however, need a bus wider than 8-bit, as all your data objects are single bytes, as are the system ports.

Neither will you need exceptionally high speed, as the fastest parallel printer port is limited to about 64K per second by the duration of its strobe/acknowledge sequence. However, to directly map the data buffer into the CPU, you are stuck with a 16-bit processor for this application.

Alternatively, you may need very high speed and a 16-bit bus for a specialised high resolution transient capture unit but you are very unlikely to need 1Mb or more of memory for it.

A Fistful Of CPUs

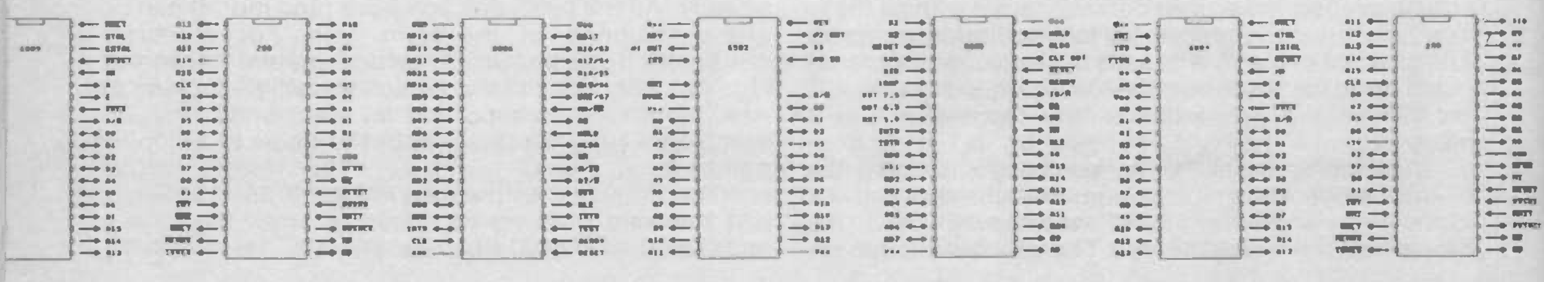
The most common devices and the ones I am mainly considering here are:

- 8-bit: 6500, 6800. Z80 and their derivatives;
- 16 and 328-bit: 8068, 68000 and their derivatives;
- pseudo 16-bit: 8088

Let's take the 8-bit devices first. Most of us are familiar with the 6502 which is the simple entry point of the 6500 system. It has been around since about 1978 and is very well documented.

It has its problems. The original NMOS device has only ever been available at 1MHz and 2MHz which makes the throughput rather low in real terms and some unused op-codes can lock it solid or perform rather random operations.

However, even the NMOS chip is about the cheapest processor available in pounds per throughput. It is probably the easiest processor to use to build hardware as you can (but are not obliged to) use the standard support chips such as peripheral interfaces and so on. Specifically for control jobs, it is



probably one of the simplest processors to write for (a close runner-up being 6809).

The real beauty of the 6502 is, however, in the upgrades which have materialised with the conversion to CMOS technology. Rockwell, one of the largest suppliers of 6500 parts, has produced a set of three R65C00 processors which, apart from the power consumption improvements inherent in CMOS, also have the following enhancements:

- no action taken on any invalid op-code
- clock speeds to 4 (yes! FOUR) MHz
- price in the under £10 bracket.

This is characteristic of the upgrade trend in 8-bit processors.

A Few CPUs More

Among the 8-bit devices, the Z80 is probably the most fiddly to work with. Many experienced users swear by it whereas most newcomers swear at it. The Z80 has, however, the distinction of being one of the very earliest 8-bit CPUs readily available and was given an enormous boost by the creation of CP/M.

It is still the preferred engine for 8-bit office tasks but I feel that this is more probably tradition than anything else.

Overall, I think there is little to distinguish the various mainstream 8-bit processors except for personal preference, as long as your selection criteria are correct.

It is no good, for example, just looking at clock rate to gain an idea of relative throughput. You have to examine the instruction execution cycle in detail. For example, a Z80 with a standard clock speed of 4MHz sounds a lot faster than a standard 6502 with a 1MHz clock. However, when you look at real instruction execution rate you find the Z80 averages about 15 clock cycles per instruction, while the 6502 averages about 3½. When you work the result through, you find that both processors have (surprise, surprise!) about the same throughput.

The other set of processors under discussion is the generation of 16-bit and beyond.

Around the time we were all coming to grips with 8-bit microprocessors, the silicon industry was taking a radical new direction in CPU architecture.

This was not just the expansion of bus width and memory map (which results from the greater number of address lines available as a wider bus) or in the enhancement of the silicon geometry to increase system speed. The underlying principle was *uniformity*.

The idea was to create a totally application-independent hardware solution with the application defined solely by software. The incentive was, of course, essentially commercial. Software redesign is cheaper than hardware redesign when you find you have goofed. Nevertheless, this idea has persisted to the present day and probably is with us for the forseeable future.

You must remember that the majority of profitable microsystems manufacturers rely essentially on the office data processing market. In this field, the tasks are simple and relatively undemanding of everything except data capacity. Practically all throughput is ultimately limited by human interfaces of one sort or another, so absolute processor speed does not have to be phenomenal.

Where speed is of the essence, microprocessors are not used anyway. The junk mail houses use massive mainframes, as do all the financial processing companies. The market we are really discussing is the office personal computer boom. The ideal here is *compatibility*, the option of slotting the same program into any of the PCs where it will accept disk, keyboard, comms and printer input and output.

The ultimate result is something like the IBM PC series, which is basically an Intel recommended implementation of Intel standard chip sets, pared down to a minimum complexity. There is little need to ask whether the compatibility concept has come off!

Given this commercial climate, it is no great wonder that the newer generations of CPU are less and less flexible in their implementation. The 8086 has a dedicated bus controller (8288), DMA controller (8257) and interrupt prioritiser (8259) and you can't for practical purposes implement these functions except by use of these chips.

The interrupt prioritiser, for example, and the CPU interchange data during the priority decision process via a dedicated set of control lines and the data bus. Any alternative implementation has to obey the same protocol, as no explicity coded READ operation takes place.

Conversely, the software set of the 8086 and its family is extremely flexible. Flexible to the extent of being thoroughly confusing. The indirection of addresses via the contents of updatable registers, combined with a segmented address map (yielding 64K alternative address notations for each physical byte) make the visual analysis of disassembled code almost impossible.

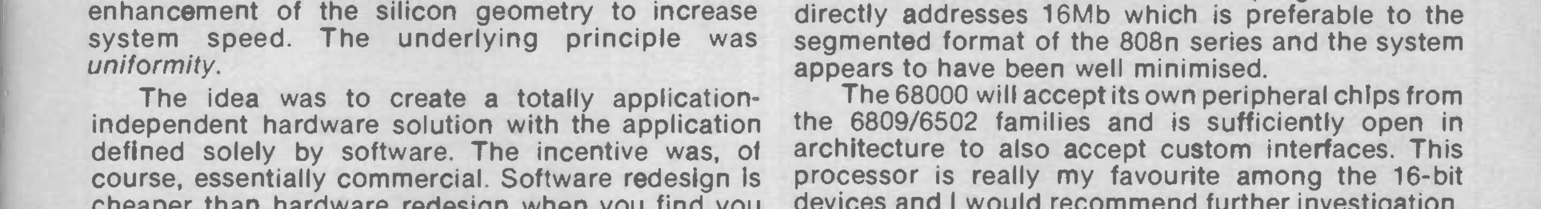
The Good

We now come to the 68000. This Motorola invention (the same people who invented the 6809) bridges the gap between the inherently simple 8-bit devices and the complex future.

The 68000 is a 16-bit processor with internal 32-bit registers and an instruction set surprisingly reminiscent of the 6809. The 32-bit program counter directly addresses 16Mb which is preferable to the segmented format of the 808n series and the system appears to have been well minimised.

The 68000 will accept its own peripheral chips from the 6809/6502 families and is sufficiently open in architecture to also accept custom interfaces. This processor is really my favourite among the 16-bit devices and I would recommend further investigation. It is, by the way, the processor used in the Apple Mac — the only non-Intel office system to prove itself viable.

Finally, under the heading of standard devices in current use we have the pseudo 16-bit processors (such as 8088). The same comments apply to each as to its parent device except that generally they have



comparatively poor performance.

Inevitably, to load 16-bit registers from an 8-bit bus, a bandwidth at least double that of the 16-bit bus will be needed to maintain system speed. Where you don't have that bandwidth (as in the IBM PC and PC/XT), the system performs badly in comparison with a true 16-bit configuration.

A final comment on the 8-bit processors: they still represent the most cost-effective solutions for general control jobs. Various derivative devices incorporating mask ROM, RAM and alternative peripheral ports in single packages form the basis of the controllers in our washing machines, central heating systems and, increasingly, in our cars.

The dedication of most standard 16-bit processors to their own support devices has recently prompted some manufacturers to hybridise. You can now get a complete IBM PC/AT equivalent on two pin grid arrays with a total board space requirement of about eight square inches!

The Bad And The Ugly

Apart from the mainstream processors, there are now many more esoteric chips around, ranging from fairly conventional devices with small user bases, such as the Zilog Z8000, through to RISC and parallel processor networks.

The really interesting departure is probably the parallel processing option. RISC, after all has been around from some time (the 6502 could be considered a RISC processor, as I think Acorn realised when they developed their own RISC along similar lines).

For the uninitiated, RISC (Reduced Instruction Set Computer) architecture consists of minimisation of the complexity of CPU operations, so that you end up with a small set of primitives running on a greatly simplified (and so extremely fast) Arithmetic Logic Unit.

However, back to parallel processing. The idea behind this is that any complex problem can be broken down into sub-problems which only inter-connect at certain critical points. A conventional sequential processor would solve sub-problem (sp) A, store a result, then solve spB using that result and so on.

However, if spB only needs spA's result three quarters of the way through its own operation, you could save time if spA and spB could be running simultaneously.

The parallel processor has in effect a CPU per sub-problem. All of them start executing at the same time and any sp which needs data from another is constrained to wait *only from the moment it needs data to the moment the data is available*. This concept results in a very fast overall execution rate.

There is, however, a point that I find rather funny. The total problem solution in a parallel network is an intensely *problem dedicated* hardware implementation for most problems which merit the technique.

This means we are back to one-job machines which we always knew were potentially faster anyway! It is quite possible that in striving for across-the-board compatibility over the last 8-10 years, the micro industry has significantly retarded the progress of computer solutions.

I leave you with the thought that this situation is unlikely to change unless the end users of micro-systems become much more critical and discerning in their quest for results on time and at the right price.

ETI

DCP INTERFACING MODULES

Martin Tame has been putting his micros to work with the new interfacing modules from DCP

Regular readers of ETI will have noticed the frequent appearance in the magazine over the last year or so of an advertisement for the special offer of interfacing modules from DCP Microdevelopments for the BBC micro and Spectrum — the Interbeeb and Interspec.

Now DCP has released a complete new series of 'Interpack' modules which can be used with a whole range of micros. The new modules use a clever system of standard interface units with 'Intercard' personality modules to link them to specific micros. At present the Intercard range covers six popular micro ranges:

- Spectrum and ZX81
- BBC micro/Master
- Commodore 64/128
- Apple II/IIe/IIGS
- Amstrad CPC464/664/6128
- IBM PC/XT

There is also an Intercard for the Scorpion micro-controller and one to adapt one Interpack unit to be added to another.

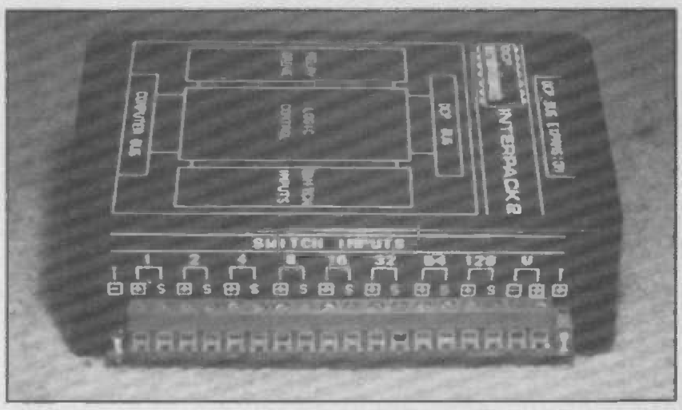
For most ETI readers the two most important and popular Intercards are those for the Spectrum and BBC micro. A Spectrum system derives all its power from the Spectrum's power supply and simply plugs onto the Spectrum's rear edge connector. The BBC micro Intercard includes a mains adaptor to provide the 9V supply and connects to the 1MHz bus.

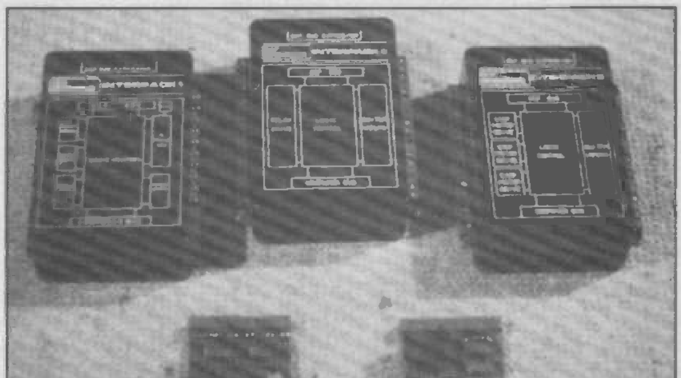
For long strings of modules or systems which will consume a lot of power, a 'Powerbus' card is available to connect into the DCP bus line with its own mains adaptor and regulator to provide extra boost for the +5V and +9V bus lines.

The necessary Intercard board fits inside the chosen Interpack unit to form a solid single unit to plug into your micro as though it was built specifically for your machine. The new modules also have the same 'DCP Bus' to connect further units — either fast ADC or DAC modules available for the old modules, or units of your own make.

The DCP bus system is organised so that the main Interpack has three locations allocated to it, either memory mapped or I/O port locations depending on the host micro. This allows the interpack units to have up to 24 output bits and 24 input bits.

Full information is provided in the Interpack and Intercard manuals as to how to write simple programs to read and write data to these locations. It really couldn't be simpler. A further two locations are provided on the DCP bus for add-on units. Two address lines, a read and write line are available on the bus along with the micro's





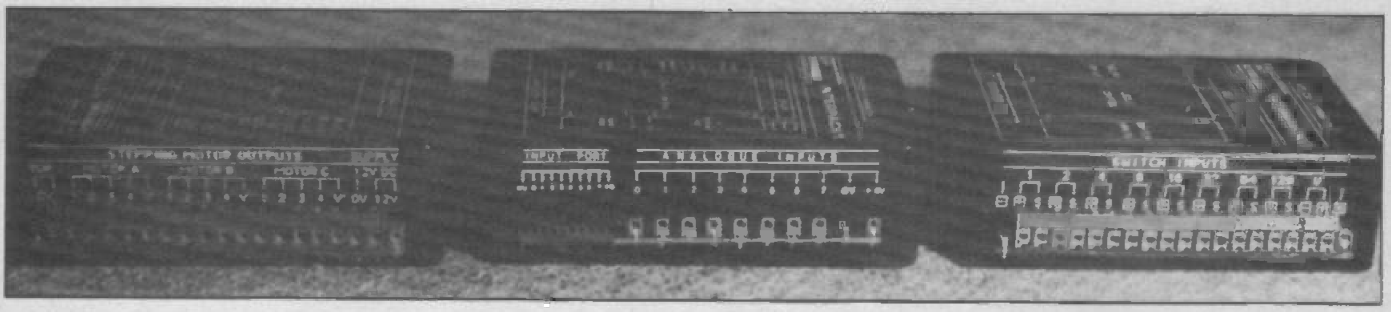
data lines and the +9V and +5V powers supply lines to allow two input and two output ports.

To make full use of these — to allow more than one unit to be connected — an 'Invertabus' unit is available with sockets for two ADC and two DAC units or your home-made equivalents.

Interpack 1

The three new modules on which the whole DCP interface range is now based are called Interpack 1, 2 and 3. Interpack 1 provides basic digital and analogue inputs and outputs. One 8-bit input port and one 8-bit output port are provided for TTL signal interfacing. These are simple buffers to the data bus with Molex connectors for connection of external circuitry.

A further 4-bit input port is configured for use with



any kind of switch, light dependent resistors or the like. The switch inputs consist of a quad buffer chip with pull-down resistors and a common positive line for switching individual inputs. The Interpack 1 also has four relay-isolated outputs. The relay contacts are rated at 24V at 1A. A little unfortunately, one contact of each relay's single pole switch is connected to a single common terminal for all four relay outputs. This restricts their flexibility somewhat.

As if that wasn't enough there is also an analogue to digital converter crammed into this 4.5x3x1in box. Eight analogue input channels are provided, each capable of 8-bit resolution of a 2.45V input with a 10ms conversion time. As such, the Interpack 1 has the same facilities as the old Interspec and Interbeeb, but without the relevant micro interfacing and decoding, of course.

Interpack 2

The Interpack 2 unit is less sophisticated than Interpack 1. This module contains just switch inputs and relay outputs.

The eight switch inputs are pulled low with resistors and must be taken high via switches to register.

The six relay outputs this time have all three terminals of each relay's single pole, double throw switch accessible. The power supply lines are also provided. The contacts to both switch inputs and relay outputs are small screw terminals so connecting up all manner of motors, lamps, switches and so forth is extremely simple.

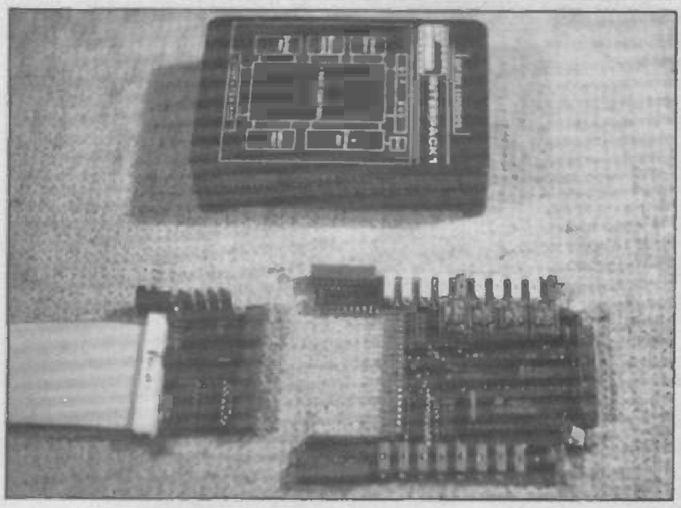
Interpack 3

The Interpack 3 module is a new departure for DCP. This is a stepper motor driver. Three 12V stepper motors (of the ID35 type) can be controlled at a time. However, a regulated DC supply suitable for the motors must also be added to the interface and connected to it. The three stepper motor driver chips (SAA1027) inside the Interpack 3 are configured so that each time the relevant register is addressed, the corresponding motor turns through one step in the direction specified by the data written to the register.

This is a simple system to use and works well. Quite complex and effective motor control programs can be easily written in Basic. For real control of floor robots or robot arms, some kind of feedback is necessary. The Interpack 3 modules provides this with eight switch inputs similar to those in Interpack 2.

It really is quite easy to produce your own robot using this unit and have only some simple wiring to do. The old Interspec and Interbeeb modules provided easy interfacing for anyone wanting to dabble with electronics with the BBC micro or Spectrum. The new range has continued the flexibility and ease of use of the old modules while vastly increasing the range of micros which can be used and adding to the flexibility of the system.

For the occasional excursion into the world of microcomputer interfacing and control or for development work, these units are tremendously useful and cannot really be faulted. **ETI**



Prices

Interpack 1	£54.95
Interpack 2	£44.95
Interpack 3	£54.95
ZX Intercard	£14.95
BBC micro Intercard	£24.95
Commodore 64 Intercard	£19.95
Apple II Intercard	£29.95
Amstrad CPC Intercard	£19.95
IBM PC Intercard	£29.95
Scorpion Intercard	£29.95
DCP Bus Intercard	£14.95
Powerbus Card	£19.95
Invertabus Card	£4.95

DCP Microdevelopments, 2 Station Close, Lingwood, Norwich NR13 4AX. Tel: (0603) 712482.

SMART TALKER

Russel Vowles has produced a speech synthesiser that will work with almost any micro and is intelligent into the bargain.

Most speech synthesisers use allophone coding of the words to be spoken. This requires the user to convert the words into their phonetic equivalent and then match up each sound of the word with a sound that can be 'spoken' by the synthesiser.

This is obviously a tedious process which, of course, like most tedious processes, is ideally done by a computer. Some speech synthesisers are manufactured to use a text-to-allophone program which requires a large amount of software resident on the host computer. This software of course differs from one computer to another due to incompatibility of programming languages.

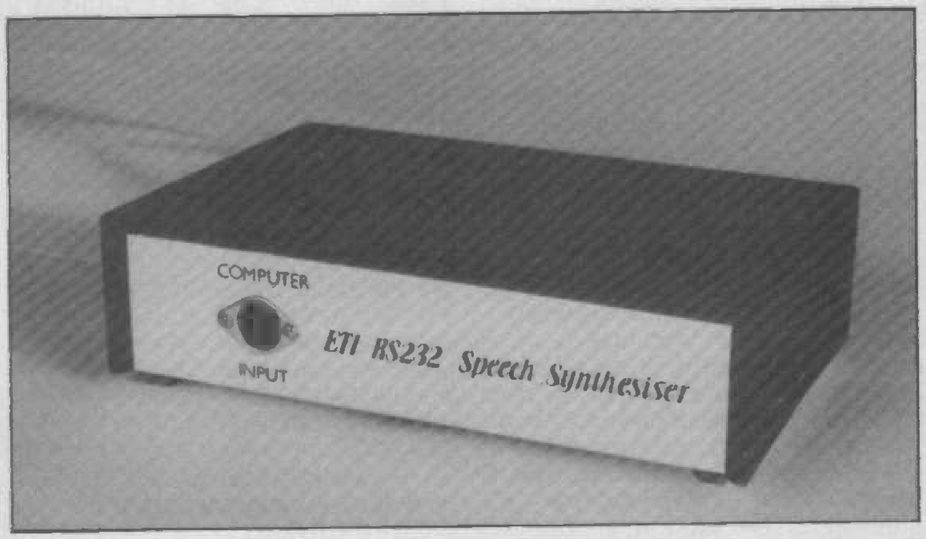
In addition, most of the speech synthesiser designs already published connect to the host computer's data and address buses via an interface circuit which also has to vary due to major differences in the allocation of memory space and types of microprocessor found in different computers.

This design has few incompatibility problems compared to earlier designs and yet has a built-in text-to-speech algorithm allowing English words to be spoken directly (Fig. 1).

The speech synthesiser can be used with virtually all computers that incorporate a serial (RS232 or RS423) output. This includes the majority of computers now available.

Here I have concentrated on using the synthesiser with the Amstrad PC1512 (IBM PC compatible) and BBC micro but this should not deter you from connecting the synthesiser to other computers.

All this has been made possible by the introduction of a new IC from General Instruments called the CTS256-AL2. This is a masked programmed version of the PIC7041 microcomputer programmed with the text-to-speech algorithm and designed to interface directly with an SPO256-AL2. This is the speech synthesis IC used in most speech



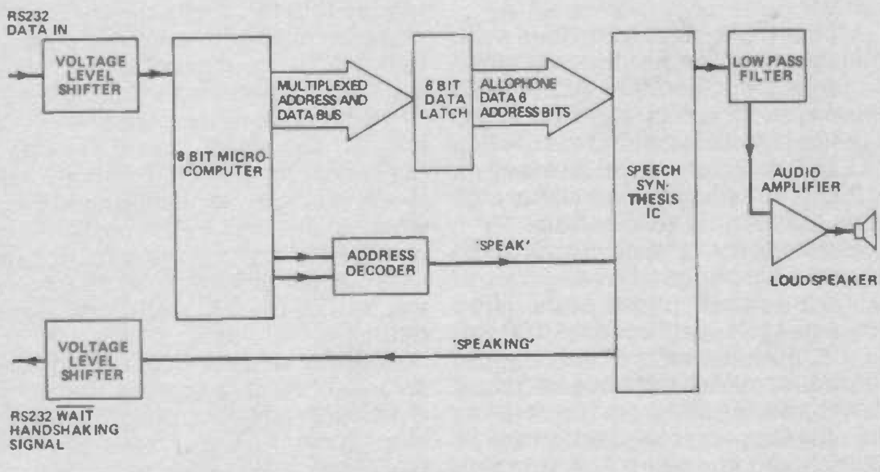


Fig. 1 Block diagram of the Smart Talker

synthesiser designs based on the allophone (phonetic) method of speech generation.

As the CTS256-AL2 is a relatively new device and probably not familiar to most readers, a more complete technical description of the device is in order.

CT256-AL2

The CTS256-AL2 (Fig. 2) is capable of receiving characters which make up the word to be spoken from a serial RS232 interface or from a parallel 8-bit interface. The characters are simply sent to the CTS256-AL2 in ASCII format followed by a space or carriage return character to signify the end of the word and to tell the CTS256-AL2 to send allophone data to the SPO256-AL2 speech synthesis IC to be spoken.

The text-to-speech algorithm built into the CTS256-AL2 was developed by General Instruments following research by the United States Navy. So, the complete circuit talks with an American accent and not with precision of the Queen's English! However, this can be overcome by spelling a few words wrong but phonetically correct.

Text is converted to allophones using the algorithm to look at each letter of the word to be spoken and then letters to the left and right. The combination of these three characters is analysed using a letter context-to-sound table and the appropriate allophone code is then stored ready to be sent to the SPO256-AL2.

This process is repeated for every letter in the word producing a string of codes. However, certain combinations of characters are treated differently to account for some of the words which are the exception to the normal rules of English.

The algorithm also interprets a few characters as being whole words. These characters are %, #, $ and they represent the words, *percent, number, dollars*. The numbers 0 to 9 are also correctly spoken by sending a single digit to the CTS256-AL2.

As each character of the word is received, it is stored in an internal input buffer. Then, when a delimiter such as a space, punctuation mark or carriage return is received, the contents of the input buffer is processed by the IC using the text to speech algorithm. The resulting allophone codes are stored in an output buffer.

If the INT1 input (pin 13) is low, then the first allophone code is output to the SPO256-AL2. The allophone code is output from the IC as part of a 15-bit address. The CTS256-AL2 outputs an address of 2000 (hexadecimal) plus the code number of the allophone. This means that a code is output when A13 is high and A0 to A5 represent the allophone code. The first eight bits of this address A0 to A7 are multiplexed with the microcontroller's data bus and so must be separated from the data bus. An address is present on the multiplexed bus when ALA (pin 38) is low.

Shortly after ALA has gone low the ENABLE signal (pin 39) also goes low to indicate that there is a valid address on the address bus. This process for outputting an allophone code is repeated each time INT1 goes low or until the output buffer is empty.

If either the input buffer or the output buffer become full, data could be lost or, worse still, the program which is running within the CTS256-AL2 can crash. If the input or output buffer does become almost full, the BUSY output changes from low to high, warning that the buffers should be emptied.

The CTS256-AL2 can be initialised by taking the RESET signal (pin 14 IC3) low. This causes all buffers and registers to be cleared followed by execution of the internal program. The program starts by outputting the allophones to speak 'OK'. This is to show the user that the program is ready to accept characters for processing.

PIN 678	MODE	BAUD RATE
000	parallel input	—
001	serial	50
010	serial	110
011	serial	300
100	serial	1200
101	serial	2400
110	serial	4800
111	serial	9600

Table 1 Selecting the data input mode of the CTS256-AL1

Selection of parallel/serial data input mode is performed using pins 6, 7 and 8. These also select the serial input baud rate that will be used by the IC's internal UART according to Table 1.

If parallel data input mode is selected, an external data latch must be provided at address 200 hexadecimal. The data must be loaded into this latch and then a negative going strobe pulse given to the INT3 input (pin 12) to transfer data into the input buffer.

When one of the serial input modes is selected, the serial data at the correct baud rate and at TTL levels is simply applied to pin 16 which is the DATA IN input.

Pin 9 allows for the selection of default or program-selected UART values. For most applications the default UART values should be used. This sets the UART to adopt an asynchronous communication mode with eight data bits and one stop bit and no parity. Default UART values are selected by connecting pin 9 to 0V.

By connecting pin 9 to 5V, various UART modes are possible using programmed values but these must be stored in an external EPROM.

Pin 10 is used to select buffers for input and output that are external to the CTS256-AL2. External buffers can be up to 2K in size, allowing whole pages of text to be sent to the CTS256-AL2 at once. However, an extra RAM IC and address decoding circuitry must be added.

The internal buffers are much smaller (20 bytes for input and 26 bytes for output) but this allows for most English words. However, the host computer must wait while the word is spoken before sending more data or the buffer will overflow causing the BUSY output to go low.

If pin 11 is tied to OV, a carriage return is the only delimiter used to initiate speaking. For this mode the input buffer must be capable of storing a whole line of text input. Since the internal input buffer can only hold 20 characters, this mode is only practical when external buffers are used. So pin 11 is connected to +5V allowing punctuation marks, spaces and carriage returns to initiate speaking.

Other advanced features of the CTS256-AL2 are its ability to run user programs written in TMS7001 assembly language and to allow users to modify the pronunciation of certain words which are not spoken very well, using the text-to-speech algorithm. Both these features, however, require extra circuitry and quite a large amount of software on EPROM.

For more information on the CTS256-AL2 refer to the General Instruments data sheet on the device. Alternatively, some information is given in the 1987 edition of the *Semiconductor Reference Guide* available from Tandy shops.

Construction

The synthesiser can be built with or without its own power supply. The power requirements of the synthesiser are +5V to +15V at 20mA, -5 to -15V at 20mA and a 0V connection. If your computer cannot supply the synthesiser with these voltages and currents then

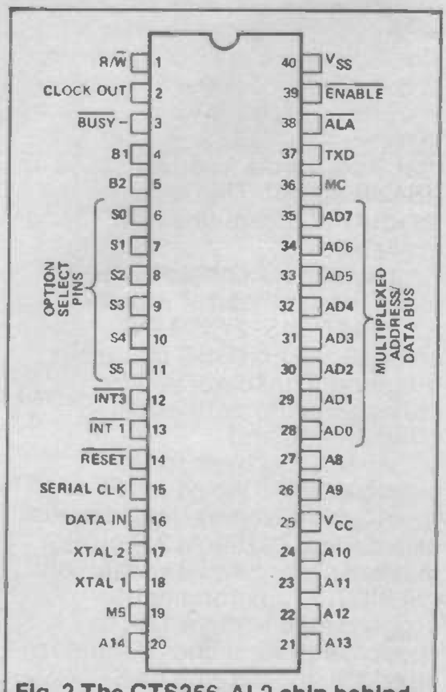


Fig. 2 The CTS256-AL2 chip behind it all

the optional power supply components will have to be added to the unit.

If the computers power supply is to be used then the +5V and 0V connections should be made with wires capable of carrying a current of a few amps (such as 3A 16/0.2mm wire) and should not be too long, to prevent large voltage drops in the 5V supply which could lead to intermittent operation of the circuitry.

The low current positive and negative supplies do not require any special precautions when connecting them but you must ensure that both supplies are well smoothed.

The synthesiser can be connected to the BBC micro using the auxiliary power output on the underside of the micro as shown in Fig. 4.

With other machines (such as IBM PC compatibles) the power supply components will probably be needed as there is no convenient way of obtaining

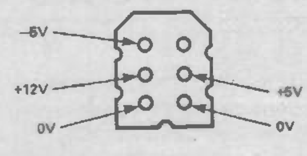


Fig. 4 The BBC micro's auxilliary power socket

power from the micro.

Construction should be started by soldering components onto the PCB according to the component overlay diagram Fig. 5 in the order: wire links, IC sockets, resistors, capacitors, followed by all the semiconductors and XTAL1.

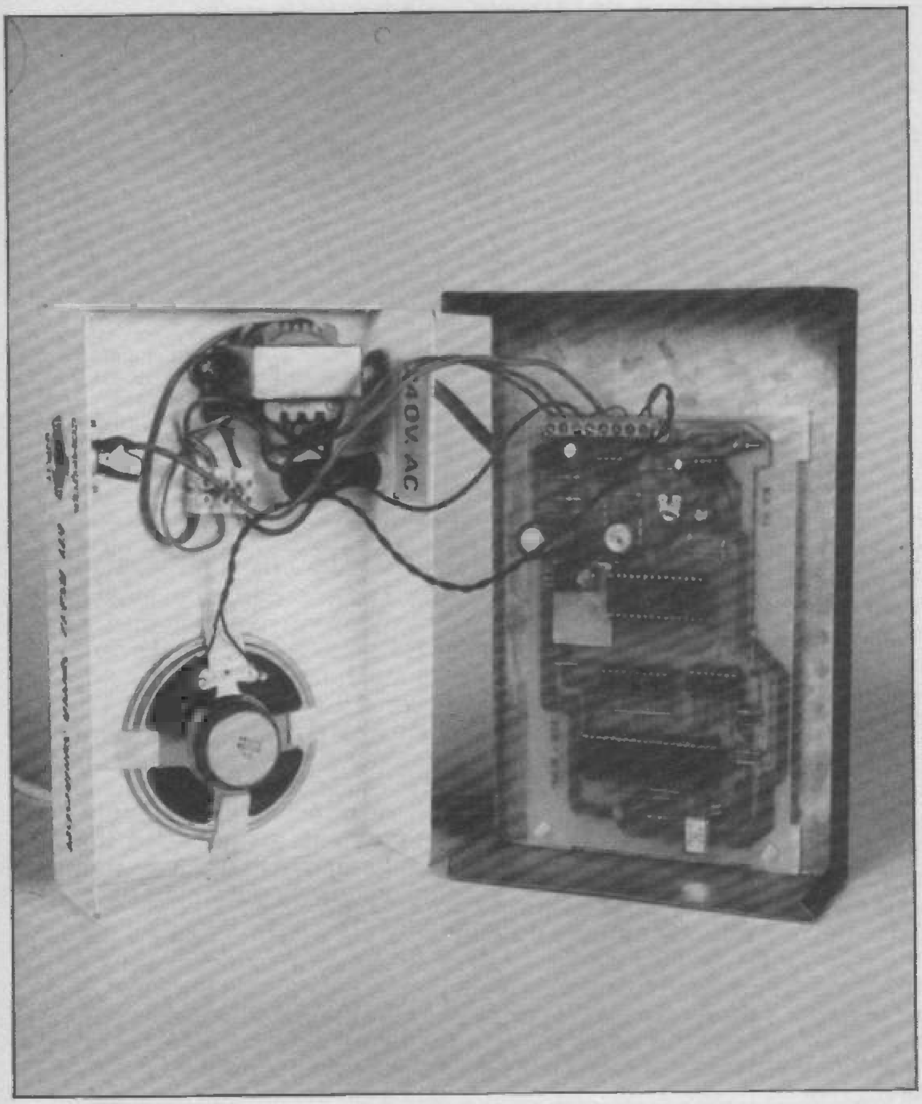
Take special note of the orientation of the electrolytic capacitors, IC1, BR1 and the zener diodes. Care should also be taken when fitting XTAL1 onto the board. The leads to this device should not be cut too short or bent close to the case and the minimum of heat should be used when soldering the crystal to the PCB. Excessive heat can easily cause damage to the crystal.

If the power supply components are used, IC1 will require a small heatsink which can be made from a rectangular piece of aluminium 30 x 20mm. This is then bolted to the PCB and IC1 as shown in the overlay diagram.

The RS232 interface and loudspeaker connections are made with any thin stranded wire that is to hand. The RS232 connections were taken to a chassis mounted 3-pin DIN sockets on the case of the prototype. However, constructors may prefer to terminate the RS232 connectors using another connector to suit the host computer.

If the power supply components are not used, power to the board must come from the host computer and is connected to the points marked A, B, C and D on the overlay as follows:

A -10V (between -5V and -15V)
B +10V (between +5V and +15V)
C 0V
D +5V



After all components and wires have been soldered onto the board it should be cleaned to remove all flux residue, especially around the connections to XTAL1. Do not use solvents that will leave a residue and take care not to contaminate CV1 or RV1.

The board should now be carefully checked for solder blobs bridging tracks, incorrect component orientation and dry joints. If all is well, the ICs can be plugged into their sockets. IC3 and IC5 are MOS devices and should not be handled too much as static electricity can damage them.

After double checking that all components, links and wires have been inserted correctly the board should be ready for testing.

Testing

The initial stages of testing can be carried out without connecting the synthesiser to the host computer's serial interface. Set RV1 to mid position and switch on. It should immediately say 'OK'. If this happens the unit should be turned off and the RS232 connections to the computer can be made. The synthesiser operation can then be tested further by sending a few characters to the board and verifying that they are spoken correctly (see below).

If you have been unlucky and

HOW IT WORKS

The complete circuit is split into two main sections — the optional power supply and the speech synthesis section.

The circuit diagram for the power supply is shown in Fig. 3(a). The mains voltage is stepped down by the transformer T1 to give 24V AC centre tapped. This is full wave rectified by BR1 to give outputs from BR1 of approximately +15.7V and -15.7V with respect to 0V. The positive supply from BR1 is smoothed by C2 and then passed to two voltage regulators.

The first regulator provides the +10V supply needed for the RS232 circuitry and is comprised of R1 and the zener diode ZD2. The second regulator (IC1) is used to provide a stable +5V supply to the synthesiser section of the circuit.

The unregulated negative supply from BR1 is smoothed by capacitor C1 and regulated using R2 and zener ZD1 to provide the -10V supply needed by the RS232 interface.

The circuit diagram of the speech synthesis section is shown in Fig. 3(b).

R3, ZD3 and IC2a provide the necessary attenuation and inversion of the RS232 data input signal. The input at R3 could by any voltage from +30V to -30V and this needs to be converted to the +5V to 0V TTL levels. R3 limits the current flowing through ZD3, which ensures that the voltage input to IC2a is never greater than 4.7V or less than 0V.

The output from IC2a is RS232 data at TTL levels and is fed to the data input of IC3. Although this RS232 interface circuitry is a little unconventional (an MC1489 RS232 receiver IC is usually used) and does not provide a great amount of noise immunity, it has proved reliable in operation with lengths of cable over one metre.

The RS232 compatible WAIT signal from the circuit is generated by the SBY output of IC5. The SBY output is normally high (+5V) but goes low (0V) when the SPO256-AL2 is 'talking'. SBY is connected to the non-inverting input of operational amplifier IC6.

In this configuration IC6 is used as a comparator. The output is +10V when SBY is high (this tells the host computer to send more data) and -10V when SBY is low, telling the host computer to stop sending data as the SPO256-AL2 is talking.

The output of IC6 does incorporate short circuit protection to 0V but can still be damaged if its output is accidently connected to a voltage other than ground which could easily occur when experimenting with connections to the host computer's RS232 port. The inclusion of R10 limits any current flowing in or out of this output and prevents damage to IC6.

The clock for the CTS256-AL2 microcomputer (IC3) is generated using XTAL1 with C4 and C5 providing the capacitive loading required by the crystal. It may be tempting to replace the 10MHz crystal with one of lower cost (6.144MHz). IC3 would then still operate correctly (albeit at lower speed) but the baud rate for RS232 communication would be wrong and so a 10MHz crystal must be used.

Power-on reset for IC3 and IC5 is provided by C7 and R5. A reset condition is also caused if the BUSY output (pin 3, IC3) should go low, indicating that the input buffer is full. This is to prevent the program within IC3 from crashing if the host computer sends too many characters to IC3 before speech has started. R4 limits the current from BUSY into C7.

Decoding of A13 and the ENABLE signals from IC3 are provided by IC2b and IC2c. This circuitry ensure an allophone code is only loaded into IC5 when A13 is high (when an address of &2000 + the allophone code is being output) and the ENABLE output is low, implying that the address is a valid one. When both these conditions are met, the output from IC2c goes low. This negative pulse on the address load (ALD) pin of IC5 causes an allophone code to be loaded and speech to start.

Allophone codes are transferred from IC3 to IC5 via the address latch. This 74LS373 latch separates the first six address lines (A0-A5) from the multiplexed address/data bus (ADO-AD5). A new address is latched onto the outputs of IC4 each time pin 38 of IC3 (ALA) goes low.

The clock generation circuitry used for the SP0256-AL2 (IC5) is a little unusual. A 3.12MHz crystal with loading capacitors is usually used, being connected between pins 27 and 28. However, use of a 3.12MHz crystal does not allow the user to vary the pitch of the speech and can be expensive as 3.12MHz crystals are not common.

The design shown allows the user to vary the pitch of speech by altering the value of CV1 which is part of the resonating circuit formed by L1, C9 and CV1. The resonant frequency of this arrangement is given by the equation:

$$f = \frac{1}{2\pi\, L1 \left(\frac{CV1 + C9}{CV1 \times C9} \right)}$$

This arrangement can often be used when a low cost variable alternative to a quartz crystal is needed.

The speech output from IC5 is in digital pulse width modulated form which is low pass filtered by R8, C10, R9 and C11 to give an analogue voltage across RV1 (used as a volume control). The voltage on the wiper of RV1 is passed via DC blocking capacitor C12 to the input of IC7.

IC7 is an LM386 audio amplifier. Capacitor C18 is used to prevent DC current from flowing through LS1. C15 sets the gain of IC7 to around 46dB. C14, C16 and R11 ensure stability of the amplifier circuit. Capacitor C13 was added to improve the sound quality from a low cost miniature loudspeaker and may not be necessary if a good quality speaker is used.

Power supply decoupling is provided by C6, C8 and C17.

the unit does not reassure you by saying 'OK' then immediately switch off the unit. A good mug of tea or stronger brew is recommended at this point to calm the nerves!

The ICs should be removed from their sockets and the operation of the power supply checked (if used) using a volt meter to check the voltages across C6, ZD2 and ZD3 which should be +5V, +10V and -10V respectively. If these are incorrect, check that all the power supply components have been mounted on the board correctly and make any changes necessary.

Once the power supply is in order check that all the IC sockets have power on the correct pins and then re-check all connections. With the power off, plug the ICs back into their sockets and start testing the unit again. If the unit still does not work then a damaged IC should be suspected, especially if the power supply was faulty.

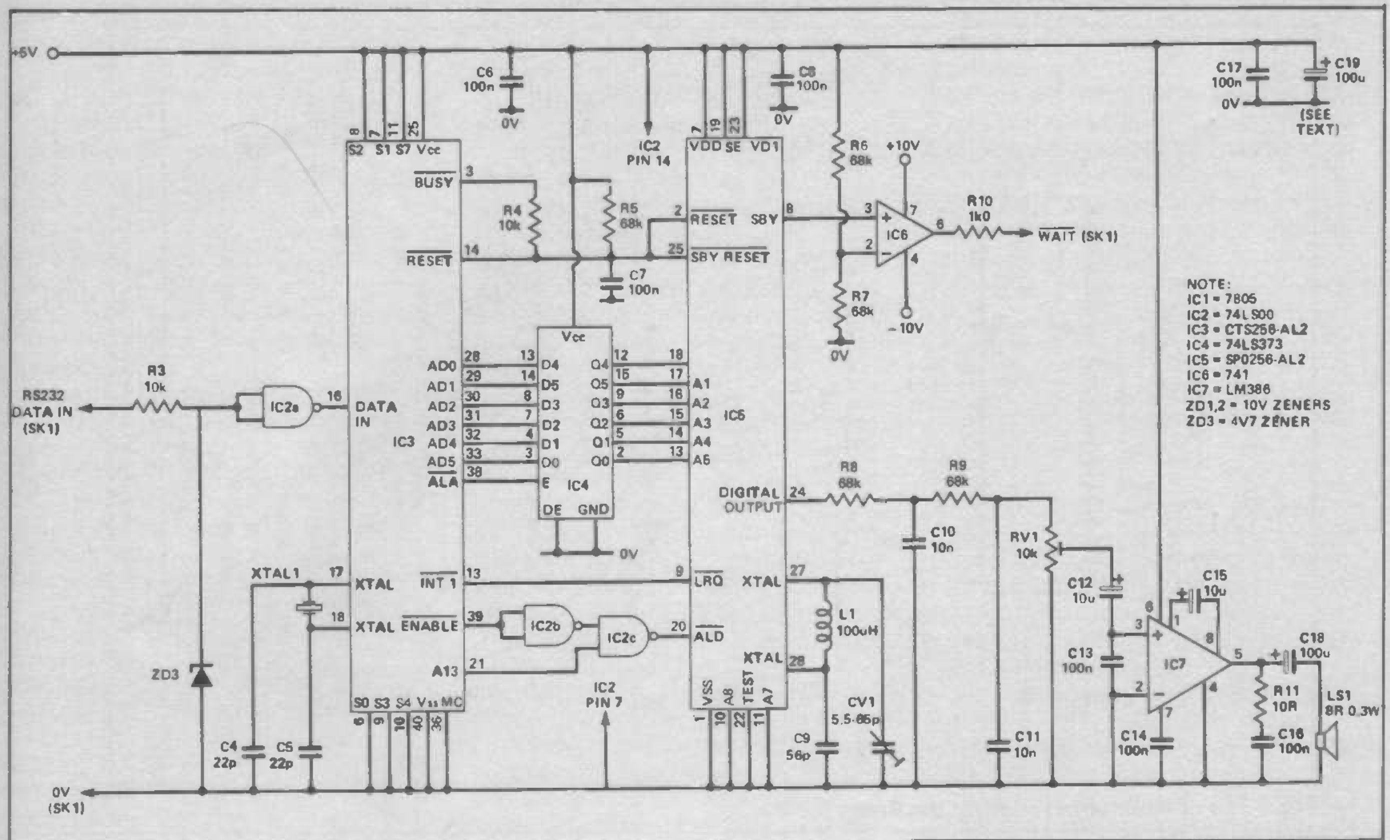
After testing has been completed the pitch of speech and the volume can be set with CV1 and RV1. The board can then be fixed into the box using the four mounting holes on the board. The prototype board was fitted to the lid of the box with self adhesive board mounts with the speaker mounted on the base which was drilled with a series of holes for the speaker. The base of the box was then fitted with adhesive rubber feet.

Using The Synthesiser

The host computer must meet the following requirements:

- RS232 or RS423 serial port
- baud rate set to 300
- serial port configured for eight data bits, one stop bit, no parity
- ability to send text characters to the serial port
- if the optional power supply components are not fitted, the computer must be able to supply the necessary power lines.

The connections to the computer's RS232 port are straightforward but some experimentation may be required to determine whether the WAIT line from the speech synthesiser



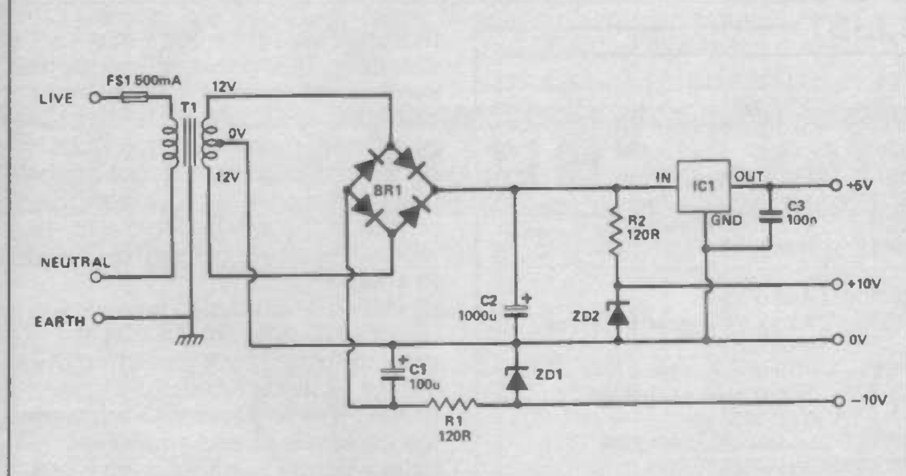


Fig. 3 The circuit diagram of the Smart Talker

should be connected to CTS or DCD and DSR on the host computer.

Details for connection of the synthesiser to the BBC micro's RS423 port are shown in Fig. 6a. Connection is made via a 5-pin 'domino' DIN plug which can unfortunately be inserted either way up. This connector should be inserted with care as plugging it in the wrong way round will prevent the synthesiser from working.

Connection to the Amstrad PC1512 or other PC compatible is made via a 25-pin 'D' socket, details of which are shown in Fig. 6b.

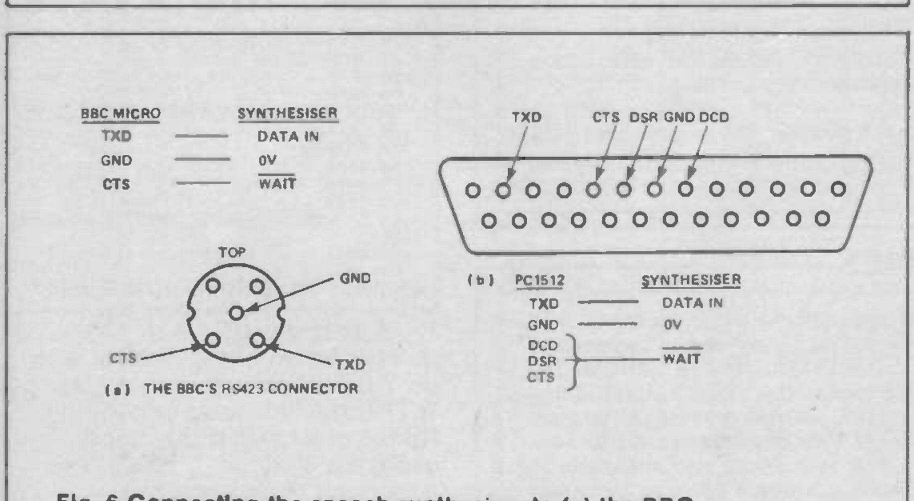


Fig. 6 Connecting the speech synthesiser to (a) the BBC micro and (b) the Amstrad PC1512

Software

Most computers will require very little software to use the synthesiser. The basic functions of the software are to:

- initialise the computer's serial port to transmit at 300 baud with eight data bits, one stop bit and with no parity.
- set the serial port as the output device rather than the screen or parallel printer. This can often be achieved by setting the computer to use a serial printer and then treating the speech synthesiser as a pseudo printer.
- ensure the synthesiser is not overrun with data.

Even with the hand shaking provided, it is still possible to fill the input buffer by sending more

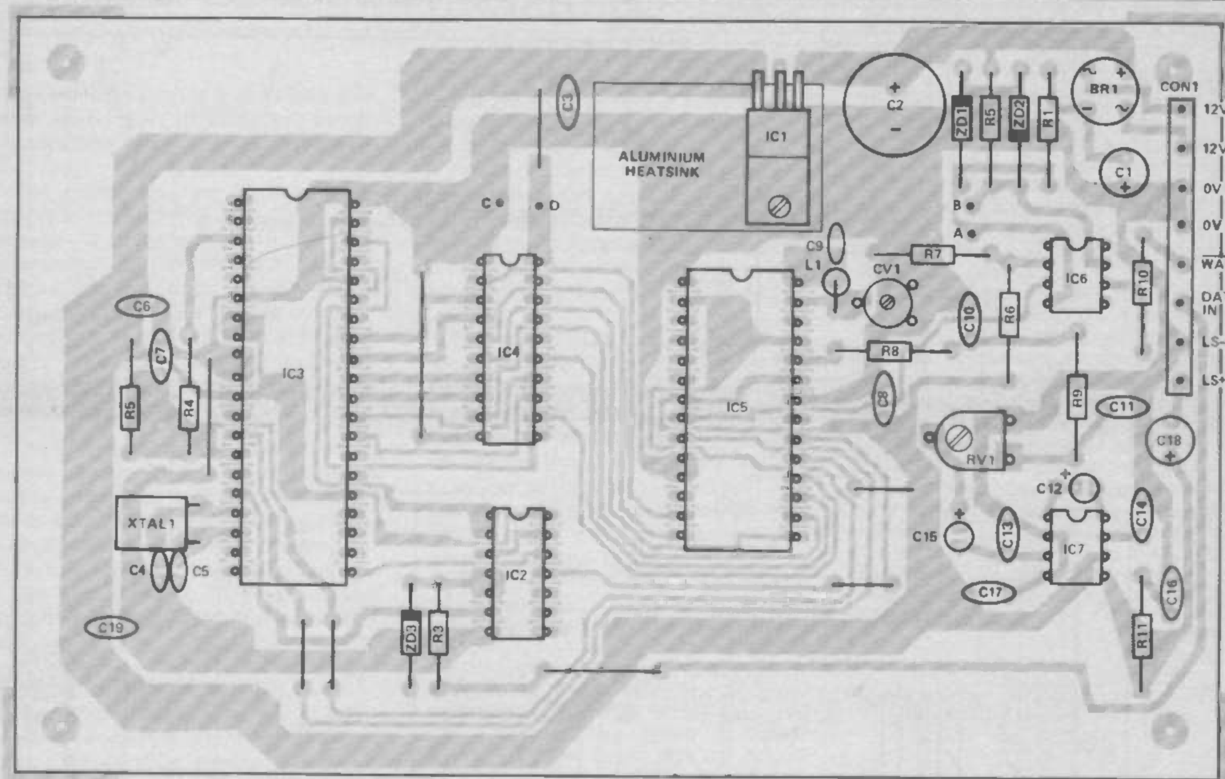


Fig. 5 The component overlay for the Smart Talker

PARTS LIST

RESISTORS (all ¼W 5% unless otherwise stated)

*R1, 2	120R
R3, 4	10k
R5-9	68k
R10	1k0
R11	10R
RV1	10k horizontal preset

CAPACITORS

C1*, 18, 19	100µ 16V radial electrolytic
C2*	1000µ 16V radial electrolytic
C9	56p ceramic
C3*, C6, 8, 13, 14, 16, 17	100n ceramic
C4, 5	22p ceramic
C10, 11	10n ceramic
C12, 15	10µ 16V radial electrolytic
CV1	55-65p trimmer

SEMICONDUCTORS

IC1*	7805
IC2	74LS00
IC3	CTS256-AL2
IC4	74LS373
IC5	SP0256-AL2
IC6	741
IC7	LM386
ZD1*, 2	10V 400mW zener
ZD3	4V7 400mW zener
BR1*	W004

MISCELLANEOUS

CON1	8 way PCB mounted screw terminal
FS1*	500mA quick blow fuse
L1	100µH choke (Siemens B78108S)
LS1	Loudspeaker 8R 0.3W
SK1	3 pin DIN socket
T1*	12-0-12 250mA mains transformer
XTAL1	10MHz crystal

PCB; case; connection wire; RS232 cable; nuts and bolts.

Items marked * are only required if the optional power supply circuitry is to be built.

BUYLINES

The box is available from Maplin (stock number LH38R) as is the transformer (stock number YN16S). The CTS256-AL2 (IC3) should be available from Tandy Stores. However, the author can supply the CTS256-AL2 for £17.00 and the PCB for £8.00.

A complete kit of parts excluding case but including the power supply components and PCB can also be supplied by the author for £40.00. A kit excluding power supply components costs £37.50. Please include 75p postage and packing. Orders should be sent to Russel Vowles, 3 Orchard Waye, Uxbridge, Middlesex, UB8 2BN.

The author will also endeavour to repair any board made to the layout shown for £6.00 plus parts.

than 19 characters without a delimiter. Doing this will cause the synthesiser to reset itself and say 'OK'. If for example, a word of 13 characters is sent and this word is converted to 26 allophones by the text to speech algorithm, the output buffer will be filled and, at worst, this could cause the system to crash.

Users should also be aware that if large amounts of text are sent, there will be times when the output buffer is nearly full. The easiest way to prevent overrun of the buffers is to add small time delays before sending each word to the synthesiser.

```
 10 REM BBC MICRO SPEECH
 20 ON ERROR GOTO 100
 30 *FX8,3
 40 REPEAT
 50 INPUT "ENTER A WORD"; A$
 60 *FX3,7
 70 PRINT A$
 80 *FX3,4
 90 UNTIL FALSE
100 *FX3,4
110 IF ERR<>17 REPORT:PRINT " at line
";ERL
120 END
```

Listing 1 The BBC micro program

A simple program to demonstrate the synthesiser with the BBC micro is shown in Listing 1. The transmit baud rate for the RS423 port is set to 300 baud using the command *FX8,3. The command *FX3,7 tells the computer to send any output from PRINT commands to the RS423 port rather than the screen. Output can be returned to the screen using the command *FX3,4.

When using the synthesiser with the PC1512 it should be noted that different software packages use different hand shaking protocols. For example, MS-DOS has a time-out condition which prevents the use of the synthesiser because it receives its data too slowly. However, DOS Plus is also supplied with the PC1512 and uses the serial port without any time-out condition.

Use of the synthesiser under DOS Plus V1.2 is simplicity itself using the copying command PIP. To use this command, the file PIP-CMD must first be copied from DISK 4 (which was supplied with the computer) onto a bootable formatted DOS Plus work disk.

Execute the NVR program supplied on DISK 3 with the Amstrad and select the *STANDARD RS232 PARAMETERS* option. Set the BAUD RATE to 300, PARITY to NONE, DATA BITS to 8 and STOP BITS to 1. Press escape twice to bring up the EXIT MENU, then press the carriage return key twice to *SAVE THESE ALTERATIONS TO NVR* and *EXIT TO DOS*. The computer must now be re-booted by pressing CTRL, ALT and DEL to ensure that the new RS232 settings are used.

The computer can now send text to the synthesiser using the PIP command on the work disk. Entering the command PIP AUX:=CON: will allow anything typed at the keyboard (console) to be spoken. Small text files can also be spoken using the command PIP AUX: file name. The COPY command can also be used to carry out the above operations but text is sent a line at a time and so the synthesiser more likely to be overrun with data.

The synthesiser can be made more versatile if it is used with the programming language Basic2. When using Basic2 the synthesiser must be used as a pseudo printer. This is achieved by closing the current printer stream and then opening a printer stream as COM1 (the serial port). Any words that would normally be sent to the printer will now be sent to the speech synthesiser instead. The relevant commands are:

CLOSE #0 — closes the current printer stream which is by default stream #0, linked to the parallel printer port.

OPEN #0 PRINT 4 — re-opens #0 as a printer stream. The number 4 tells the computer to link the printer stream to COM1.

LPRINT "any text" — used in the usual way but text will be spoken instead of printed.

```
rem AMSTRAD PC1512 SPEECH
close £0
open £0 print 4
label again
input "ENTER WORD TO BE SPOKEN ";a$
if a$="STOP" or a$="stop" then end
lprint a$
goto again
```

Listing 2 The Basic 2 program

The RS232 parameters must have been set up first with the NVR program as described above. An example Basic2 program is given in Listing 2.

The Speech Synthesiser can also be used with many other languages, operating systems and communications packages. Indeed it can be used with most modern microcomputers and readers are recommended to give it a go.

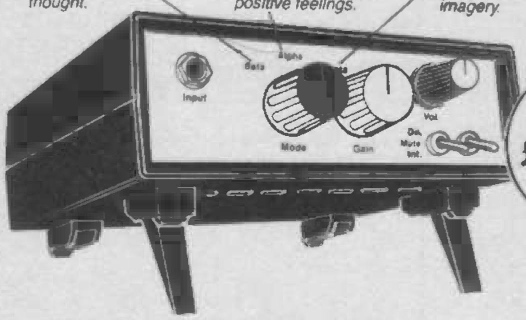
ETI

Brainwave monitor

β BETA – *Concentration, problem solving, active thought.*

α ALPHA – *Relaxation, pleasure, tranquility, positive feelings.*

θ THETA – *Imagination, creativity, hynagogic imagery.*



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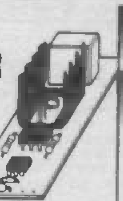

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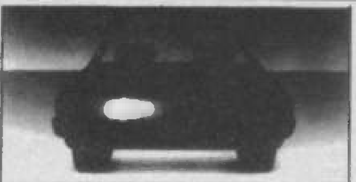

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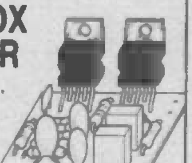

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Two amplifier modules were described, both based on the powerful L165V IC. The single IC version will deliver over 20 Watts with a suitable speaker and power supply. The bridge version can provide up to 50W! Although the specified supply voltage and speaker impedance must be used to achieve maximum power, both modules are quite happy to work from any voltage between 12V and 32V, and will accommodate any type of speaker. The bridge version is ideal for giving a boost to car Hi-Fi systems, driving two 4 Ohm speakers in parallel on each channel for best effect.

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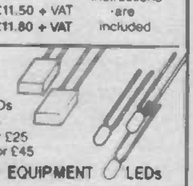

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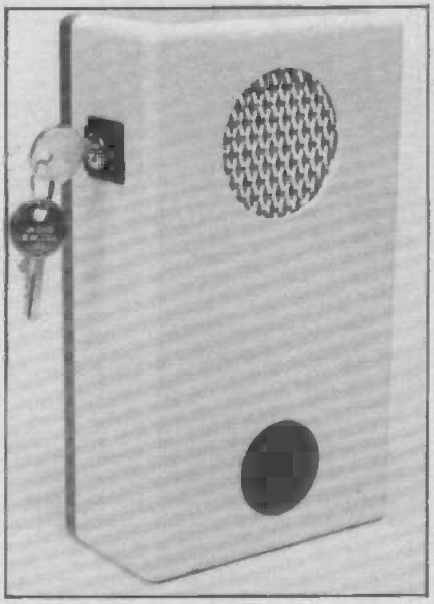


Burglar alarms which rely on an infra-red beam being broken by any intruder are not new and devices of this type must have been in existence for at least 20 years. The same principle has been applied to automatic doors and similar applications and it is now a standard form of 'presence' detection.

Although this unit could be described as an infra-red broken beam detector, it is not of the normal active variety. Those generally have a transmitter which sends a narrow beam of infra-red pulses to a receiver unit. Anyone passing between the two units momentarily cuts the signal to the receiver and triggers the system.

The system described here is a single-ended type which is based on passive infra-red detection techniques. In other words, it detects the body heat of anyone passing through the 'beam' of high sensitivity.

Most passive infra-red detection systems are designed to cover a wide area, generally with the aid of a fresnel lens which gives zones of high and low sensitivity. A different approach has been taken with this design which has an ordinary convex lens ahead of the pyro sensor. It therefore has a very narrow corridor of high sensitivity and in use it is more directly comparable to a broken beam type alarm than a normal passive infra-red detector.

There are both advantages and disadvantages to this type of detector. It offers what is generally a much better range than a wide angle passive detection system but has substantially lower performance in this respect when compared to an active beam system. However, with a maximum range of around 30m it is perfectly adequate for most likely applications and does not require the difficult alignment procedures associated with active systems. A passive beam system is also less prone to problems with spurious triggering as there are no problems with the system slipping slightly out of alignment or moths flying through and breaking the beam!

Compared with an active system there is also the advantage that only a single unit is required. This can greatly ease installation.

As described here the unit is a burglar alarm, complete with switch-on and activation delays, automatic alarm switch-off, and a built-in modulated alarm generator. However, the detector section of the unit can easily be extracted from the design and used as the basis of automatic doors, or whatever.

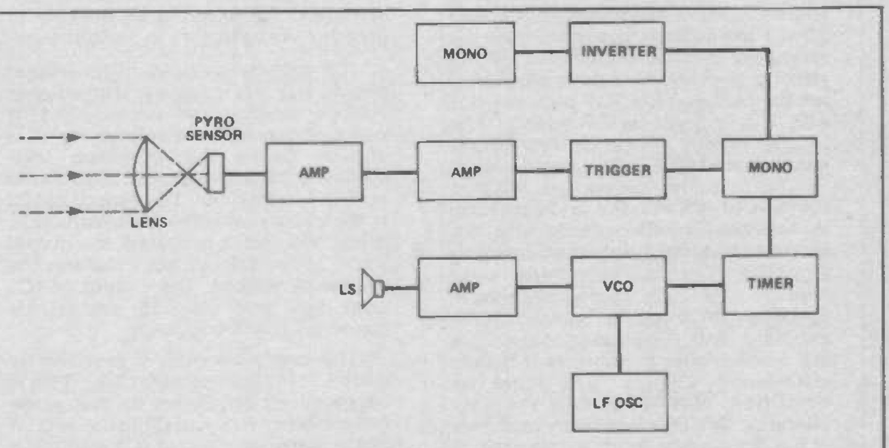


Fig. 1 Block diagram of the alarm system.

The System

The block diagram of Fig. 1 helps to explain the way in which the unit functions. Obviously some means of detecting the infra-red energy radiated by someone passing through the beam is required. Ordinary photo-transistors and the like are completely useless in this application.

Although many semiconductor photo-sensitive devices have peak performance in the infra-red part of the spectrum, this is normally at wavelengths quite close to the visible red part of the spectrum. The actual wavelengths involved are in the region of 0.7 to 1 micron. For effective detection of body heat it is at much longer wavelengths (around 7 to 15 microns) that good sensitivity is required.

This requires the use of special sensors based on ceramic crystal materials that produce a small charge when a change in the infra-red level is detected. An important point to realise when dealing with these devices is that it is a *change*

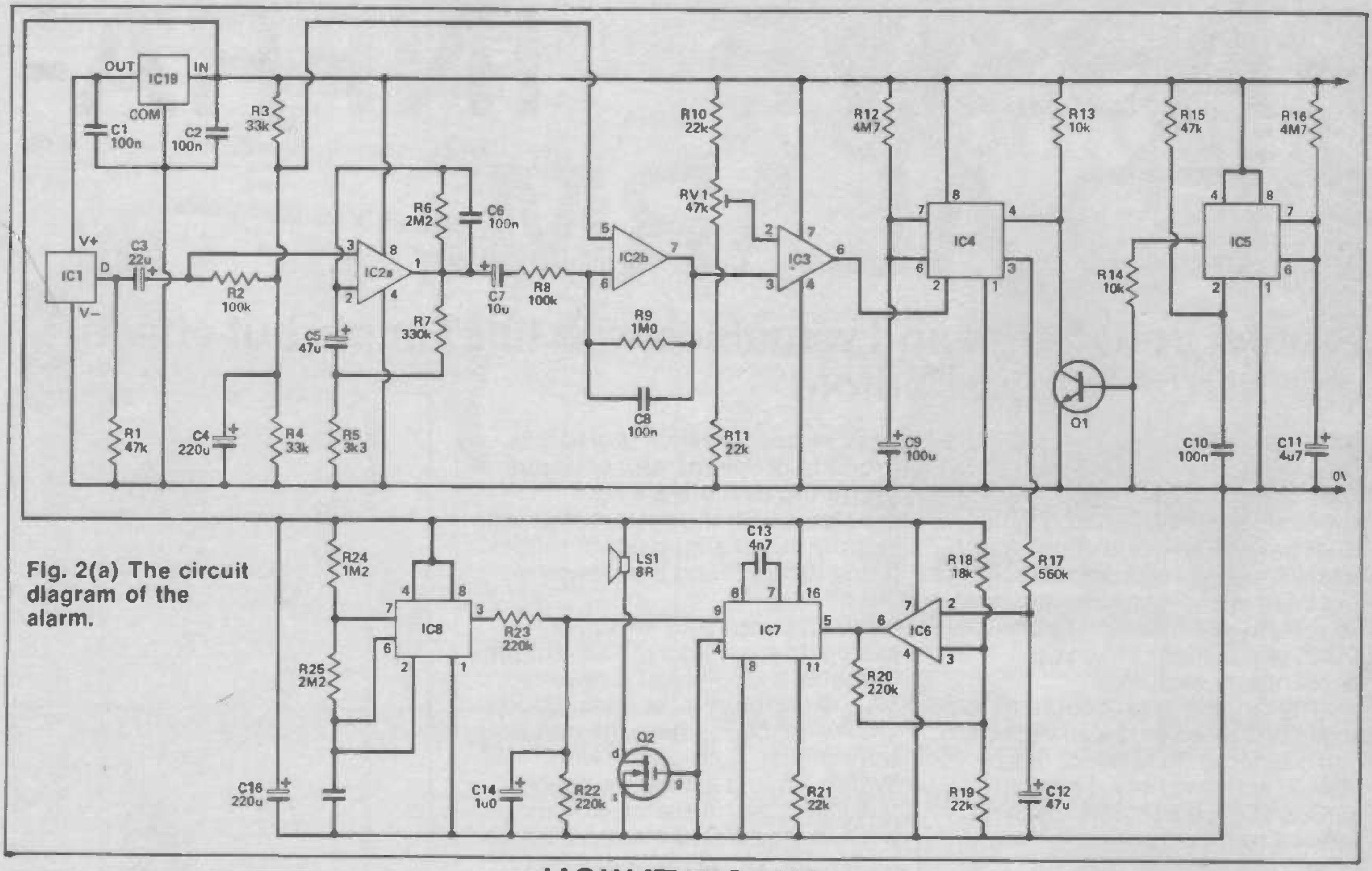


Fig. 2(a) The circuit diagram of the alarm.

HOW IT WORKS

IC1 is the pyro sensor and this is a single element type. In common with other pyro sensors it has a built-in source follower buffer amplifier which gives a low output impedance from the very high source impedance of the sensing element. R1 is the load resistor for the buffer stage. IC9 provides IC1 with a highly stable 5V supply. The supply voltage range for the SSC10 pyro sensor is 2.2 to 10V, incidentally.

The amplifier stages use the two sections of IC2 with the first operating in the non-inverting mode and the second one functioning as an inverting amplifier. The configurations used here are very similar to standard operational amplifier audio types but the coupling and decoupling capacitors are much higher in value as it is only infra-audio signals that must be amplified. C6 and C8 severely attenuate the high frequency response of the circuit, with 'high' in this context meaning frequencies of a few Hz or more!

With passive infra-red detectors the limiting factor on the degree of sensitivity that can be obtained is the noise level of the pyro sensor itself. The gain of the amplifier could easily be increased but it would be unlikely to give any improvement in performance.

IC3 acts as the basis of the trigger circuit, and this is really just an op-amp voltage comparator circuit. RV1 is adjusted to provide a voltage which is slightly below the minimum level achieved by the output of IC2b under standby conditions. The output of IC3 is therefore normally at the high state. When the unit is activated, the output from IC2b briefly goes below the reference voltage, the output of IC3 goes low and the 555 monostable based on IC4 is triggered.

The switch-on delay is provided by a second 555 monostable (IC5). This is triggered at switch-on by the pulse generated by R15 and C10 and via Q1 it holds the reset input of IC4 in the low state. When the pulse from IC5 ceases, the reset input of IC4 goes to the high state and IC4 will then respond to any subsequent triggering.

IC6 provides the alarm activation delay and this is a Schmitt trigger preceded by a basic C-R timing circuit. About 25 seconds from the start of the pulse from IC4 the charge on C12 reaches the trigger voltage and the output of IC6 switches to the low state.

This gates on the VCO which is part of the 4046BE (IC7). The 4046BE is actually a CMOS micro-power phase locked loop but in this circuit only the oscillator section is utilised and the other stages of this component are just ignored.

The modulation is provided by IC8 — a standard 555 astable circuit having an operating frequency of just under 2Hz. Its almost squarewave output is attenuated slightly by R22 and R23 and filtered by C14. This gives an almost triangular modulation signal of a few volts peak to peak, which sweeps the audio tone from the VCO over a wide frequency range. This gives a very effective alarm signal. Q2 is a VMOS power FET which is used to drive the loudspeaker and provides an output power of a few watts.

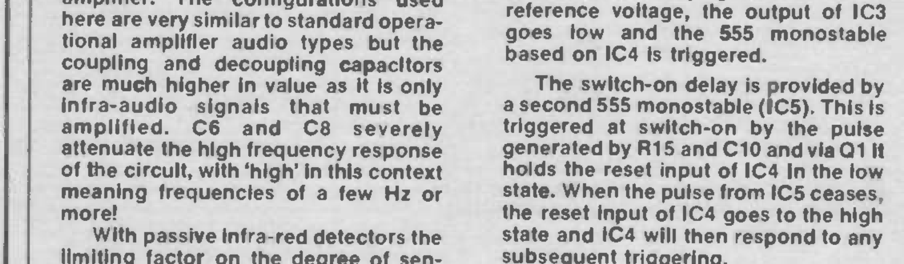


Fig. 2(b) Power supply circuit.

in the infra-red level that is detected and not the absolute level.

An increase in the strength of the received signal produces a larger output voltage but this voltage soon starts to subside, even if the intensity of the signal is maintained. The bandwidth of pyro sensors is usually very restricted, with 0.3-3Hz being typical. However, this is adequate for intruder alarms and similar applications.

To achieve a really good maximum operating range a convex lens must be added ahead of the sensor. This gathers up infra-red radiation over a relatively large area and concentrates it onto the sensing element. This gives an effective boost in gain but makes the system highly directional. This is analogous to a high gain radio aerial, where increased signal strength but also greater directivity are obtained.

The output from the sensor is still quite low — often under one millivolt peak to peak. A great deal of amplification is therefore needed in order to bring the signal up to a usable level and in this case a two stage amplifier is used. This is followed by a trigger circuit which is activated when the output voltage from the second amplifier stage goes below its quiescent level by more than a preset amount.

Anyone passing through the 'beam' of high sensitivity will produce a signal from the sensor that results in the output of the second amplifier varying widely either side of its quiescent level, activating the trigger circuit.

The negative output pulse from the trigger stage is used to activate a monostable multivibrator. This has a long output pulse duration of about ten minutes. It activates the alarm generator via a delay circuit.

The point of driving the alarm generator via a monostable rather than a latch is that an automatic switch-off is obtained after about ten minutes. This ensures that once the alarm has served its purpose it does not cause unnecessary annoyance to your neighbours.

The delay circuit prevents the alarm from being sounded as soon as the unit is activated but only about 25 seconds elapses before the alarm is switched on. This gives someone legitimately entering the premises an opportunity to switch off the unit before the alarm generator is activated.

Although the alarm generator is a fairly simple type, it is nevertheless quite effective. It is based on a VCO (voltage controlled oscillator) that is frequency modulated over a wide range by a low frequency oscillator. A power amplifier stage provides the unit with an output of several watts, which gives a very loud alarm sound when used with any reasonably efficient loudspeaker.

A second monostable controls the first one via an inverter stage. This second monostable is automatically triggered at switch-on and it has an output pulse duration of about 25 seconds. Its purpose is to prevent the unit from being triggered until the person who switches on the alarm has had time to move out of the monitored zone.

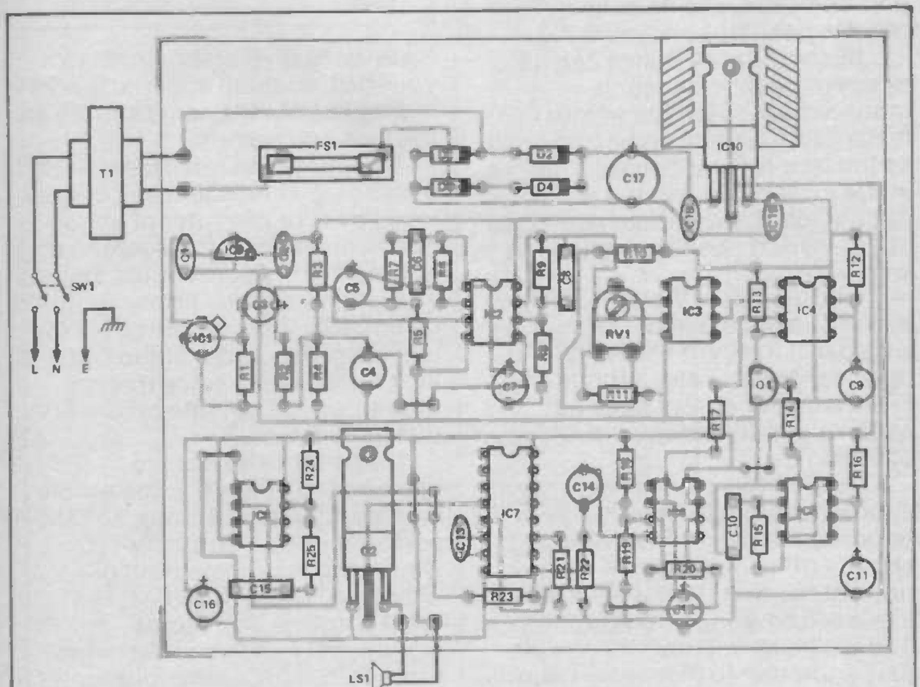


Fig. 3 The component overlay for the alarm PCB.

Construction

Most of the components fit onto a single printed circuit board, including the power supply components apart from SW1 and T1. The component overlay is shown in Fig. 3.

Parts List

RESISTORS (all ¼ watt 5% carbon)

R1, 15	47k
R2	100k
R3, 4	33k
R5	3k3
R6, 25	2M2
R7	330k
R8	180k
R9	1M0
R10, 11, 19, 21	22k
R12, 16	4M7
R13, 14	10k
R17	560k
R18	18k
R20, 22, 23	220k
R24	1M2
RV1	47k sub-min horiz preset

CAPACITORS

C1, 2, 18, 19	100n ceramic
C3	22µ 16V radial electrolytic
C4, C16	220µ 16V radial electrolytic
C5, 12	47µ 16V radial electrolytic
C6, 8, 10,15	100n polyester
C7	10µ 25V radial electrolyte
C9	100µ 16V radial electrolytic
C11	4µ7 63V radial electrolytic
C13	4n7 mylar or ceramic
C14	1µ 63V radial electrolytic
C17	470µ 25V radial electrolytic

SEMICONDUCTORS

IC1	SSC10 pyro sensor
IC2	LF442
IC3	LF441
IC4, 5, 8	NE555P
IC6	CA3130E
IC7	4046BE
IC9	78L05
IC10	7812
Q1	BC549
Q2	VN67AF or similar
D1, 2, 3, 4	1N4002

MISCELLANEOUS

LS1	8R, 8W loudspeaker
FS1	20mm 1A anti-surge fuse
SW1	Mains switch
T1	15 volt, 1A mains transformer

PCB; Case; CE01 lens; small finned heatsink; six 8 pin DIL IC holders; 16 pin DIL IC holder; pair of 20mm fuse-clips; pins; wire; nuts and bolts.

IC6 and IC7 are MOS devices and the usual anti-static handling precautions should be taken when dealing with these components. Q2 is a MOS device but it has an integral zener protection diode that makes special handling precautions unnecessary.

I used a VN67AF for Q2, but similar devices such as the VN46AF and VN66AF are equally suitable.

As Q2 is operated as a switch in this circuit it does not have to dissipate much power but it is advisable to fit it with a small heatsink to ensure safe operation. A small fin made from an odd scrap of aluminium is all that is needed here.

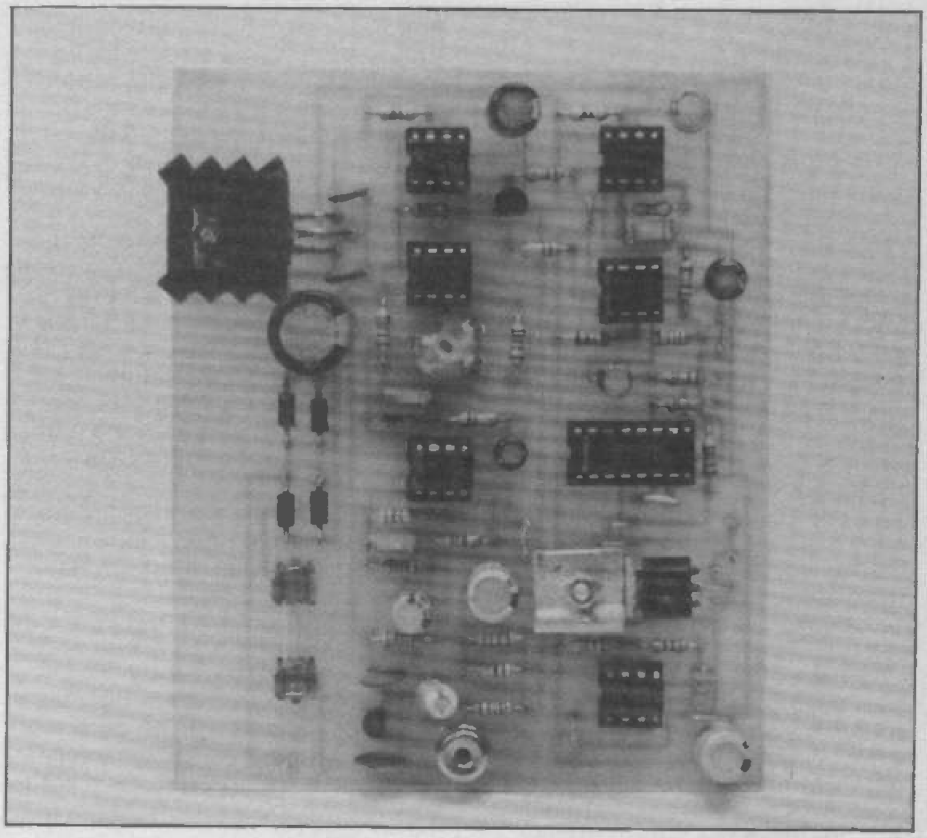
In the power supply circuit IC10 has to dissipate a few watts of power when the unit is activated and it should also be fitted with a small heatsink. It has to dissipate somewhat more power than Q2 and the use of a ready-made finned heatsink is recommended.

It is advisable to use an anti-surge fuse for FS1, as a quick-blow type might be blown by the initial surge of current at switch on as C17 charges up.

If the three timer circuits in the unit are to function properly it is essential that the timing capacitors are good quality types. Superior grade electrolytics are usually satisfactory but tantalum types probably offer the best reliability. Even using good quality components it is not possible to set the various times particularly accurately and they will generally be somewhat longer than the calculated times. This does not really matter here as timing accuracy is obviously of little importance.

The ideal delay times will depend on the extact circumstances under which the unit is used but they can be altered by changing the value of the relevant timing resistor and/or capacitor. The delay times are proportional to the values of both components.

Mechanical construction must be varied to suit the conditions under which the unit will operate. As the unit is mains powered it is essential that the normal safety precautions are observed. The unit must be fitted in a case that has a screw fixing lid or cover, so that there is no easy means of gaining access to the dangerous mains wiring. It is a good idea to insulate any exposed mains wiring anyway and any exposed metalwork must be earthed to the mains earth lead.



For security reasons the unit could be fitted in a really tough case and the on/off switch SW1 should be a key type. The alternative which is preferred by many is to disguise the unit so that the alarm goes off before the unit is discovered.

The only slightly awkward aspect of construction is mounting of the lens. Assuming that the recommended lens is used, the photocell and lens must be in the relative positions shown in Fig. 4.

In some cases things can be easier if the pyro sensor is mounted off-board but in most instances the unit can be arranged so the lens is fixed behind a cutout in the front panel and the printed circuit board is mounted with IC1 in the correct position behind the lens.

It is important that the 30mm distance from the lens to the window in the pyro sensor is reasonably accurate, although a millimetre either way does not seem to greatly reduce the range of the unit.

Getting the window well centred behind the lens is also important. If the pyro sensor is slightly off centre this will not prevent the unit from working but there will be a slight loss of range and the beam will not run perpendicular to the lens. This will make it difficult to aim the finished unit correctly.

If you require some window

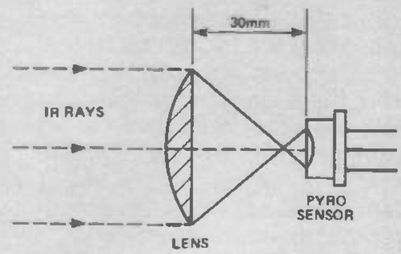


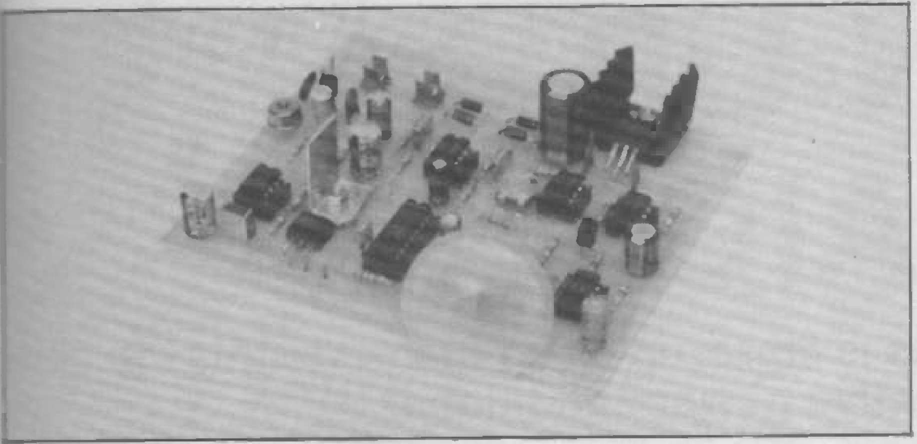
Fig. 4 Positioning the collector lens.

material to give a neat finish to your cell, suitable material is available from the same source as the lens and sensor.

In theory it is not essential to use the CE01 lens and any convex lens having a diameter of about 30mm or so and a focal length of around 25 to 30mm should suffice. The lens to sensor distance should be equal to the focal length of the lens. In practice use of the CE01 lens is advisable, since this is guaranteed to operate properly in this application.

Most other lenses are designed to operate in the visible light part of the spectrum and their performance at long infra-red wavelengths is something of an unknown quantity. At best the focal length is likely to be significantly shifted and at worst there will be little transmission of long infra-red radiation.

I tried a few other lenses in the unit but they all failed to work



properly and did in fact seem to be opaque at the wavelengths involved in this application!

Adjustment

The only adjustment needed before the unit is ready for use is to give RV1 the optimum setting. With this set fully anti-clockwise the unit will probably function reasonably well but with a relatively low maximum range. Advancing RV1 should improve sensitivity but adjusting it too far in a clockwise direction will result in frequent spurious triggering of the unit.

Finding the best setting is really a matter of experimenting a little with various settings. When making these adjustments it is probably best to disconnect the loudspeaker and to use a voltmeter to monitor the output of IC3. This saves your ears from the alarm generator and it also circumvents the delays which would otherwise make adjustment of RV1 a very slow and difficult business.

Remember that the output voltage from IC3 is normally high and goes low momentarily when the unit is activated.

Alarms of this type have reasonable immunity from false alarms but be careful not to position the unit where there are any obvious sources of infra-red that could trigger it. In particular, when used out of doors avoid aiming the unit in the direction of passing cars. These can trigger the unit at more than its 30 metre 'human' range.

Bear in mind that the unit responds most readily to someone passing through the 'beam' at a right angle to it and that the sensitivity is relatively low for someone moving along the beam.

BUYLINES

The majority of the components used in this project are easily available from the usual sources. The Pyro detector and the Infra-red lens are available from Chartland Electronics, PO Box 83, Chobham, Surrey, KT11 2QB.

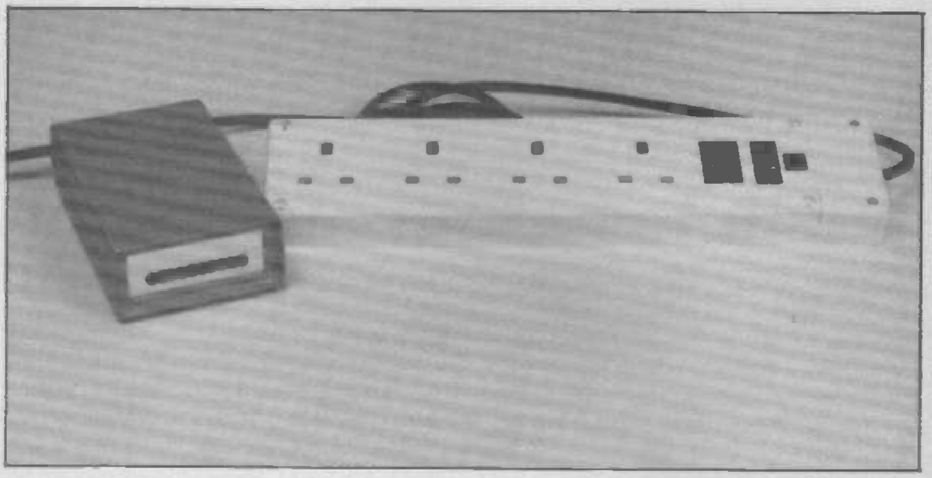
The power supply is a basic stabilised type having a fullwave (bridge) rectifier and stabilisation provided by monolithic voltage regulator IC10. Under standby conditions the current consumption of the circuit is around 35mA but when the alarm generator is activated, the current drain rises to well over 600mA.

CLEAN UP CAMPAIGN

Paul Chappell's mains is close-up clean thanks to this top spec and remarkably attractive power conditioner.

Year by year the pollution of the mains supply grows steadily worse. In addition to the usual industrial effluents from rotating machinery, waste products from switch mode power supplies, sewage from drills, washing machines, vacuum cleaners and oven thermostats, there are now plans afoot to pollute the mains deliberately.

I hardly need to mention the consequences — streaky TV pictures, popping and crackling radios, mushy hi-fi sound. Greenpeace — where are you when we need you?



Mains borne interference is not a thing to be taken lightly. Spikes of 1kV and above are a common (in some areas frequent) occurrence and this can and does damage unprotected equipment. A simple voltage dependent resistor (VDR) connected between live and neutral of the mains plug will usually forestall damage to the equipment but it doesn't prevent the annoying interference effects.

Apart from spikes and impulsive interference, there is a constant background of more regular interference which gets steadily worse as time goes on. RF interference has become more of an annoyance since the CB boom and the increasing use of switch mode power supplies adds its own contribution. The latter are supposed to be suppressed at source but this only serves to reduce the interference and doesn't eliminate it.

Another development has been the increasing use of the mains for signalling purposes. At its lowest level this can be equipment such as cordless

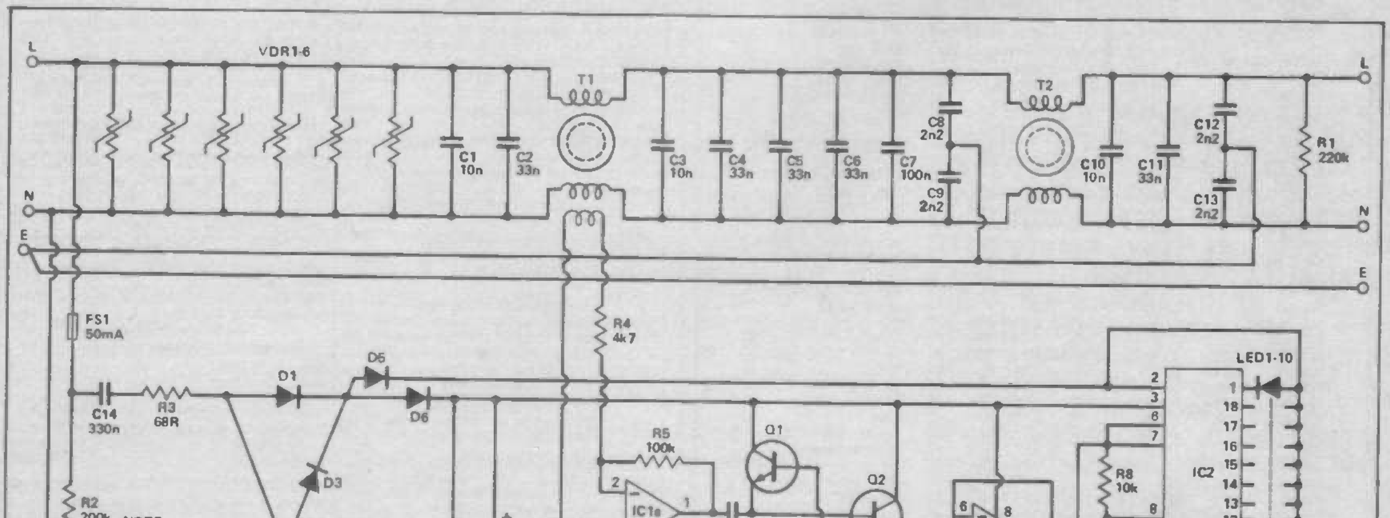


Fig. 1 The circuit diagram of the Power Conditioner.

intercoms but the problems associated with sending digital signals through the mains are rapidly being overcome.

Some years ago National Semiconductors introduced the Bi-Line system, the front end of which was an IC (the LM1893) which puts data through the mains by means of an FSK modulation system. It was, by its nature, for localised use but this and similar systems — even the home computer add-ons for through the mains control — are all adding to mains borne interference.

A system to eliminate gas and electricity meter readers has now reached the stage of field trials. The idea is that meter readings are sent via the mains as far as the nearest sub-station, from where they will be transferred to the telephone lines by means of a modem.

This long distance use of mains signalling obviously can't be suppressed, so a band has already been set aside for it. One can envisage a time when the 'mains waves' will be just as strictly regulated (and just as crowded) as the air waves. The effects on hi-fi and audio equipment have yet to be seen.

In addition to all this man-made interference, there is another source which will always be beyond any kind of legal regulation and control — the weather. Electric storms and even lightning strikes make their presence felt through the mains.

The only way to be sure of an unpolluted power supply for your audio equipment, TV or computer is to clean it up yourself. The ETI power conditioner is the tool you need for the job.

Inside the conditioner the mains supply is purified, transients are cleared and RF interference is blocked. The clean supply is then fed to a socket or multi-way outlet which can supply power to all your sensitive equipment.

If you find it hard to believe that the mains is really as polluted as I say, this project will certainly convince you. A unique feature is its bar graph display which actually lets you see how much interference it is removing.

As you watch the LEDs move and occasionally flick way up towards the top of the scale, you'll be in no doubt that the power conditioner is working for its living.

The Dorchester Doorman

The correct way to avoid any problems with mains connections the gospel goes is to plate all your plugs with gold. The reasoning behind this was explained to me by the proprietor of Hi-Price Audio to be something like this:

The gold plating on the plug acts very much like the uniform of the doorman at the Dorchester Hotel. Nice, well-bred sine waves know that they will be welcome inside, whereas interference is overawed by the golden splendour of the doorman's uniform and embarrassed by its own scruffy appearance. It knows that it will feel out of place in such magnificent equipment and wanders on in search of the electronic equivalent of a Yummy Eater fast food bar.

"Besides," he said, "if punters fink they can hear a difference, am I going to argue?" I was impressed by his logic and bought a dozen.

Of course, back in the real world we have a mains filter which works to consider.

The circuit is shown in Fig. 1. The filter begins with six VDRs. This is partly a concession to the fringe hi-fi community who believe that if one is good, six must be six times as good. For a given spike, the clamping voltage will be reduced by an infinitesimal amount by having a number of VDRs in parallel, due to the highly non-linear voltage to current relationship of these devices.

It's rather like hoping to reduce the forward voltage drop of a diode by wiring half a dozen in parallel. It will be reduced very slightly but not so's you'd notice the difference.

For more rational beings, there is another reason for having half a dozen VDRs.

A VDR will only absorb a certain amount of energy from a spike before becoming stressed beyond its limits. If these limits are exceeded, it can result in the VDR breaking open and scattering zinc oxide far and wide. After that, your equipment is no longer protected.

One of the essential figures on a VDR data sheet is the maximum energy it can absorb in a short period of time. Figures of 5 to 20 Joules in 10μs are common for small components. To increase the energy you have the choice of buying a larger VDR or using several in parallel.

Parallels

The parallel option has the advantage that you can choose how much protection you want to give (an upgradable mains filter!) and that the average absorption over a longer period of time will be

HOW IT WORKS

The filter section begins with six VDRs, which are intended to remove the damaging effects of high energy transients on the mains. To some extent they will reduce impulsive interference effects too but will not eliminate them.

The filter section will remove RF interference from the power lines. The current balanced inductors in combination with the Y-capacitors (C8, 9, 12, 13) serve to clean up common mode interference, while the X-caps (C1-6, 10, 11) do the same for differential mode noise.

The current balancing in the toroids prevents the cores from saturating under the effects of the current drawn by the load.

The pick off coil from the first toroid detects any imbalance caused by interference currents flowing to ground via via the Y-capacitors. The signal is amplified by IC1a and passed to the detector circuit consisting of Q1 and 2 and associated components.

This detector responds to the peak value and to the duration of the signal, so a short, high voltage pulse will give the same reading as a sustained, low amplitude burst.

IC1b feeds the detected voltage to IC2, which is a common or garden bar-graph drive IC.

The LEDs are fed with current pulses from D5 to reduce the overall current consumption of the circuit and dissipation in IC2. The IC is switched to dot mode twice each cycle of the mains (via pin 9) to reduce the current requirements still further.

If you look closely at the display, you might just discern a difference in brightness between the highest dot and the rest of the bar but the overall effect is of a continuous bar display.

The power for the low voltage circuit is derived from the mains via C14. R3 prevents damaging inrush currents if the mains happens to be close to its peak value at the time the circuit is switched on.

R2 provides a discharge path for C14 when the conditioner is disconnected from the mains or if the fuse should blow.

This kind of power supply does not isolate the low voltage circuit from the mains and is only suitable for use in completely self-contained pieces of equipment like the conditioner. The supply capacitor will be large but nowhere near as bulky or heavy as a mains transformer for circuits requiring small currents (up to 100mA or so).

A capacitor used in this way should be X-rated since it is effectively connected across the mains.

greater than for a single large VDR.

It could be that because of an electric storm you get just the conditions to pop a large VDR (and your equipment) but which would allow the parallel combination to continue giving protection. Speaking as one whose new TV set has just been zapped by a thunderstorm which exploded the plug VDR too, the more protection you can give, the better.

For those of you who are not familiar with the characteristics of VDRs, they are rather like AC versions of the zener diode, although the voltage clamping is not so sharp.

Below their rated voltage they are virtually an open circuit. A little above this they begin to conduct until at about twice the rated voltage they have virtually no resistance at all. It may seem that a sharper cut-off would be an advantage but too quick a conduction would lead to blown VDRs every time there was a long term surge in the mains voltage. They are, in fact, very well suited to their job.

The clamping voltage is usually measured at 100A and will be somewhere between 600V and 800V for a device rated for 240V mains operation (which will begin to conduct at about 350V — just above the mains peak). The peak current for even a small VDR will be many hundreds of Amps but this can only be sustained for a few microseconds.

High peak currents for a very short time is exactly what impulsive interference will give.

Capacitor, heal thyself

The main section of the filter consists of a pair of current balanced inductors and banks of capacitors to remove RF interference. A number of capacitors in parallel are used in preference to a single large capacitor to take advantage of the much higher self resonant frequency of the smaller caps and also because they are generally able to withstand short term thermal and voltage overload better than their larger brothers.

The value of the capacitors to earth is limited by the need to comply with earth leakage regulations — they are the maximum allowable values, taking into account their tolerance and should not be increased under any circumstances.

Connecting capacitors across the mains puts them under enormous stress and components not designed for the job can easily catch fire, short circuit, or at best just quietly fail — even if the voltage rating is high enough.

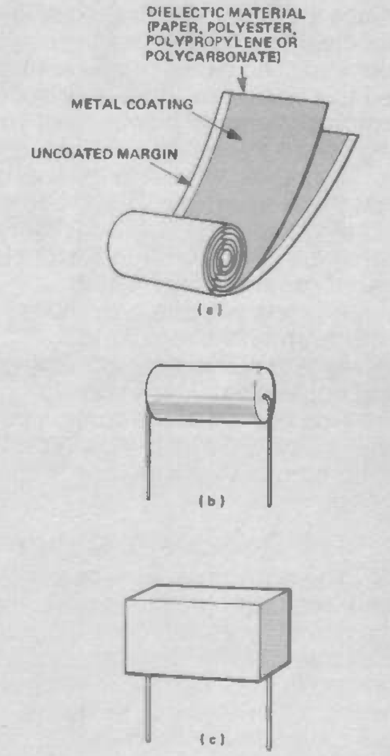


Fig. 2 The basic construction of a metallised film capacitor. (a) The two strips of metallised film are rolled together. (b) The ends of the roll are coated with metal and the leads welded on. (c) Finally the whole assembly is dipped or encapsulated to give the capacitor you buy from your component supplier.

Capacitors which have been designed to withstand the stresses and to comply with the appropriate standards are divided into three main categories:

Class X1 These are for connection between live and neutral in situations where pulses of over 1.2kV can be expected.

Class X2 These are for connection between live and neutral where transients will not exceed 1.2kV.

Class Y These are made to the highest standard of all and are used for connection between a power line and earth or any other situation where failure might expose someone to a lethal shock.

Most capacitors for mains use have the rather magical sounding property of self-healing. This is a consequence of the metallised film construction, the essentials of which are shown in Fig. 2.

The dielectric material is coated with a very thin layer of aluminium — around 300 Angstroms (3×10^{-8} metres) thick. Two dielectric strips will be coated — one with a margin on the left hand side and one with a margin on the right. The two will then be wound together so that the metal film of one 'plate' extends to one side of the roll and the other to the opposite side.

To make the connections, the two sides of the roll are sprayed with metal from a flame or arc gun and the leads attached.

You can see this kind of construction in the 'naked' metallised polyester capacitors — the block shaped ones with metal at either end and leads that fall off at the slightest provocation. These caps are layered in long strips and then sawn up into individual capacitors rather than being individually wound, but the principle is the same.

The difference between class X and Y capacitors and the cheap 'n' cheerful metallised types is mainly in the standard of construction. The mains capacitors may be interleaved with paper (sounds an odd material but it has some excellent properties), be vacuum impregnated with epoxy to remove air pockets where ionisation may take place, be series wound to reduce electrical stresses, have several layers of bonding metal, be encapsulated in fire retardant material and so on. Construction varies from manufacturer to manufacturer.

If the dielectric is punctured by a high voltage spike, instead of short circuiting through the carbonised mess left behind when the dielectric burns, the very thin metallisation is vapourised away from the area and the capacitor carries on as if nothing had happened!

Strictly speaking, the metallisation is oxidised, the oxygen being supplied by the decomposition of the dielectric. The oxide doesn't conduct, so the damaged area is sealed off. It's not quite self-healing but almost as good!

Construction

The component overlay for the project is shown in Fig. 3. Some of the components are mounted vertically to save space — the leads should be bent carefully and not too close to the body of the component to avoid stressing the bonding.

The best way is to hold the lead just above the component body in a pair of pliers, then to bend the lead in a smooth curve with finger and thumb.

The VDR positions have two holes for the 'live' connections, allowing components with either a 0.2in or 0.3in lead pitch to be mounted. Similarly, the capacitor which supplies the low voltage circuit has two pads for one of its connections to allow two popular sizes of capacitor to be mounted. The remaining hole is left unused.

Each coil on the two toroids has 15 turns of 1mm diameter enamelled or the circuit will not work properly. In addition to the power windings, T1 has a further pick-off coil of 15 turns of 0.25mm diameter wire over the centre of the coil in the neutral line. This connects to points A and B on the circuit board. The direction of this winding is not important.

The 1mm diameter wire is firm enough to support the toroids on its own (in fact, you'll need quite strong fingers to wind it into a neat coil) but holes have been provided on the PCB for strapping them down with cable ties, just to be sure.

Figure 4 shows details of the inlet and outlet cables and connections. A 2BA bolt and solder tag is used to earth the metal chassis of the case and to provide a connection point for all the earth wires. Strain relief grommets must be used on the panel cable holes to clamp the leads firmly in place.

The front panel is drilled with a line of holes at 0.2in intervals for the LEDs. I used 3mm round red LEDs in the prototype but there is no reason why you should not use other shapes or colours if you wish. The usual black mounting clips can be used but they will have to be pared slightly with a sharp knife to fit the 0.2in spacing of the holes. Otherwise, you may prefer the appearance of the LEDs without clips.

Whether or not the clips are used, the LEDs should be stuck in place with epoxy resin so there is no possibility of the leads touching the panel or slipping through and becoming exposed.

The low voltage section of the circuit is not isolated from the mains, so for safety purposes must be thought of as being live.

When the LEDs and the inlet and outlet cables have been attached to their respective panels, you can solder the power connections to the PCB. The LEDs are best left unconnected until the case has been assembled, otherwise you won't know how short to trim the leads. Screw the chassis together, with the PCB resting on the bottom flanges of the side pieces. Turn the whole assembly over and check that there is enough clearance between the metal flanges and the pads and tracks of the PCB. Check also for solder blobs, untrimmed leads or any swarf on the flanges that might cause a short between the metal and the PCB tracks.

When you are sure that all is well, fit the chassis into the bottom section of the case and screw the PCB to the support pillars. The LED leads can now be trimmed to size and soldered to the header pins on the PCB.

All that remains is to put in the fuse, screw down the lid of the case, press in the rubber feet and your Power Conditioner is complete!

PARTS LIST

RESISTORS	
R1, 2	220k ½W
R3	68 1W
R4	4k7
R5	100k
R6	47k
R7	10k
R8	27k
CAPACITORS	
C1, 3, 10	10n class X2
C2, 4-6, 11	33n class X2
C7	100n class X2
C8, 9, 12 13	2n2 class Y
C14	330n class X2
C15	2,200µ 16V radial electrolytic
C16	10n ceramic
C17	2µ2 16V electrolytic
C18	2µ2 tant or 10µ electrolytic, 16V
SEMICONDUCTORS	
IC1	LM358
IC2	LM3915
Q1, 2	FS40
D1-6	1N4001
VDR1-6	V250LA2, Mullard 593/4 series, or equivalent
LED1-10	3mm red LED
ZD1	12V 1.3W zener
MISCELLANEOUS	
T1, 2	FX4054 coated toroid cores wound with 1mm and 0.25mm enamelled wire as per the text
FS1	PCB mounting fuse clips and 50mA fuse

PCB; case; 20-way right angle PCB header; mains plug; mains socket or multi-way connector; 0.75mm² mains cable; strain relief grommets; LED clips; nuts and bolts.

Testing

There is very little that could be wrong with the filter section of the circuit except for open or short circuits (you did check the PCB carefully, didn't you?)

Before plugging in, it's best to do a quick resistance check. Set your multimeter to a high resistance range and check the resistance between ground and live on the inlet lead, then between ground and neutral. Both should appear as an open circuit.

If there is any movement of the meter whatsoever, *don't attempt to use the conditioner*. Check the PCB again, check your input lead connections and if both of these seem OK, take out each Y-capacitor in turn and check its resistance. The fault can only be in one or other of these places, so you won't have far to look.

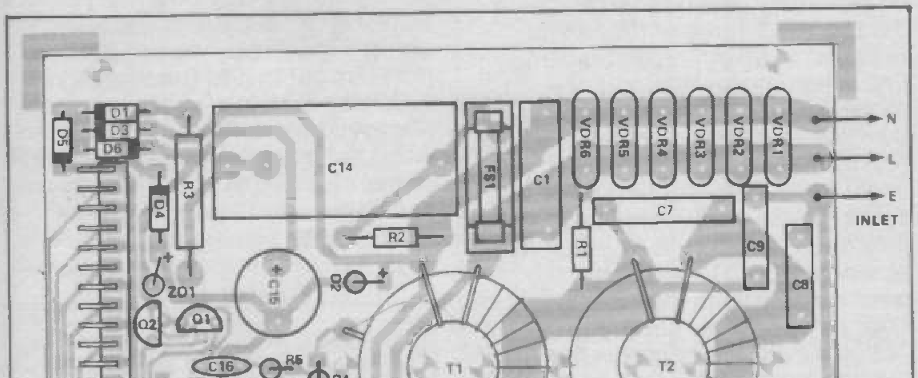


Fig. 3 The component overlay for the project.

A resistance measurement between live and neutral on the inlet or outlet lead should show up a resistance of about 220k — the discharge resistor. If it is much below this (say, below about 180k, which could just be the result of resistor tolerance and meter inaccuracies) take out the fuse to the low voltage circuit and see if this makes any difference.

If not, check the PCB carefully and as a last resort check the resistance of each of the X-capacitors. A final possibility — if you've damaged the coating of the copper wire on the toroid coils and allowed the two coils to touch (I hope not!) this will also cause problems (to say the least!)

If all is well so far, check the continuity of the live, neutral and particularly the earth connections. (Check the resistance between the input earth and output earth and make sure it's zero and so on).

After making sure that there is a suitable fuse in the plug, apply power to the conditioner but don't plug anything into the output socket yet. You should see the LED display flick upwards as you turn on the power, then the LEDs will go out one by one until they are all extinguished. If you keep watching the display for a while, you'll probably see it flick upwards every now and again as the conditioner catches some interference. Even with nothing connected to the output, it still removes pollution and gives an indication of how much there is around.

If all the LEDs light up and remain lit, don't instantly conclude that there's something wrong. Take a look around and see if you can find anything that might be causing a lot of interference.

When I first tested the prototype in the ETI lab, all the LEDs lit up and I spent several minutes puzzling what could be wrong — everything seemed OK. Then the photocopier in the next room stopped printing . . .

Now is the time to find out how good a job you've made of winding the coils. Plug your hi-fi, TV set or whatever into the outlet socket and take another look at the LED display. The sensing circuit will always pick up a certain amount of 50Hz signal from slight imbalances in the inductor and from slight differences in the Y-capacitor values, but it should not be enough to swamp the display.

If most or all of the LEDs remain lit ten seconds or so after plugging something into the output socket, there is a good chance that you have one turn too many or too few on one of the coils.

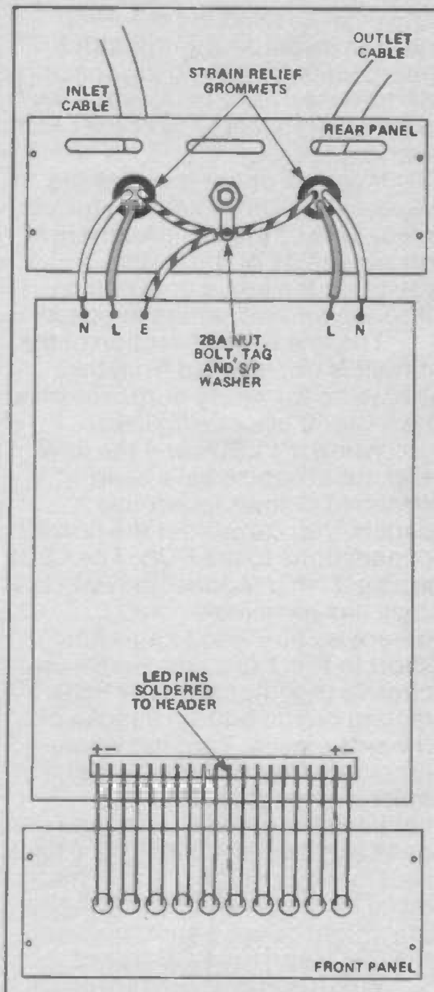


Fig. 4 The front and rear panels and connections to the PCB.

If one or two LEDs remain constantly lit, you can improve matters by adjusting the coils (or re-winding them if they're untidy!) or as an absolute desperation measure the value of R5 can be reduced to bring the display into line. The heavier the load, the more apparent any imbalances will be — an electric fire makes a good test load.

If the display section does not seem to be working properly, don't attempt to test it with its capacitor power supply. Remove all connections from the mains, set your bench power supply to about 16V, connect the negative lead to the negative lead of C15 and the positive lead to the junction of C14 and R3. Connect the negative lead of the multimeter to the negative terminal of your power supply.

Check the voltages on pins 9 and 3 of IC2. Both should be 12V (or within 1V either way). If both are higher, ZD1 is probably faulty. If only one is higher, check D5 or D6. If either or both are low, disconnect the power and check all the diodes (in particular, check they are the right way around). Also check C15 and C18 and the PCB for shorts.

If the readings are OK so far, check the voltage at pins 6 and 7 of IC2 and pins 1, 2 and 3 of IC1. They should all be the same at about 6V. Touching a finger to pin 2 of IC1a should cause all the LEDs to light. Remove the finger and they should turn off one by one.

If this works but the display doesn't seem to pick up anything from the mains, check R4 and the connections to the pick-off coil.

If nothing happens at all, measure the voltage at the positive plate of C17 and see if it rises when you touch the IC pin. If not, check for a short in C17 (or a solder blob across its pads!) and the connections of Q1, Q2 and C16.

If the voltage across C17 rises, but the LEDs don't light, check the voltage at pin 5 of IC2. This should also rise. If not, IC1 is faulty. If it does rise but the LEDs don't light, check all the connections around IC2 and replace it if necessary. If the voltage across C17 remains high at all times (without the finger), suspect Q1, Q2 or C16.

Using The Conditioner

In the form presented so far, the Power Conditioner can be used with loads of up to 1.5kW. It will, in fact, cope with loads of 2kW intermittently — I tested the prototype by running it for an hour with a 2kW electric fire as a load. It didn't come to any harm but it did get rather hot!

Most domestic equipment will have a label or tag on it somewhere to say how much power it consumes. If you are using a multi-way output socket, don't forget to add the loading of all the equipment you have plugged into it.

As a very rough guide, a TV set consumes 100 to 150W, a 100W per channel hi-fi will consume about 300W with the volume

BUYLINES

The case is available from West Hyde Developments, toroids and X- and Y-rated capacitors from Farnell. The PCB can be obtained from our PCB service and other components from your usual supplier.

The plug, socket and mains cable is available from Woolies or from your local electrical shop.

A complete parts set for this project, including case, PCB, components, (but not the mains plug, socket and cable) is available for £28.50 + 60p postage + VAT from Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent.

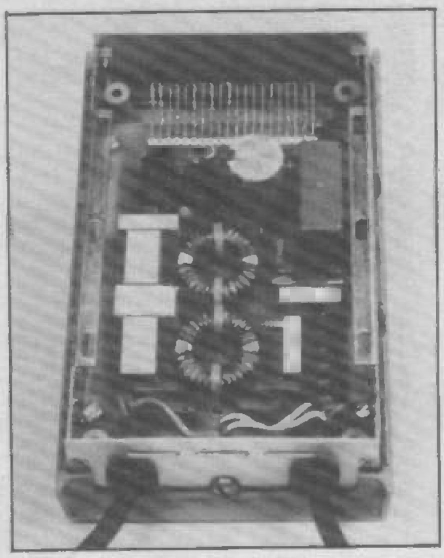
turned up to full blast, a home computer may be anywhere between 10W and 250W depending on whether it has its own screen, disc drives, or whatever.

It is also important to use mains cable that is suited to the load. To be on the safe side, you could wire the conditioner up immediately with 13A cable but it's wasted if you're only running small, sensitive devices.

The normal 0.5mm² mains flex will cope with loads of up to 750W total. The thicker 0.75mm² cable will be OK up to 1.5kW, so this is probably the best compromise.

Unless you intend to load it to the limit, a 5A fuse in the inlet plug is advisable. If you are in doubt about any of this, your local electric shop will probably have an electrician who can advise you.

The conditioner will cope with all likely loads as it is (you don't really want to decontaminate the power to your electric fire, do you?) However, there are always one or two big-number enthusiasts who want to upgrade to the limit.



The way to do it is simply to use thicker wire to wind the toroids. You'll be faced with the option of using fewer turns (which is OK as long as all the coils have the same number, although lower frequency performance will be impaired) or of overlapping the turns slightly. I wish you luck!

If you do have an application for the higher current version, it would be advisable to solder some thick copper wire along the main current carrying tracks (the wide ones) on the PCB.

Unless you can find a way of winding the coils evenly, or are willing to accept fewer turns, you will probably find the bar graph registering 50Hz pick up. Reducing the value of R5 will prevent it from swamping the display, which will then be less sensitive but should still give a good indication of the suppression.

There is no lower limit to the value of R5 — it's up to you to choose a suitable compromise between rejection of unwanted pick up and display sensitivity.

In areas of high RF interference, it is a good idea to keep all leads *after* the conditioner as short as possible. Use the inlet lead to give you the reach you need, then keep the outlet leads trimmed short. Most of the time this will not be critical but it's worth bearing in mind if you live next door to a CB enthusiast. Twelve-ten till we do it again, good buddies. **ETI**

RGB AUTO-DISSOLVE

Brighten your home with a kaleidoscope of colours from this novel lighting display from M P Horsey

The Auto Dissolve enables three coloured lights (or three sets of lights) to fade up and down in sequence, creating a wide variety of effects. When directed towards a white surface, the three colours — normally red, blue and green — mix to produce varying shades from green to cyan, blue, magenta, red, orange, yellow and back to green.

Four potentiometers and three presets are provided to set up the desired sequence and Fig. 1 shows the particularly pleasing effect achieved by placing a red light in channel 1, blue in channel 2 and green in channel 3 and by setting the controls as described later.

The unit is ideally suited to projecting on to a white ceiling and could be placed behind a piece of furniture with the light spilling up the wall. Alternatively it could be used with the spotlamps pointing towards the room, in which case an alternative choice of colours and settings could be tried.

Each channel is more than capable of handing the current required by a single spotlamp and the project will drive three sets of spotlamps if required.

The values in the circuit are calculated to produce quite a slow transition from one colour to another and the unit is at its most effective at slow settings.

The RGB Auto Dissolve relies on a thyristor dimmer controlling the light output of each of the three channels. The lamps are run on rectified mains at 240V DC to simplify the design and to use just one thyristor for each channel. These are controlled by separate triangular waveforms produced from and synchronised by a free-running oscillator (see Fig. 2).

The ramps for the red and blue channels are largely in phase but produce different rates of increase and decrease in brightness. The green channel in out of phase with

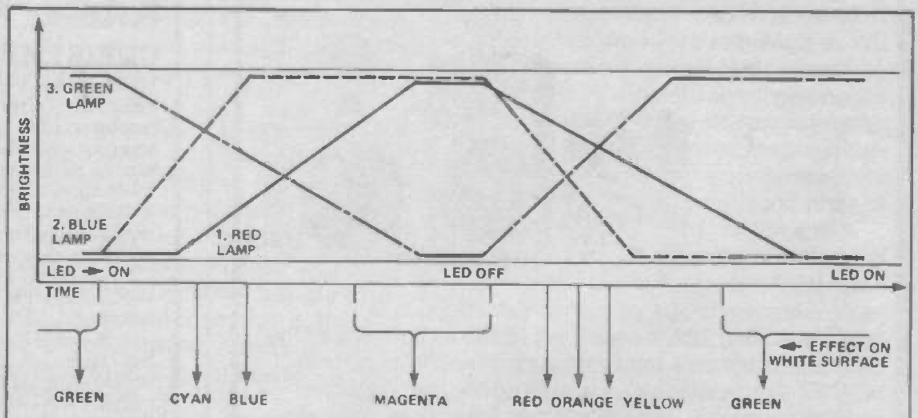


Fig. 1 The colour combinations produced by the RGB Auto-dissolve

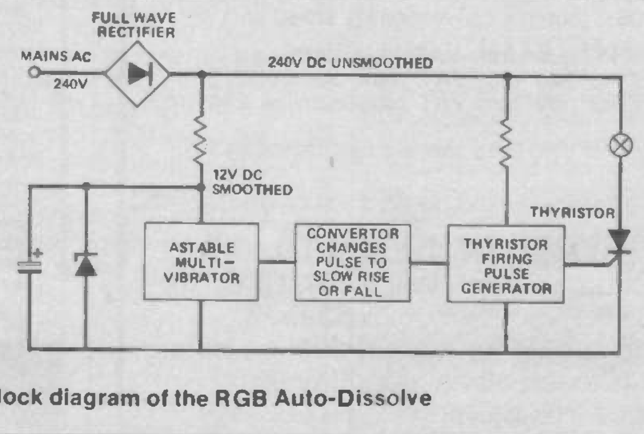


Fig. 2 Block diagram of the RGB Auto-Dissolve

HOW IT WORKS

The circuit operates at two DC voltage levels — 240V for the mains coloured spot lamps and 12V for IC1 and the thyristor firing pulse circuits.

The AC mains enters via SW1, and fuse FS1, to full wave rectifying diodes D1 to D4.

The 12V power supply is derived via resistor R7 and zener diode ZD1. This diode maintains exactly 12V across smoothing capacitor C1 providing a smooth supply for IC1 and associated components.

The triggering circuit from RV5 onwards is best considered separately. It acts like a high quality manual dimmer circuit, with preset RV5 controlling the brightness of channel 1, RV6 for channel 2 and RV7 for channel 3.

This part of the circuit must be synchronised with the unsmoothed DC supply and this is achieved with transistors Q1 and Q3.

Resistors R2 and R1 form a potential divider so the voltage at the base of Q1 causes it to switch on at all times except when the 240V DC supply is at 0V.

So, the base of Q3 falls to zero whenever the 240V DC supply is not at zero, with the result that the presets and resistors R14, 16 18 are all connected to the 12V supply for a mains half cycle (See Fig. 4).

During this half cycle, current flows via preset RV5 and will charge capacitor C6. At a certain voltage the unijunction transistor Q4 will deliver a pulse from C6, via R20 to the gate of thyristor SCR1.

The point in each mains half cycle where this pulse will occur is determined by the rate at which C6 charges and so by the setting of RV5. RV5 acts like a manual dimmer control, able to control the brightness of lamp LP1 from zero to virtually full power. Channels 2 and 3 work in a similar way.

In this circuit, RV5-7, are set to provide a low brightness level. Additional current flowing via diodes D7, 8 and 9 is used to charge capacitors C6-8 providing automatic control.

IC1 is the CMOS version of the NE555 timer IC and is wired as an oscillator. Output pin 3 changes state at an interval set by the values of resistor R3, variable resistor RV1 and capacitor C2.

The values chosen enable RV1 to select a time from a few seconds to several minutes. The IC is wired to produce an equal mark/space ratio. To achieve this, discharge pin 7 is ignored, and the resistor chain R3 and RV1 is connected to pin 3.

An LED is provided to monitor the output. This is useful when setting up and testing. As the supply current via R7 is limited, the value of R4 is calculated to pass a current of about 3mA. A standard red LED will operate on this rather low current but for best results a low current LED should be used.

So, the voltage at pin 3 of IC1 is switching between nearly zero and nearly 12V, at a rate determined by the setting of RV1. With output pin 3 at nearly zero volts, capacitors C3 and C4 will be fully discharged and no current will flow via diodes D7 or D8 so the lamps LP2 and LP3 will be at a low level determined by RV5 and RV6.

When output pin 3 goes high, current will flow via R5 and RV2, charging C3. As C3 charges, current will flow via R10 and D7 causing C6 to charge earlier in each mains half cycle and lamp LP2 to increase in brightness. The rate at which C3 charges is determined by the setting of variable resistor RV2. Channel 2 works in the same way, except that the value of C4 is half that of C3 and it will tend to charge more quickly. When output pin 3 goes low again, C3 and C4 will slowly discharge, causing the lamps LP2 and LP3 to fade.

When pin 3 goes high, channel 2 fades up first, followed by channel 1. When pin 3 goes low, channel 2 fades down first, again followed by channel 1.

Channel 3 works in reverse with transistor Q2 inverting the output at pin 3. With pin 3 low, Q2 will be switched off, and current will flow via resistor R8, RV4 and D6, to charge capacitor C5. As C5 charges, the current flowing via D9 will charge C8 more quickly and Q6 will fire SCR3 earlier in each half cycle.

When output pin 3 goes high, transistor Q2 turns on and the voltage at its collector falls to nearly zero. Capacitor C5 therefore discharges slowly, and lamp LP3 falls in brightness.

D5 is wired in parallel with R9 to allow C5 to charge more quickly than it discharges. This produces a more pleasing colour mixing effect. The value of R9 is chosen to match a slower range of settings of the circuit. If a higher speed is required R9 should be reduced in value, otherwise lamp LP3 will not have time to fade down properly.

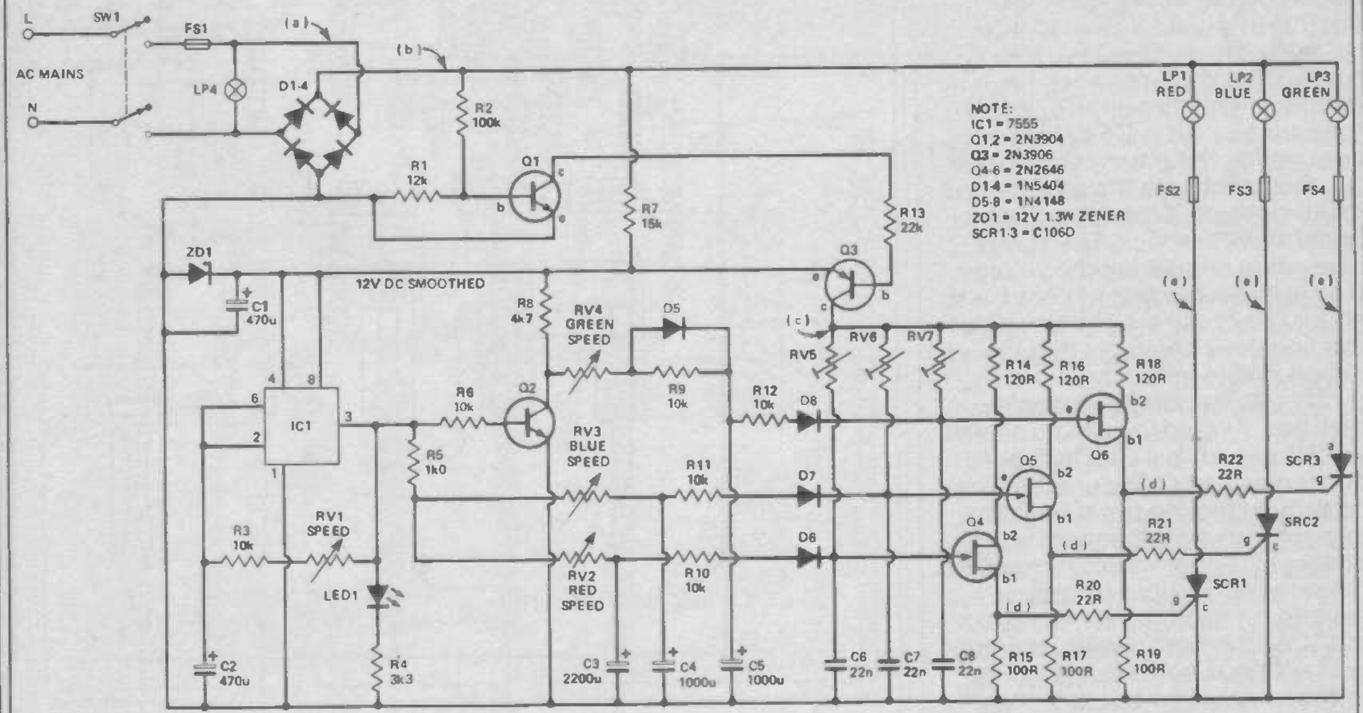


Fig. 3 The circuit diagram

the other two.

The power supply for the whole unit is derived directly from the rectified mains and requires no transformer.

Construction

The circuit is constructed with the majority of components on one printed circuit board and the overlay is shown in Fig. 5. Note that resistor R7 is rated at about 10W. If this type proves difficult to obtain, lower wattage types may be connected in series to make up the total required value. For

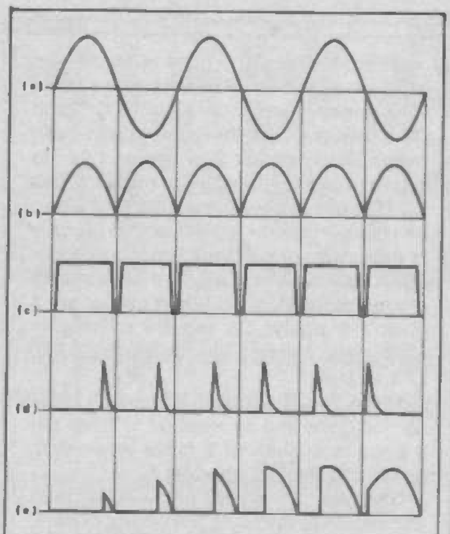


Fig. 4 Voltages at points on the circuit diagram. (a) 240V AC mains supply. (b) 240V DC full wave rectified mains. (c) The collector of Q3. (d) Trigger pulses to the gates of the thyristors (increasing in brightness). (e) The supply to a lamp (increasing in brightness)

example, three 3W 4k7 resistors wired in series will achieve the same effect as the resistor specified. Resistor R2 should be a 1W type.

Failure to connect zenner diode D5 properly will cause the low voltage supply rail to rise to a dangerous level. A precaution against this type of mishap is to solder in the diodes D1-4, the fuses, R7 and D5 and then to connect the mains supply to test the voltage across D5 before connecting the other components.

Note that both the positive and 'zero' sides of D5 can provide a lethal electric shock. Take great care when measuring the voltage. If all is well a reading of about 12V should be obtained. However, this reading does not imply that the circuit is safe to touch.

The other components may now be soldered in, using a socket for IC1 (which is a CMOS type to conserve power). Ensure that the polarity of the diodes, transistors and electrolytic capacitors is observed. The thyristors should be mounted vertically. No heat sinking is necessary for lamps up to 100W. If more powerful lighting sets are used, some heat sinking may be necessary but note that the metal tabs on the thyristors are live.

Complete the external connections to the potentiometers, switch and so forth and plug IC1 into its socket the correct way round.

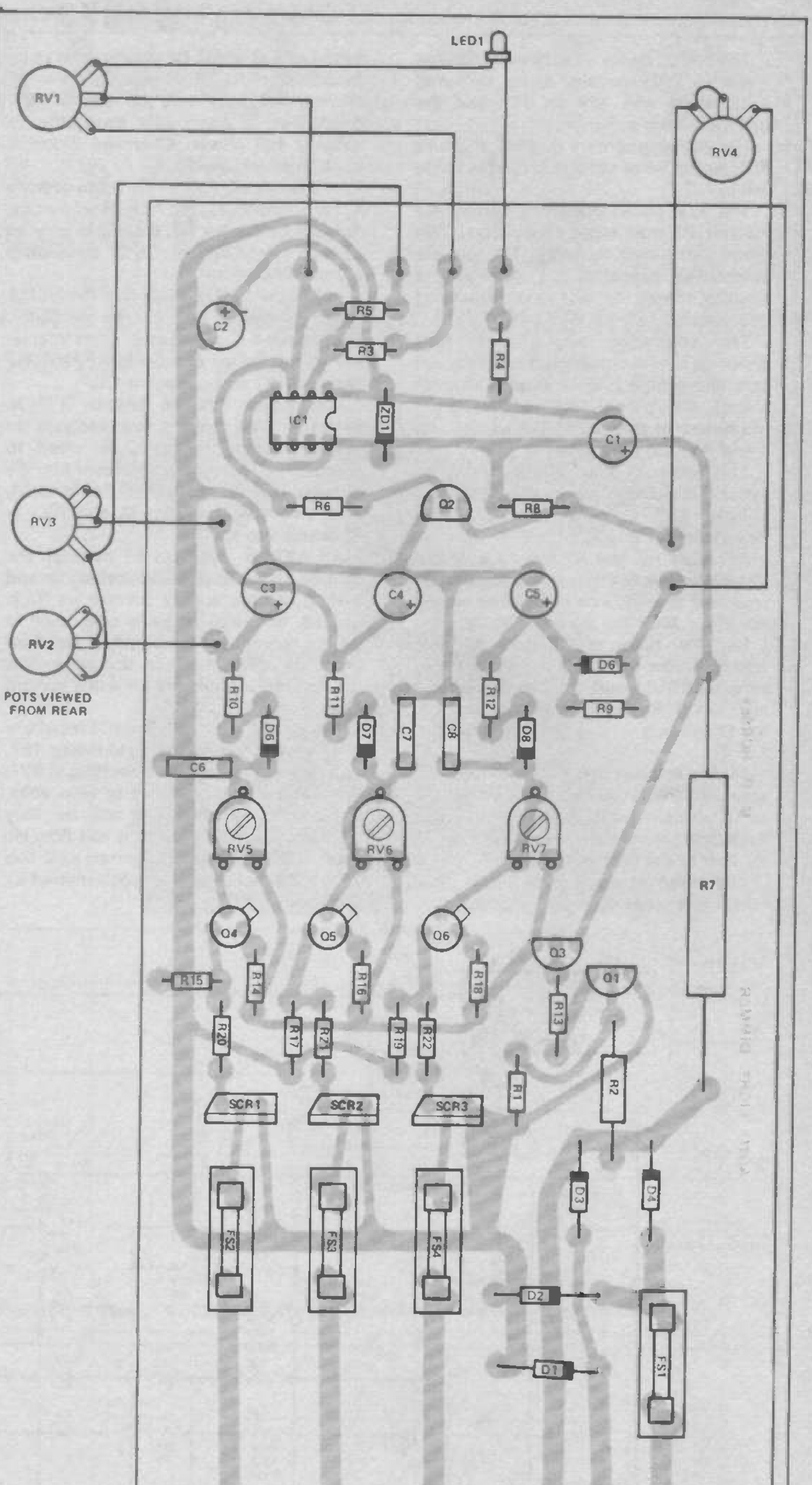
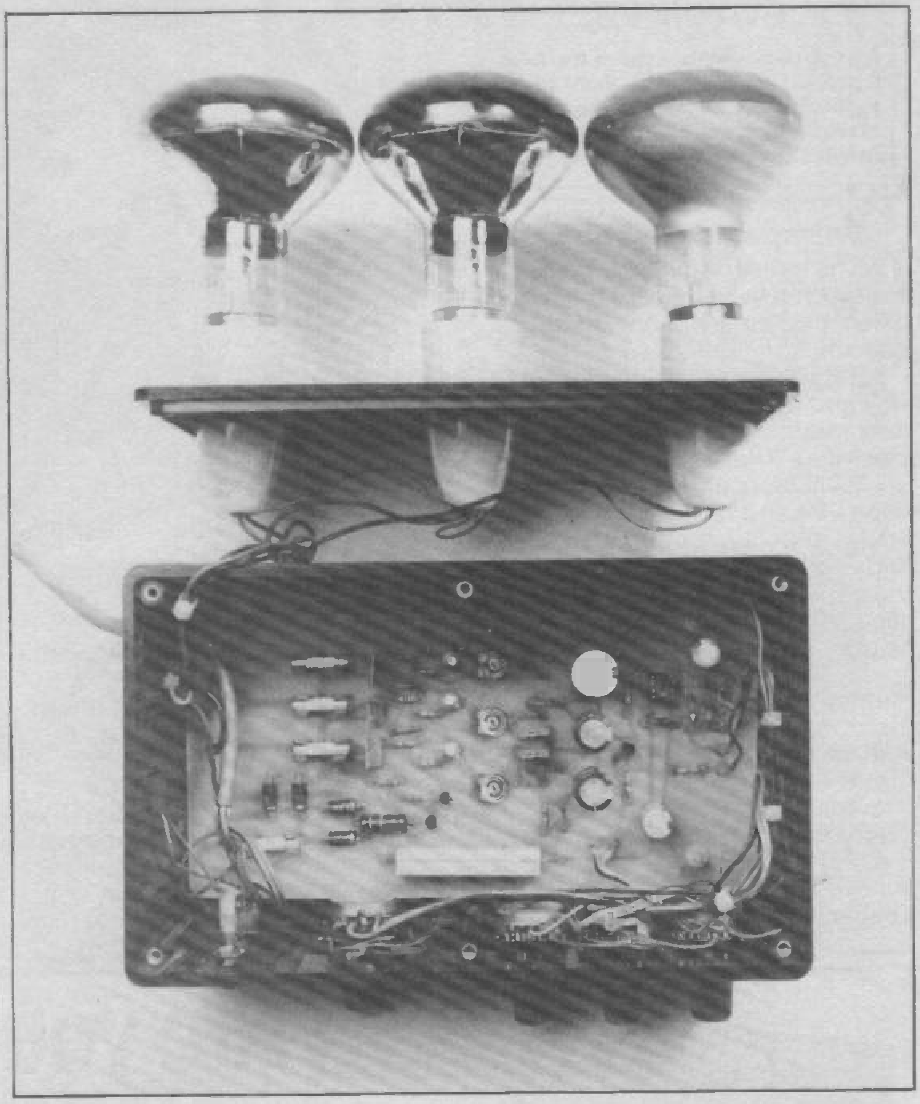


Fig. 5 The component overlay for the RGB Auto-Dissolve PCB

PARTS LIST

RESISTORS (all ¼ watt 5% unless stated)	
R1	12k
R2	100k 1watt
R3, 6, 9-12	10k
R4	3k3
R5	1k0
R7	15k 10 watt
R8	4k7
R13	22k
R14, 16, 18	120R
R15, 17, 19	100R
R20, 21, 22	22R
RV1	1M0 lin pot
RV2, 3, 4	100k 1in pot
RV5, 6, 7	470k horiz preset
CAPACITORS	
C1, 2	470µ 16V electrolytic
C3	2200µ 16V electrolytic
C4, 5	1000µ 16V electrolytic
C6, 7, 8	22n polyester
SEMICONDUCTORS	
IC1	ICM7555 (CMOS 555)
SCR1-3	C106D
Q1, 2	2N3904
Q3	2N3906
Q4-6	2N2646
ZD1	12V 1.3W zener
D1-4	1N5404 (3A 400V).
D5-8	1N4148
LED1	red LED (low current type)
MISCELLANEOUS	
FS1	3A fuse and fuseholder
FS2-4	1A fuse and fuseholder
LP1-3	coloured spotlamps (40W or 75W — see text)
SW1	DPST mains switch

PCB; case; IC socket; lamp sockets; knobs; wire; nuts and bolts.



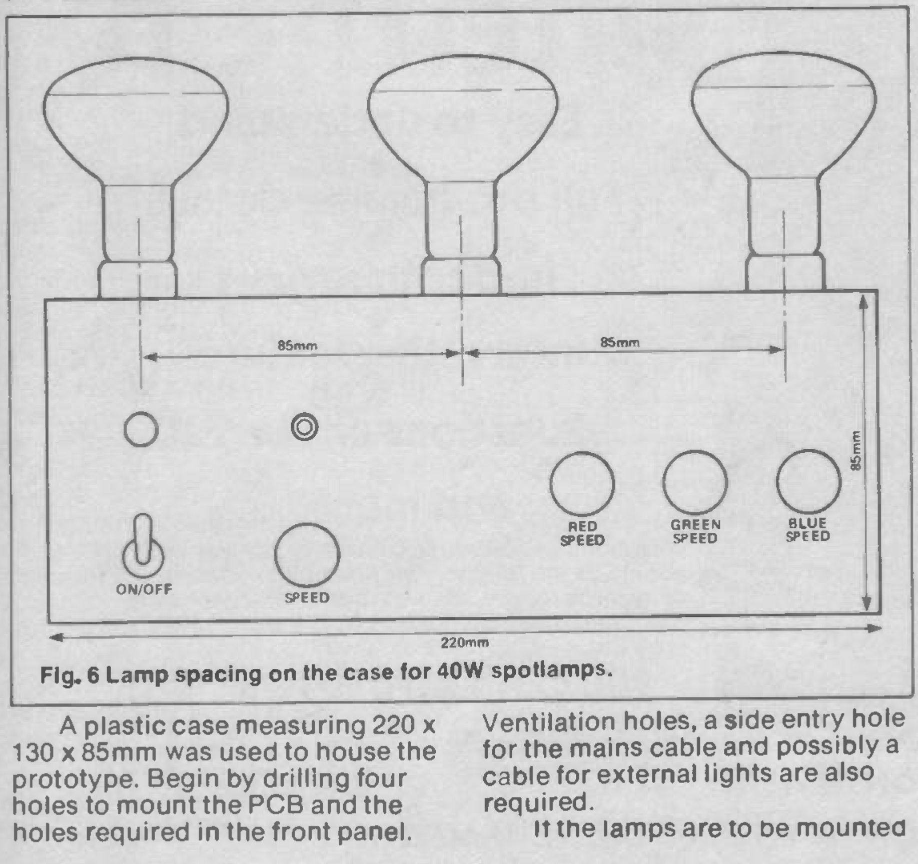


Fig. 6 Lamp spacing on the case for 40W spotlamps.

A plastic case measuring 220 x 130 x 85mm was used to house the prototype. Begin by drilling four holes to mount the PCB and the holes required in the front panel. Ventilation holes, a side entry hole for the mains cable and possibly a cable for external lights are also required.

If the lamps are to be mounted in the top, three large holes are required as shown in Fig. 6. If external lights are required as an alternative to, or in addition to the lamps shown, a small hole should be drilled to mount a four way terminal block.

A minor problem ocurred in the prototype where the plastic ridges of the case prevented the switch and pots from fitting correctly with their threads right through the plastic. An old 25W soldering iron was used to melt the ridges near the holes and allow the threads to project correctly.

The spacing of the lamp-holders shown in Fig. 6 is suited to most 40W coloured spotlamps available. However, providing the centre lamp is a 40 watt type, the two outer lamps may be the larger 75W variety. Alternatively the lamps could be mounted elsewhere in which case three 75W or 100W lamps could be used.

The 75-40-75 watt arrangement is ideally suited towards red (outside) for channel 1, blue (outside) for channel 2, and green (in the centre) for channel 3.

BUYLINES

All the components used in the RGB Dissolve are available from usual suppliers such as Maplin. The PCB is available from the ETI PCB Service as detailed at the back of this issue.

Set-up And Testing

The entire circuit should be considered live and care must be taken, particularly when testing and adjusting the presets.

Set the presets to about mid-way and the potentiometers to their minimum values (fully clockwise if wired correctly).

Switch on, and ensure the neon LP4 and the LED both light up. If either fail, switch off at once and check for faults. If all is well, the LED should go out after a few seconds, then light up again, and so on.

Switch off SW1 and wait a minute or so for the capacitors to discharge. Now switch on SW1, wait for the LED to go out, then turn RV1 fully anticlockwise. Wait a few seconds for C3 and C4 to discharge, then adjust the presets RV5 and RV6 using an insulated screwdriver. RV6 should be adjusted so that the blue lamp (channel 2) is just glowing. RV5 should be turned until the red lamp (channel 1) is just off.

Switch off SW1, and check that RV1 is still fully anticlockwise. Switch on SW1, and adjust preset RV7 to make the green light (channel 3) glow dimly.

Now check the operation of RV2, RV3 and RV4 noting that they should each control the speed at which their respective lamps fade up and down. Note however that resistor R9 increases the fade-down time of channel 3.

The controls may now be set to achieve the correct balance, noting that slower rates provide the greatest colour effects when reflected from a white surface.

If the coloured spotlights are interchanged a different set of combinations is possible and it is well worth experimenting with a variety of settings of the controls.

ETI

ELECTRONIC VIOLET

Ronald Alpair continues his search for the perfect musical instrument with a description of the stand-alone version of last month's Violet.

We met the BBC micro version of the Electronic Violet last month. For those readers who don't own a BBC micro and Music 5000 or who just want to get their teeth into a more complex version less reliant on the electronic efforts of others, this month we look at a stand-alone version providing a totally independent instrument.

The mechanics of the keyboard (or rather the fingerboard) for the instrument is constructed in the same way as described last month. Figure 1 serves as a remainder.

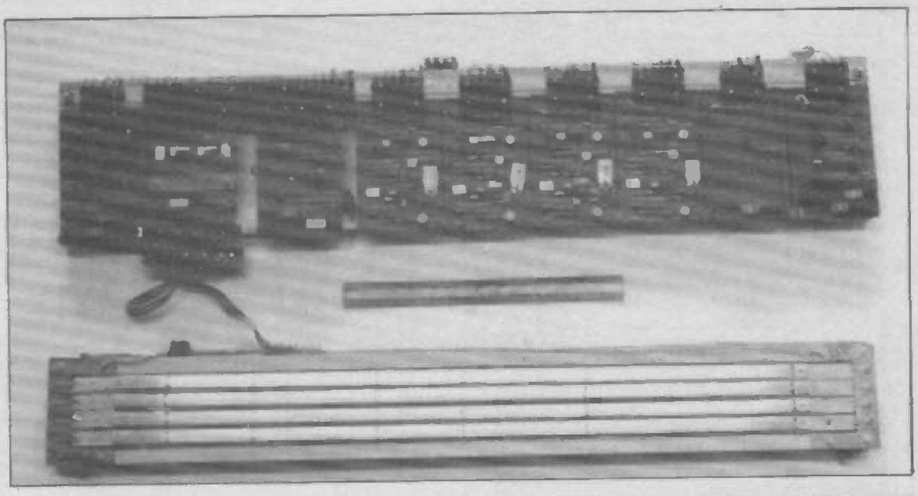
Each string has a potential drop along its length and when touched to the metal plate the voltage at that point is fed to the circuitry providing a pitch signal.

Each plate is mounted on pressure pads which change resistance as they are compressed. The alteration of voltage from these provides touch sensitivity signals.

In the stand-alone version of Electronic Violet, electronics replaces all the operations which were performed by the Ample program running on the BBC micro in last month's version. This version is entirely computer independent. It requires only a hi-fi or backline amplifier to form a complete instrument.

In the author's prototype, a separate circuit board is dedicated to each major function and the whole set of boards (nine altogether) are plugged into a rigid frame by means of plug-and-socket terminal blocks. The plug-and-socket sequence on each type of board is different, making it physically impossible to plug a board into the wrong frame location.

Each board is approx 6 x 4in and is cut from lengths of fibreglass stripboard (or 'Veroboard').



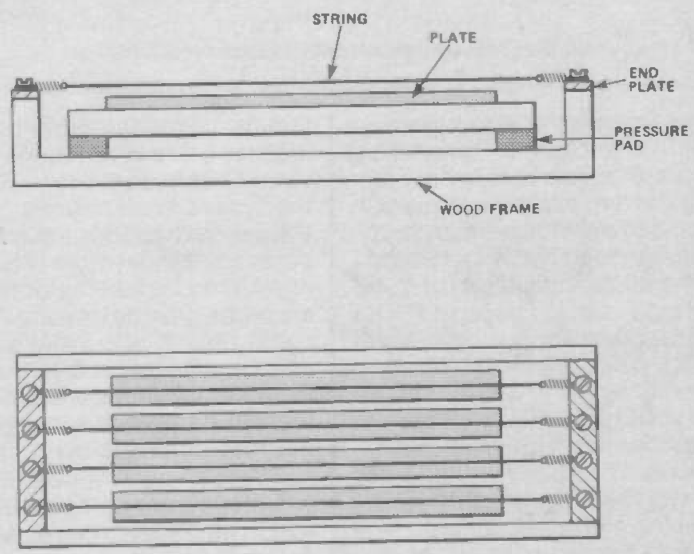


Fig. 1 The mechanical construction of the Violet's fingerboard

The plug-and-socket terminal blocks are screwed firmly along one 4in edge of each board or along both 4in edges in the case of the 'Test' board. This board interfaces with a matching terminal block and, via flat cable, to the fingerboard assembly.

Several boards also have slide pots along the other 4in edge, within easy reach of the player. These enable the instrument to be transposed in pitch, fine tuned, and allow for setting of its degree of touch sensitivity, overall volume and tone.

Like the BBC micro version of the Electronic Violet, the stand-alone version is presented here in a very open-ended manner.

You can just construct what is given here on a series of stripboards, as did the author, and leave it at that but that is only half the fun! The Electronic Violet is a young invention and both an

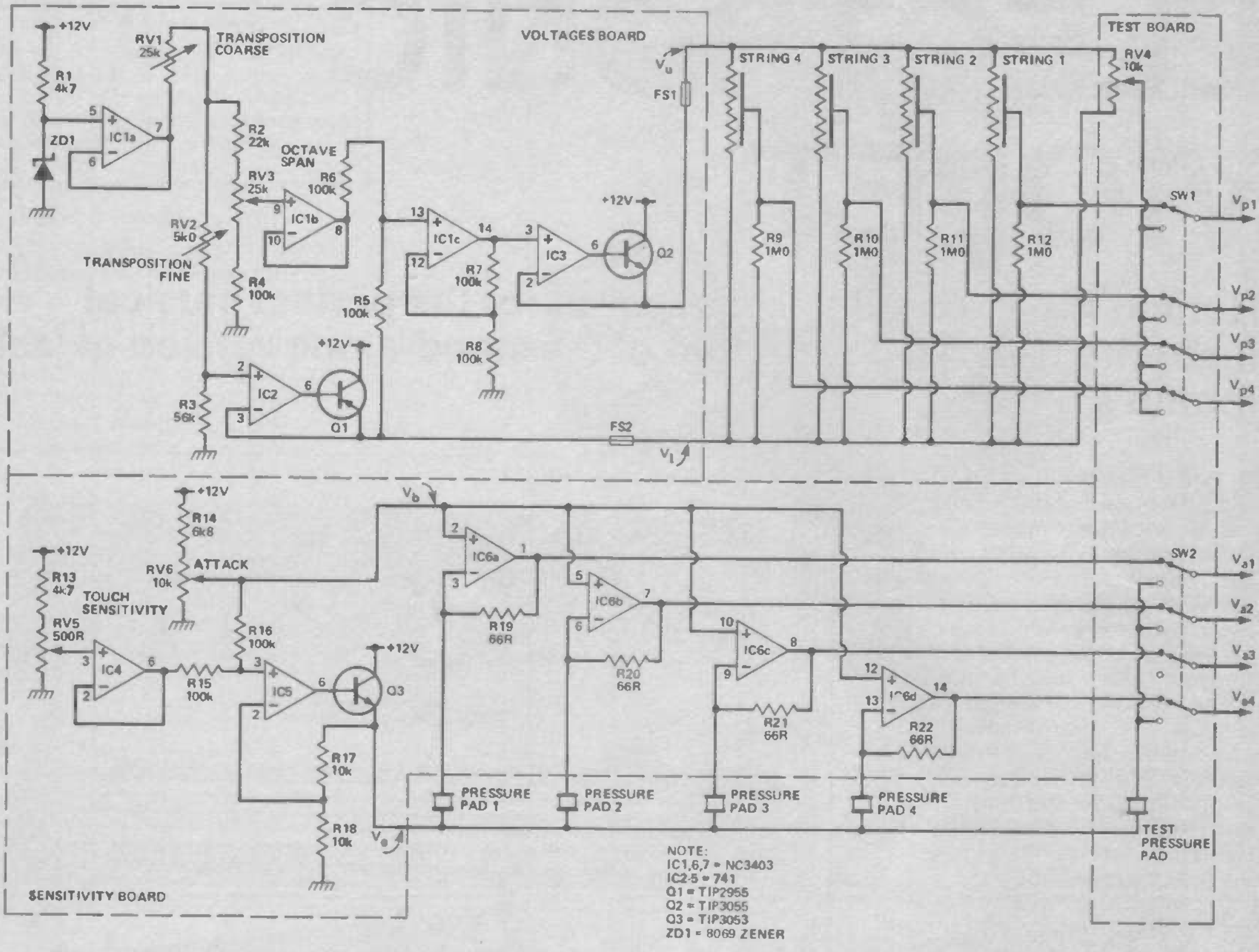


Fig. 2 The circuit diagram of the complete Electronic Violet

improved instrument and a great deal of fun is likely to arise from a bit of experimentation.

An external dual power supply is required to provide a balanced ±12V at 2A to feed the fingerboard frame and all the op-amps.

The Voltages Board

The voltages board supplies stabilised but adjustable voltages V_l and V_u to the 'lower' and 'upper' ends of the four parallel strings. It contains three slide pots for coarse and fine adjustment of V_l and for fine adjustment of (V_u-V_l).

The first two pots (RV1 and RV2) determine the transposition of the instrument (from the register of the cello up to that of the violin). The third pot (RV3) allows for adjustment of the span of an octave, normally covering 9in of the 30in string length.

V_l determines the lowest note playable on the strings while V_u-V_l) fixes the range of the strings and hence the spacing of octaves. To span the cello-viola-violin family, V_l is adjustable between 0.88 to 1.20V and (V_u-V_l) can be varied between 0.8 to 0.96V so that the octave marks on the fingerboard produce pitches an octave apart.

As the resistance of the string assembly is only around 7R0, some 130mA of current is consumed. This is too much for ordinary op-amps which are therefore boosted with power output transistors on heatsinks.

Voltage reference ZD1 produces a very stable 1.2V from which all other voltages are derived. After buffering, one resistance chain (RV1-RV2-R3) generates V_l, which is again buffered and boosted by PNP power transistor Q1. It then proceeds to the fingerboard via a 500mA fuse.

The other resistance chain (R2-RV3-R4) generates (V_u-V_l). This voltage is then added to V_l to give simply V_u. Again this is buffered and boosted, this time by an NPN power transistor Q2, before proceeding via a fuse to the fingerboard.

The Test Board

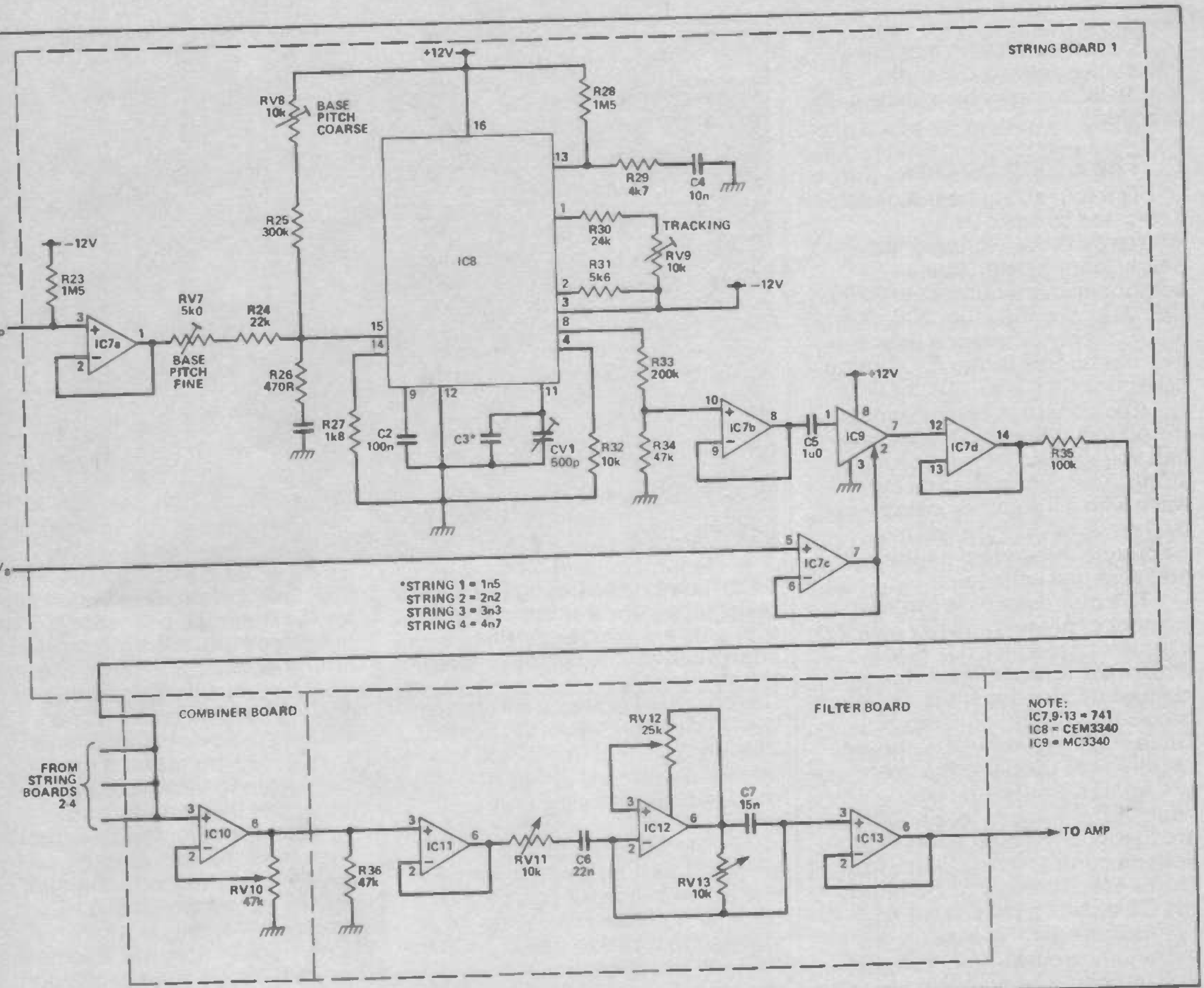
An optional but extremely convenient extra, this board enables the electronic performance of the circuit board assembly to be tested quite independently of the fingerboard.

Two banks of four changeover DIL switches determine whether the pitch and amplitude signals for each string come from the fingerboard or from signals generated internally on the test board itself.

The 10k pot (RV4) generates an on-board pitch signal and a mock-up pressure pad unit also on the board produces the amplitude signal.

The Sensitivity Board

This provides stabilised but manually adjustable voltages to the four sets of pressure pads in the fingerboard assembly. The adjustment allows for variable attack and degree of touch sensitivity ranging from zero (touch insensitive) to maximum sensitivity.



The resistance of the pressure pad assemblies varies from about 1R0 (string pressed down fully) to infinity (string fully released). These resistance changes must be translated into voltages for the voltage controlled attenuator in the string board.

The attenuator requires a control voltage of about 5V to completely attenuate the input signal. At the other extreme, a control voltage of about 3.5V produces zero attenuation.

So we need a circuit in which a falling resistance produces a falling control voltage. This is accomplished by placing a voltage V_c on the base contact of the pressure pad and comparing (using IC6) the voltage on the upper contact of the pad with a slightly smaller voltage V_b.

The resistance chain R14-RV6 generates the comparison voltage V_b. This is fed to the positive input of op-amp IC6. It also goes to a second op-amp IC5 where it is added to a small difference voltage V_d (generated by the resistance chain R13-RV5). The resulting voltage ($V_c = V_b + V_d$) feeds the base contact of the pressure pads.

The four op-amps of IC6 operate as comparators. Assuming a feedback resistor of R_f (R19-22) and a pressure pad resistance of R_p, the output voltage V_a of the comparator is given by:
$V_a = V_b - V_d(R_f/R_p)$.

The best value for R_f will depend on the characteristics of the pressure pad material. With the prototype, R_p varies between 1RO and effectively infinity, giving a suitable value of 66R for R_f and voltages V_b=5V and V_d=22mV. This gives a range for V_a from 3.55 to 5V.

On the sensitivity board V_b and V_d are individually controlled by slide pots RV6 and RV5 respectively. The value of V_b determines how loud a note sounds with absolutely minimal finger pressure on the string. By means of V_b we can thus move from a smooth to a percussive attack.

If the attack is too smooth, the finger action is 'spongy' and the note does not sound till the string has been pressed down a small distance.

This makes the performance of rapid passages difficult so at one stage a footswitch was added to the design with the effect of decreasing V_b and firming-up the attack phase of notes. This footswitch is depressed when individual notes require special accentuation, or when fast passages of music occur.

However, a similar effect can also be produced without using a footswitch, purely by finger techniques. The notes are 'rolled' rather than depressed. This causes the pressure pad to be slightly compressed before the resistance string contacts its base plate to produce the required pitch.

By adjusting V_d we can vary from a touch insensitive fingerboard to one with maximum sensitivity. It is inadvisable to make the action too touch sensitive because, although greater expression is offered, it requires careful finger discipline to produce a smooth legato phrase.

Instead, start with a touch insensitive setting and only gradually increase sensitivity with practice.

The String Boards

The four string boards (each dedicated to one of the instrument's four strings) are nearly identical and the components are numbered R25, 125, 225, 325, C5, 105, 205, 305, etc. The only difference between the four boards is the VCO timing capacitor C3 (C103, C203, C303).

Each board takes two inputs, the pitch voltage (V_p) and pressure pad voltage (V_a) from its own string. The output is a sawtooth wave with a frequency determined by the pitch voltage and an amplitude dependent on the pressure pad voltage.

The boards each include a number of preset pots (RV7-9) and a trimmer capacitor (CV1) to ensure the four strings are accurately tuned to fifths and track precisely over their full range. Once set, these trimmers should require little further adjustment.

Apart from the timing capacitor C3, these four boards are identical. At their heart lies a voltage controlled oscillator from Curtis Electromusic Specialities, the CEM3340.

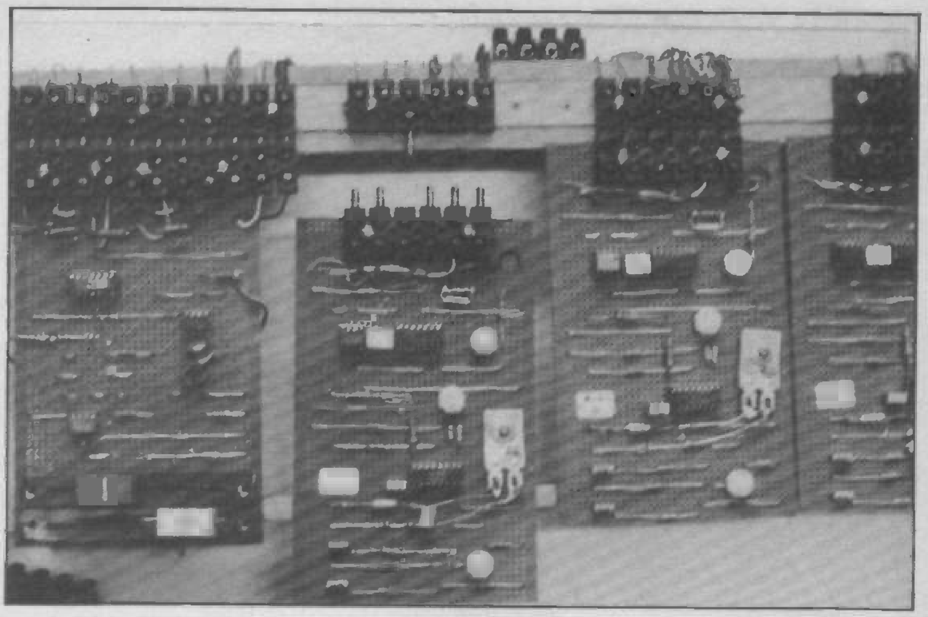
Essentially, this is an extremely precise, wide-ranging and temperature-stabilised converter, which translates linear changes of input voltage into exponential changes of output frequency. This exponential law is exactly what is needed to produce equal pitch ratios from equal displacements along the strings.

In other words, the *exponential* voltage controlled oscillator (VCO) gives us a *linear* fingerboard. As was explained last month, this fingerboard linearity is similar to that of conventional keyboards, as opposed to members of the fiddle and guitar family, where the higher notes are squeezed together.

The CEM3340

The VCO is a sophisticated IC and readers requiring a detailed description should study the helpful manufacturer's literature. However, a quick look is in order here. The supply voltages (±12V and 0V) are supplied to pins 3, 12 and 16.

Pin 15 is the voltage control input to the VCO. It is derived from the buffered frequency signal, V_p, from the strings (via the test board) and via buffering IC7a and resistance networks including two trim pots for coarse and fine adjustment of the bottom pitch of the string.



The input is also anchored to the -12V supply via a 1M5 resistor. This ensures that oscillation is inhibited when the string is released, giving us a gateing effect.

Pin 11 provides tuning of the strings. The timing capacitor C3 is fine tuned by means of a parallel trimmer CV1. Since successive strings are tuned to musical fifths, the ratio of capacitors on successive boards should be 3:2. The series of standard values 1n5, 2n2, 3n3, 4n7 come close enough for the trimming capacitor to iron out any errors, allowing accurate tuning of fifths.

The resistance chain and preset (RV9) on pins 1 and 2 enable the scale to be adjusted. This is very important if the four strings are to track accurately to fifths over their entire span.

We have selected a sawtooth wave from the four output waveforms (sawtooth, triangle, square, pulse) which this IC provides. Not only is it harmonically rich, it is also not unlike the relaxation oscillation produced by the bowing action on stretched strings.

PARTS LIST

RESISTORS

R1, 29, 129, 229, 329	4k7
R2, 24, 124, 224, 324	22k
R3	56k
R4-8, 15, 16, 35, 135, 235, 335	100k
R9-12	1M0
R13, 34, 134, 234, 334, 36	47k
R17, 18, 32, 132, 232, 332	10k
R19-22	66R
R23, 123, 223, 323, 28, 128, 228, 328	1M5
R25, 125, 225, 325	300K
R26, 126, 226, 326	470R
R27, 127, 227, 327	1k8
R30, 130, 230, 330	24k
R31, 131, 231, 331	5k6
R33, 133, 233, 333	200k
RV1, 3, 12	25k slide pot
RV2	5k0 slide pot
RV4, 6, 11, 13	10k slide pot
RV5	500R slide pot
RV7	5k0 preset
RV8, 9	10k preset
RV10	47k slide pot

CAPACITORS

C1, 101, 201, 301, 4	10n ceramic
C2, 102, 202, 302	100n ceramic
C3	1n5 ceramic
C103	2n2 ceramic
C203	3n3 ceramic
C303	4n7 ceramic
C5, 105, 205, 305	1µ0 tantalum
C6	22n ceramic
C7	15n ceramic
CV1	500p trimmer

SEMICONDUCTORS

IC1, 6, 7	MC3403
IC2-5, 7, 9-13	741
IC8	CEM3340
IC9	MC3340
Q1	TIP 2955
Q2	TIP3055
Q3	TIP3053
ZD1	8069

MISCELLANEOUS

FS1, 2	500mA fuse
SW1, 2	4 pole changeover

Circuit boards; wire; plates; resistance wire; pressure pad material; wooden frame; nuts and bolts.

BUYLINES

The majority of components used to construct the Electronic Violet are easily available from usual suppliers (and the local hardware shop!) The CEM3340 VCO chip is the exception and not widely available. These may be obtained from Cicada Engineering, 54 Gibson Square, London N1 0QR.

The wave output is from pin 8 ranging from 0 to about 10V. This is too large for the attenuator (IC9) and is accordingly scaled down to a maximum of 2V by a resistor chain (R33-R34) before being buffered by IC7b and fed to the input IC9.

IC7c buffers the V_a signal from the pressure pads and feeds it to the control voltage at pin 2 or IC9. The output from IC9 is buffered by IC7d and fed to the combiner board.

Physically the string boards are the densest of all. It is well worth investing some time and effort to design a nice clean layout.

The Combiner Board

This simple board combines the outputs of the four string boards into a single signal. It also includes a slide pot for overall volume setting.

In contrast to the preceding boards, this board is so simple as to hardly justify a board of its own. Indeed there is plenty of room on the next board to accommodate it. However, our modular design which allows alternative boards to be plugged in for experimental purposes dictates that logically different operations be physically separate.

Moreover, this 'additional' board produces a total frame width for the nine boards (36.25in) close to the width of the fingerboard assembly (36in), a serendipitous source of aesthetic satisfaction!

The op-amp IC10 simply sums the outputs from the four string boards and for good measure a 50k pot (RV10) in its feedback loop provides a convenient overall volume control.

Bandpass Filter Board

The bandpass filter allows for great variations in the timbre of the instrument. Three slide pots control the position and depth (Q) of the passband.

In the prototype the critical capacitors (C6, 7) simply plug into IC sockets, enabling the values to be changed easily for experiment.

The signal is buffered before and after filtering by IC11 and IC13. A series RC filter (RV11-C6) operates on the negative input to filter op-amp IC12 with a parallel RC filter (RV13-C7) in the feedback loop.

For any input frequency, there are an infinite number of settings of the pots RV11, 12, 13 which will result in resonance instability.

No attempt has been made to modify the circuit so as to block such instabilities, as this would inevitably also delimit the very wide variety of effects of which this filter is capable.

The Last Word?

The Electronic Violet is merely the latest of a long line of predecessors, too numerous to count, which have been constructed over a decade or more.

Every year or so, the current model is dismembered, cannibalised, or left to haunt some dark cupboard or attic, awaiting the next domestic clearout and consignment to an overflowing rubbish skip.

A new model, often dramatically dissimilar from its parent takes its place for a few proud months in the living room. So it will go on.

Were I to reconstruct a new Violet today, I doubt it would resemble the instrument described here. The general principles may indeed survive, while successive reincarnations evolve in unexpected directions.

So, while recommending the underlying philosophy to readers, I am loathed to present the current design as a model to be slavishly copied. On the contrary, the author is eager to hear from any readers who develop the Violet in any direction.

ETI

TECH TIPS

CB Television Interference

A. Armstrong
Leighton Buzzard

Legal CB uses frequency modulation and is less likely than the old illegal variety to interfere with television reception. Problems can still occur but they will be different in character from those caused by any form of amplitude modulation, including SSB. In particular, the effect on TV picture or sound is unlikely to depend on the modulation.

Typically, the picture may change from colour to black and white, and/or may show diagonal lines. The sound is less likely to be affected, but it may be reduced in volume or suffer from a humming noise when the CB rig is transmitting. If a case of interference is identified, the first thing to do is to try to find out which route it is taking into the signal path of the television set.

The obvious first experiment is to disconnect the television aerial and find out if the CB transmitter is still able to influence the television. You can't tell for certain that it is not because it may be necessary to have a picture to detect the problem. If, on the other hand, the transmitter is still affecting the television, then interference is probably getting in via the mains cable. In this case, a mains filter will probably cure the problem. In some cases, simply looping the mains cable a few times through a toroidal core can remove the inteference.

If a mains filter does not cure the interference, even with the television aerial unplugged, the interfering signal is probably being picked up in the IF amplifier. This is unusual and can be virtually incurable. The first thing to try is repositioning the transmitting aerial. If that doesn't work you could always accidentally hit the TV with a 14 pound sledgehammer!

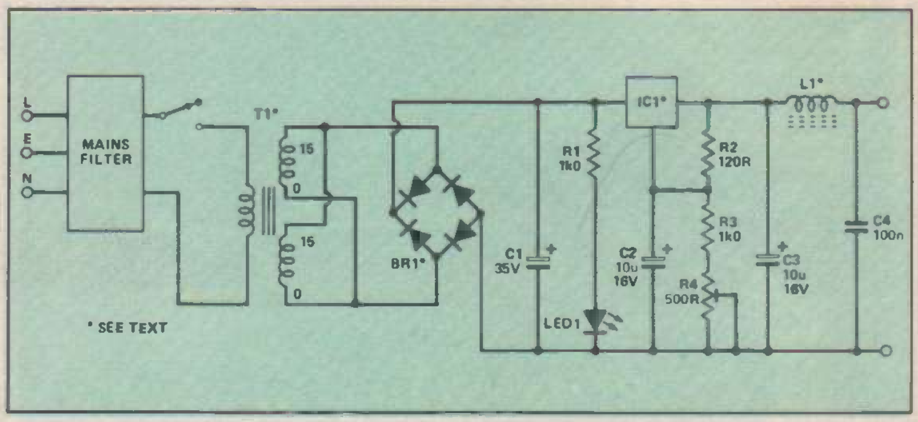
If the interference is found to be entering the set via the aerial lead, the next step is to find out precisely why. It might be that the connection to the aerial, the aerial plug or any intermediate connector, is corroded and is acting as a rectifier, which will work as a crude modulator and impress the CB signal on to the received television signal. A few minutes with a soldering iron will cure this.

It is more likely that the tuner itself is acting as a frequency multiplier to multiply the 27MHz signal up onto the UHF TV band. This is not surprising because the tuning is controlled by means of varicap diodes, which are specifically used as high efficiency frequency multipliers in another guise. If this is happening, the answer is to use an inline filter tuned to reject CB frequencies while providing minimal attenuation at UHF. Such filters are not costly to purchase but if you wish to make your own, fit a parallel tuned circuit tuned to citizens band in series with the inner conductor of the aerial lead. The circuit should be tunable by means of a preset capacitor. Adjust this to eliminate interference while the CB transmitter is running.

There is one situation in which this may not work as expected. If a masthead aerial pre-amplifier is in use, the CB signal may be overloading that and causing it to generate spurious frequencies. In this case, the CB filter should be inserted between the aerial and the preamp. If this is outside then the filter must be waterproofed very carefully because a box full of water will eliminate the interference and the TV signal impartially!

CB Homebase Power Supply

A. Armstrong
Leighton Buzzard



Here is a simple power supply design which can be adapted for different load currents. All the components marked with an asterisk should be chosen for the load current required. The available current ranges are set by conveniently available types of voltage regulator IC. This circuit is designed to use an LM317T for up 1.5A, and an LM338K for 1.5A to 5A.

When a transformer is used on a rectifier and capacitor load, it should not be expected to provide as much current as its VA rating might suggest. In most applications a reasonable limit is to draw a direct current of ⅔ the AC rating if a bridge rectifier configuration is used and under half the AC rating if a dual half wave rectifier configuration is used.

In this design, a load current of 1.5A would seem to require a transformer rated at 33.75VA but it would be reasonable to use a 30VA toroidal transformer. Toroidal transformers do not exhibit as much sag as conventional types and the maximum current is only drawn when transmitting so the heating of the transformer will not be excessive. However, the bridge rectifier should be rated at the full 1.5A.

The choice of the value of C1 is a compromise between a monster sized component and excessive ripple. A reasonable value would be 4700μ, which will give a ripple of just under 3V at maximum load. This is cutting things a little fine to avoid

Guitar Pick-up Switching

M. Mullen
Glasgow

This circuit gives a unique type of switching arrangement to any electric guitar employing three electromagnetic pickups. Eleven different arrangements of individual or combined pickups are made available using this system. The switching facilities are as follows:

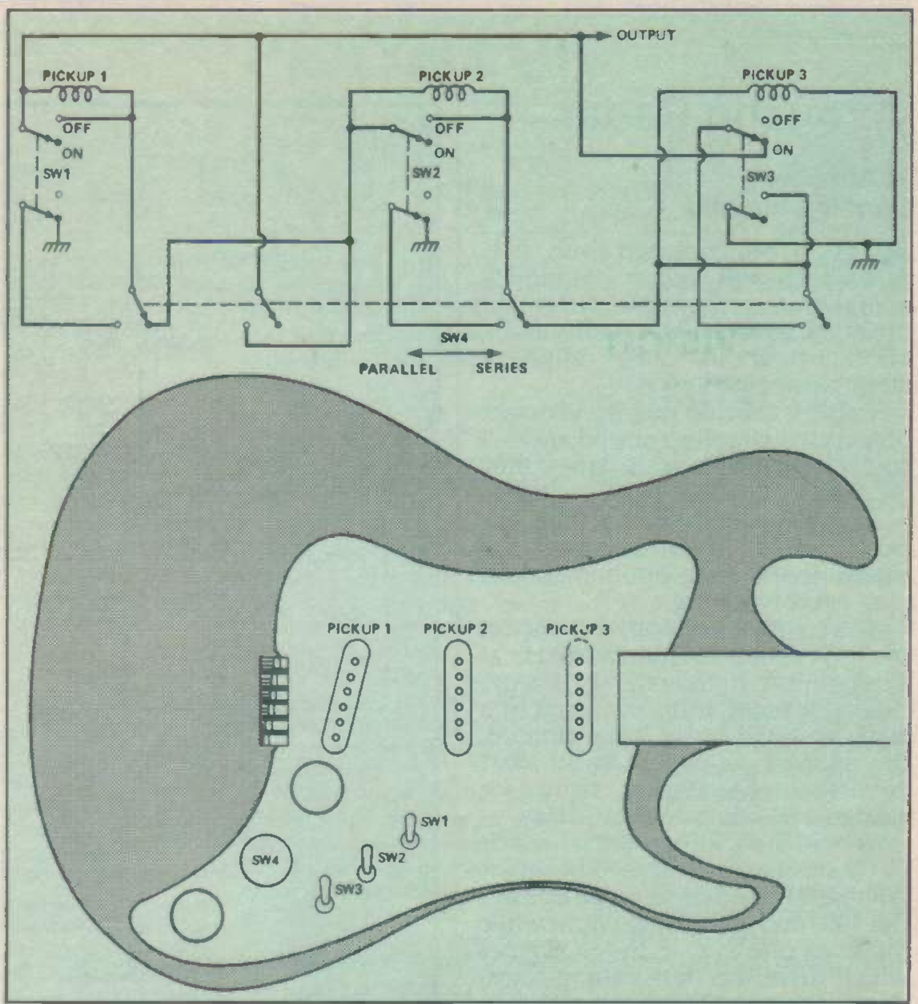
- any one pickup from three can be individually selected.
- any combination of two pickups from three, either in series or in parallel can be selected.
- all three pickups, either in series or in parallel can be selected.

These switching arrangements provide a wide range of tonal variation, ranging from a sharp hard treble to a very rich mellow sound.

An additional advantage is that the system employs no active electronics, the switching components consisting of just three double-pole changeover toggle switches and one four-pole, two-way rotary switch.

The three toggle switches SW1,2,3 function as on-off switches for pickups 1, 2 and 3, respectively.

This arrangement allows any one, two or all three of the pickups to be selected depending on which of the three switches are down in the on position.



Switch SW4 has two positions. One position connects the pickups in a parallel configuration and the other position connects them in a series configuration. This arrangement applies no matter which combination of two or three pickups are selected by the toggle switches.

In addition, any single pickup can be individually selected regardless of whether the switch, SW4 is in the parallel or the series position.

The output from the pickups and switching circuit is connected, in the conventional manner, to the guitar's own volume and tone control circuitry.

---

regulator dropout and a minority of units may exhibit this problem at maximum load. If this does occur, use a second 4700µ capacitor in parallel with C1 to remove the problem.

If a 5A current rating is required then a higher transformer voltage must be used because it will be necessary to allow a higher ripple voltage on C1 to keep the required value within bounds. A transformer with two 9V secondaries connected in series would be suitable or, of course, two 18V secondaries in parallel. A rating of 135VA would seem to be required but once again it is probably reasonable to use a standard 120VA transformer so long as full load is applied only intermittently. Once again, the bridge rectifier must be rated for the full 5A and it should be mounted on the metal case to dissipate the heat.

If a 15000µ capacitor is used for C1, the ripple will be just over 3V at full load, which should pose no problems.

The voltage regulator, ICI, should be mounted on a heatsink. A fairly small heatsink will do for the 1.5A option but a much larger one will be needed for 5A because of the higher voltage on C1. For the LM317T running at 1.5A max, Electromail type 402-995 rated at 6.8°C/W should be adequate, particularly if it is mounted on a metal box which will provide a little extra heatsink capacity. For the LM338K running at 5A, a heatsink of 1.5°C/W or better should be used. Electromail type 403-083 would be suitable but type 401-807 would be better and more compact.

Inductive filtering is shown on the output of the power supply. This has two purposes. One is to remove any switching noise which may be generated by the rectifier, to avoid interference to the rig. L1 and C4 also prevent RF being picked up on the output lead and interfering with the operation of the voltage regulator. L1 should be about 20 turns of 1mm wire wound on a length of ferrite rod. Ideally, C4 should be connected directly across the output terminals.

A mains filter is also shown. Either a filtered IEC input connector may be used or the ETI mains filter would be suitable. For the reasons mentioned above, it is necessary to prevent radio frequency interference from entering or leaving the power supply box.

The unit must be constructed in a metal case to provide both screening and heatsinking. The LED should be mounted on the front panel to indicate power on. A neon is not used, to avoid the radio interference which they usually generate.

When the supply has been built, it should be adjusted to provide an output of 13V5. Most rigs are rated to give maximum output at 13V8, but reducing the voltage by 0V3 will allow a small margin for error or drift, while not affecting the output significantly.

Acoustic Radar

A. Armstrong
Leighton Buzzard

Not to be confused with bats (which the author is rapidly going) this is a simple system to provide a quantised range discrimination of acoustically reflective targets.

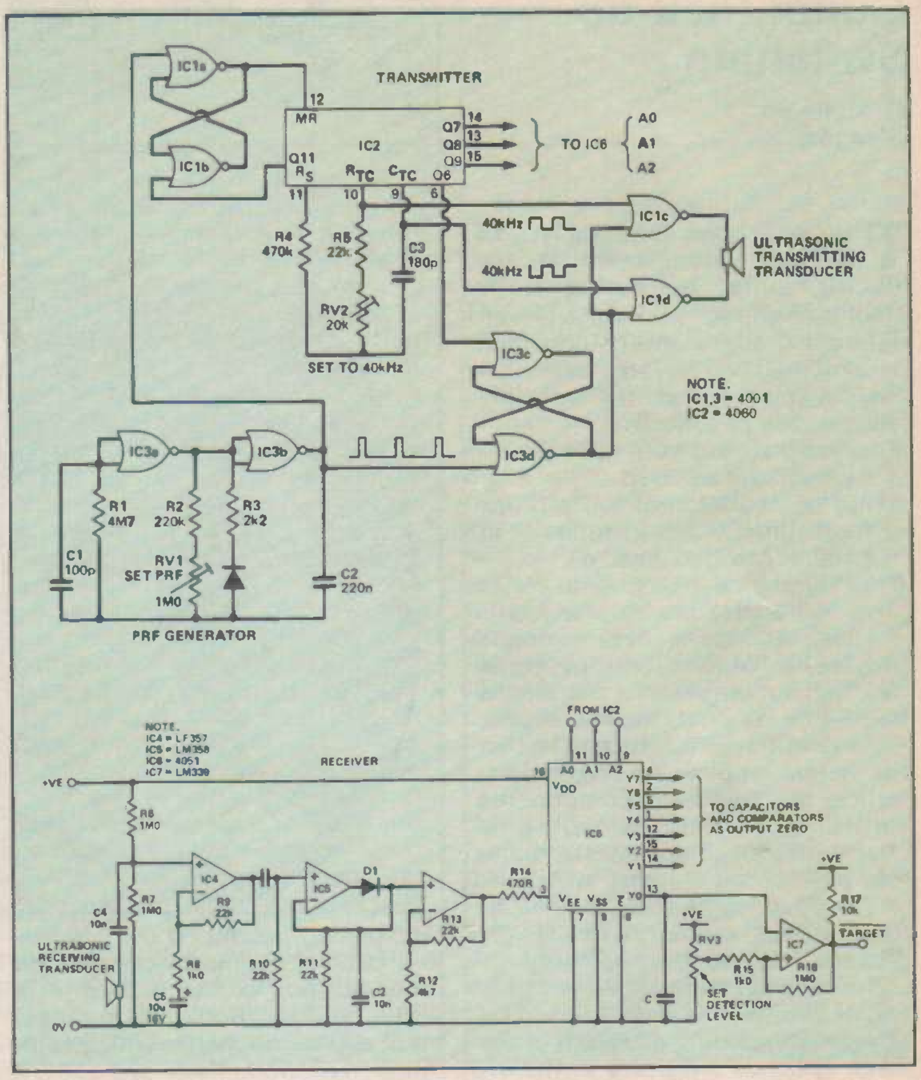
To put it another way, it will detect objects which reflect sound and tell you which ranges of distance they fall into.

Not every part of the idea has been tested. It is intended for experiment and component values may need tweaking.

The transmitter sends out a short burst of sound frequency 40kHz at a repetition frequency set by the oscillator made from two parts of a 4001. After the pulse is transmitted, the address signal fed to the 4051 counts round so received signals are graded according to their delay.

When the PRF generator sends out a short pulse, the two bistables are reset. The upper bistable enables the 4060 and allows it to count while the lower one enables the NOR gates which drive the transmitting transducer. The lower bistable is set when the Q_6 output of the 4060 switches to logic one for the first time. This sets the pulse length for a given range by moving this connection. Outputs Q_7, Q_8 and Q_9 switch the address lines of the 4051 data selector to route signals with different delays to different comparators for detection.

When the Q_{11} output of the 4060 switches to logic one, the upper bistable is set and the 4060 is held reset. Unfortunately, because there is not a Q_{10} output, the address of the 4051 is cycled round twice, but this is not likely to matter as later reflections are likely to be very weak.



If it is a problem, a three input AND gate could be used to decode address 111 and set the bistable. This, however, will gate off the last channel as soon as it is switched on, so the longest range detector will do nothing. More complex solutions are unlikely to be worthwhile.

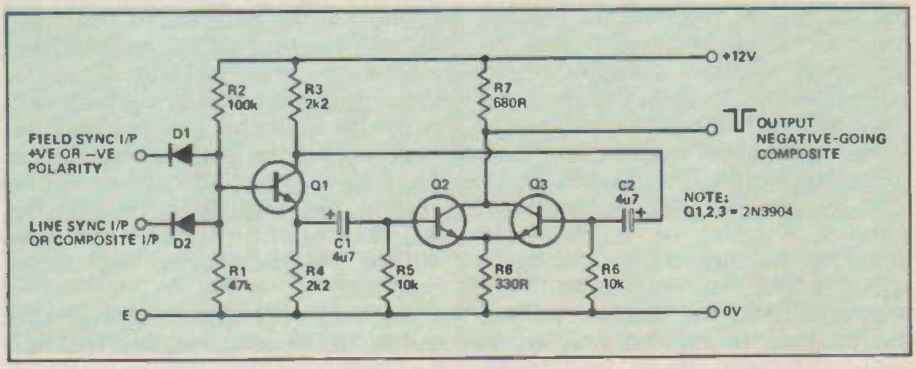
The receiver itself consists of a fast op-amp used to provide gain at 40kHz, followed by a half wave precision rectifier and a buffer with gain. The gain of this should be altered by changing the feed-back resistors to suit the signal levels found in practice. The capacitors on the output of the 4051 average the target over several scans and their value can be chosen by experiment.

VDU Sync Sorter

L. Sage
Bingley

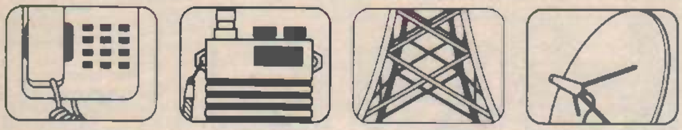
The circuit will accept either positive or negative sync pulses, and either composite or separate line and field sync, at TTL or CMOS levels. It produces a negative-going composite sync output. This greatly enhances the versatility of a monitor allowing it to be connected to a wide variety of different signal sources without the need to fiddle with sync switching.

This is particularly useful for schools and colleges where the person setting up or operating the video equipment may not be technical and just expects the various pieces of equipment to work without adjustment when connected up.



Separate line and field sync pulses are fed to Q1 via the two diodes. These isolate the pulse sources ensuring they cannot interact with each other. Q1 is connected as a phase splitter and together with the bias at the base D1,2 set the sync slicing level at around 2.7V. Opposite polarity sync pulses appear at the collector and emitter of Q1. Q2,3 are biased off. ETI

OPEN CHANNEL



A funny thing happened to me on the way to the office. A little bird told me a story that I couldn't ignore. I'd been doing a lot of research for the article on satellite television and the little bird was a senior manager of a large satellite supply concern.

As far as he was concerned he had no axe to grind and so I could do nothing but take the matter as fact. He told me that the arrangements for obtaining and paying for a licence to receive satellite broadcast television pictures was set to change – dramatically!

The present system involves the user applying for a TVRO (television receiver only) licence direct from the Radiocommunications Division of the DTI.

A single payment of £10 secures the licence and it is valid indefinitely.

The changes which my little bird had heard were that the licence would be only valid for one year and would cost a 'minimum of £70'. In other words, the licence is to be similar to the yearly licence required for terrestrial television services.

If this change is to take place, it means two main things. First, and most important as far as the user is concerned, it's an added expense to an already quite expensive system. As it would be paid every year, the expense is with the user for life – even before the user switches the system on, the standard television licence and the TVRP licence must be paid (a total of about £140) each year.

Second, and quite sinister, the money paid by users either goes to the Government's coffers or (more probably) to fund a specific broadcasting organisation (or organisations) much as the terrestrial licence funds the BBC.

I started some investigations with the Department of Trade and Industry, to see if this rumour could be confirmed or denied. Here, my source said he had no knowledge of the present arrangement being changed. In his own words, there is a possibility the rumour started after someone had overheard two ministers chatting in the toilets about the necessity of a yearly licence. In which case, I can only take this to mean that the rumour may well be true.

If it is true then who is to be funded by the licence fee? Surely not Aunty Beeb, because they are already funded by the terrestrial licence. Then who? British Satellite Broadcasting, who is running the British DBS system?

I have an open mind at present about the possible change. On the one hand I can't personally see why the status quo needs to be changed. It doesn't follow the rules of common sense. On the other hand, when has common sense ever prevailed where Governments and revenue are concerned?

Look, No Wires

Cordless phones have become quite commonplace over the last couple of years, with consequent price drops and raging competition by the leading manufacturers.

Such a healthy market would lead one to assume that all is well with these devices and that most manufacturers would not tamper with the successful formula. Even so, the 'second generation' (nicknamed CT2) of cordless phones is likely to be with us in a fairly short time.

Some readers may have heard the name of Sir Clive Sinclair before! One of the companies under the Sinclair Research umbrella, Shaye Communications, is heavily into CT2 and hopes to launch a model later this year.

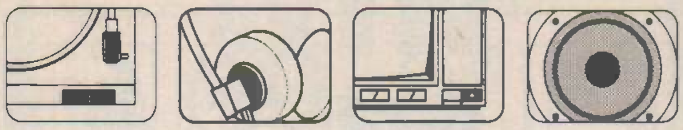
CT2 phones are digital and will operate in the same frequency range as current cellular radio phones (around 900MHz) so high quality reproduction will be possible, given the limits of the telephone network they will be connected to. The Shaye version of CT2 phones will also feature a Mercury button, to connect the phone onto Mercury's digital network.

Although the first CT2 phone to hit the marketplace will be a single-line device – they connect one user with one exchange line – the future for cordless phones will be more as PABX (private automatic branch exchange) replacing current switchboards in small offices.

Each employee who would normally have a desk-based telephone, will have a pocket-sized cordless CT2 phone and will be able to take incoming calls and make outgoing calls on it.

Keith Brindley

PLAYBACK



This month I shall take a look at cassette recorders. Not the fancy new digital jobs but the pedestrian old analogue variety, which I believe has life in it yet.

The cassette is really an example of advancing technology (and public demand) turning a simple idea upside down. Originally, Phillips designed a recording system for speech – for dictaphone use and the like. People soon started to use it for recording music because it was small and convenient.

Demand soon persuaded manufacturers to make slightly better quality recorders (still in mono) which in turn stimulated more demand.

Phillips' decision to allow other manufacturers to produce cassettes and machines conforming to the standard, was no doubt a great help in establishing it.

Initially, the frequency response was very limited, tape hiss was at a high level and the maximum recording level wasn't. There was, however, a small range of recording levels in the middle where the music was louder than the hiss but not quite loud enough to overload and distort.

Modern cassette recorders give vastly better performance and the best of them are so good that a Dolby C recording of a compact disc is, for many people, indistinguishable from the original.

Many special qualities and features are claimed for one machine or another, so how can one decide what is important and what is frippery? This matter is further complicated by the tendency for features which add quality in well engineered machines to detract from the performance of poorer ones.

Dolby

Not a lot of people know this, but Dolby B can make worse the sound from a poor quality or badly adjusted machine and Dolby C can totally ruin it!

Dolby is a compression/expansion system which boosts weak treble during recording and cuts it (and the hiss) down again on replay.

To reverse the process accurately on replay, the recorded level and frequency response must match that for which the Dolby was calibrated. Errors in frequency response or in overall signal level on the tape cause bigger inaccuracies in the decoding process. A slight deficiency in treble without Dolby can be multiplied by the Dolby to give very little treble at all.

Dolby C does much the same as Dolby B but more so. Not only does it compress a treble band but also a middle range of frequencies.

This pretty well guarantees that when the signal in a particular frequency range is not loud enough to mask the normal level of tape noise, the noise had been cut down to inaudible levels. Inevitably, errors in the recording process are accentuated more by Dolby C than by Dolby B.

To make good use of Dolby (especially Dolby C) a recorder must be able to record onto the tape the right signal levels, at all frequencies, for the system to function properly.

Calibration

If a machine is calibrated to do this with one brand of tape, the chances are that it will not accurately match another brand unless it can be readjusted. Both the post Dolby record level (nothing to do with the record level control on the front panel) and the bias may need to be readjusted to suit different tapes.

Some machines have a manual bias adjustment on the front panel and some feature automatic adjustment under microprocessor control. Rarely is the post Dolby record level adjustable by the user but it is often included in the adjustments carried out by a microprocessor adjustment system.

Unless the machine is only to be used with one type of tape (and so long as the manufacturers don't change the formula!) I would consider some form of calibration adjustment almost essential to get the best from Dolby.

Incidentally, for those machines requiring manual bias adjustment, the interstation hiss from an FM tuner is a good test signal to check that the replay sounds like the original. Small inaccuracies are easily audible with this type of noise.

Some machines provide a built in test tone generator for this purpose.

Andrew Armstrong

BOOK LOOK

With the article on satellite television elsewhere in this issue, you might be forgiven for thinking there is little more you need to know about the subject. However, these two books available from the publishers of *Satellite TV Europe* – the TV Times of the satellite world – show just how much there is to know if you want to.

Ku-band Satellite TV – Theory, Installation and Repair by Frank Baylin and Brent Gale (Baylin Gale Productions) £29.95.

A mammoth work, this, with a mammoth price too. However, I've yet to see another single book which contains so much information over such a range as this.

Now, I know most of the superficial theory of satellite TV broadcast and reception. I know much of the jargon and I'm saving busily for the price of a decent system! Nevertheless, despite my vast experience(!) this book held me relatively spellbound.

I say only 'relatively' because this is not really a book for bedtime reading. It is not a book to read from cover to cover – not only because the covers are separated by a phenomenal amount of information but also because this is a reference work.

Despite the title, this book is not divided into three simple sections. In fact there are nine sections and a useful set of appendices crammed into the 350-odd pages.

The book starts with the basic theory of satellite TV broadcast and reception. Everything from microwaves to footprints are covered here.

In the second section it's the turn of the individual components of a TVRO system – not only the antenna, LNB and receiver but the mount, actuator, feedhorn, power supply, even the co-ax cable is fully described, evaluated and the maths of its operation given.

The operation of every item in the chain from the dish surface to the TV picture and sound is investigated here.

The next section looks at the ku-band itself. If you want to get lost in rain attenuation, path loss and ground noise contributions then this is the place to look. However, you'll have to be ready for all the theory and maths of it all.

Section four looks at selecting TVRO equipment. Unfortunately, this book's American origin makes this section less useful for UK readers. The basic ideas and philosophies are sound enough but the specific equipment mentioned has little relevance here.

The next section on installing the system has as much relevance in the UK as anywhere. Most users will probably get a dealer to install their system but there's no reason, really, why you shouldn't do it yourself. Most of the information you need is given (even for the UK) and directions are given for where to go for anything else.

There's a section on retro-fitting ku-band to C-band systems next. This won't have much relevance to most people and nor will the following section on multiple receiver systems (unless you run a hotel or the like).

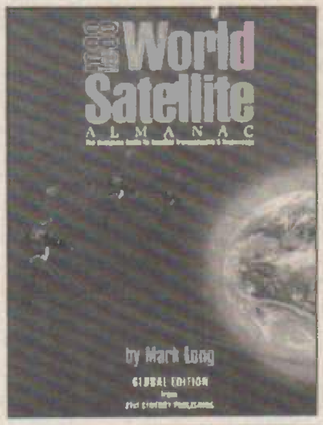
The next section is a world-wide perspective of ku-band satellite television. By its very nature this is limited in its extent. Although it makes interesting reading, if you're really interested in the details around the world you'd be better off looking at the second book reviewed here.

The book's final section deals with repair and trouble-shooting. There is not a great deal a book aiming to cover every conceivable system can say about this subject but it seems to me that this section says it. The basic ideas of checking, especially for mechanical failure (such as water ingress) is a good reminder to ETI readers who tend to become obsessed with electronics isolated from all else!

The book also has several appendices covering footprints of the major satellites around (no pun intended!) the world, lists of manufacturers, a glossary of terms and even a Basic program for calculating azimuth and elevation from published satellite data.

The US origins of the book get a bit tedious at times when the emphasis shifts from where I want it but on the whole a good attempt has been made to aim this book at a worldwide audience. It is simply packed with information and, if you can afford the high price, it makes an excellent introduction to the technical side of satellite TV.

1988 World Satellite Almanac by Mark Long (21st Century Publishing) $33.25.



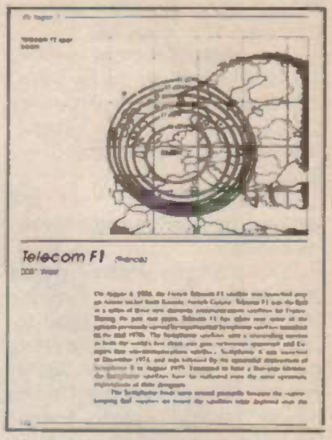
This one's even heftier than the last and is packed with even more information. A massive 650 pages and it uses both big pages and small writing. It's a true encylopaedia of satellite TV if ever there was one.

However, it is even more of a book for reference only than the last. It is solid facts and figures with hardly a scrap of erudite prose to ease the brain between them.

This work is in three main sections. Again, the book starts off with a bit of basic theory and history. Then it's into the hard stuff.

This is truly a world almanac and this first section classifies and describes the whole world picture – TV standards, voice and data transmission techniques, maritime satellites and so on, all over the world. There's even a chapter on the Russian satellite system and the Intersputnik agreement.

The second section of the book looks at the statistics of the satellites up there. Every satellite dotted around the celestial equator is there and for each there is listed the position, the frequencies used, the footprint, a brief history of the satellite and several other often intriguing items.



About 178 satellites in all are detailed here.

The third section of this book is the appendices. It's a bit odd finding a book of tables and lists with a large section of appendices containing more tables. Never mind – why not!

The appendices form a hotch-potch of different collections of data. There are lists of satellites, service providers, a GMT conversion chart, intended launch schedules and several others.

Both these books are expensive. They are just paperbacks and despite their size and length these are steep prices. However, for anyone contemplating setting up a satellite TV business, eager to track down and receive TV from far away foreign parts or just interested in the technical side of satellite TV in general, both these books in their different ways provide a bounteous source of information.

The first book provides the thorough technical background suitable for the technically interested. This last book has all the information you could possibly require for more detailed day-to-day reference of every aspect of satellite TV. I can (subject to the prices) only recommend both.

Martin Tame

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OOPS!

Flat Alarm (June 1987)
In the circuit diagram Q2 is shown as an NPN transistor. It should be a PNP device as given in the parts list. IC4 is given in Fig. 2 as a 74LS260 and C5 as 470n. They should be 74LS132 and 4µ7 as in the parts list. R13 is incorrectly given as 280R in the parts list instead of 270R.

Nuclear Strategy Simulator (July 1987)
The bridge rectifier (BR1) on the overlay diagram has no polarity markings. It should be positioned with the positive at bottom left, connected to the track which connects to IC8 IN and C4 positive.

Telephone Alarm (July 1987)
In the component overlay (Fig.2) IC1 and IC2 should be swapped. The capacitor to the right of IC1,2 is C1 and the inductor between them is L1. The unmarked resistor to the left of L1 should be a wire link. In the circuit diagram (Fig.1b) IC4a,b should be AND gates. IC5 should be NAND gates. The parts list is correct.

Kappellmeisters (July 1987)
The position of the speaker port in the front panel was omitted from Fig.2. This should be a 7¼x4½in ellipse centred across the panel with its top edge 2½in below the panel top.

Knight Raider (August 1987)
In Fig.1(a) pins 4 and 5 of ICl are swapped. IC2-3 show the correct pin-out.

Car Alarm (August 1987)
In Fig. 1 Q7 is not numbered and its emitter is shown unconnected. This connects to earth. The transistors in the parts list went a little awry. Q2-6 are BC237 and Q7 is a TIP31.

Boiler Controller (September 1987)
In Fig. 2 (a) the primary of T2 is shown connected to Earth. This should be neutral. In Fig. 2(b) one of the bridge rectifier diodes, D6-9, is shown the wrong way around. This is correctly shown in Fig. 5.

EEG Monitor (September 1987)
In Fig.3a the pins of IC1 connected to the power rails are shown swapped around. In Fig.4a R7 is unlabelled and is between C3 and C6. In Fig.5 C20 should be £10 and R18 is unlabelled. It lies between R17 and R19.

ETI Concept (October 1987)
The Power Board parts list wrongly lists R6 as 270R. This should be 270k. Also, note that the power board's 0V rail must *not* be connected to Earth or the 0V rail of the CPU board.

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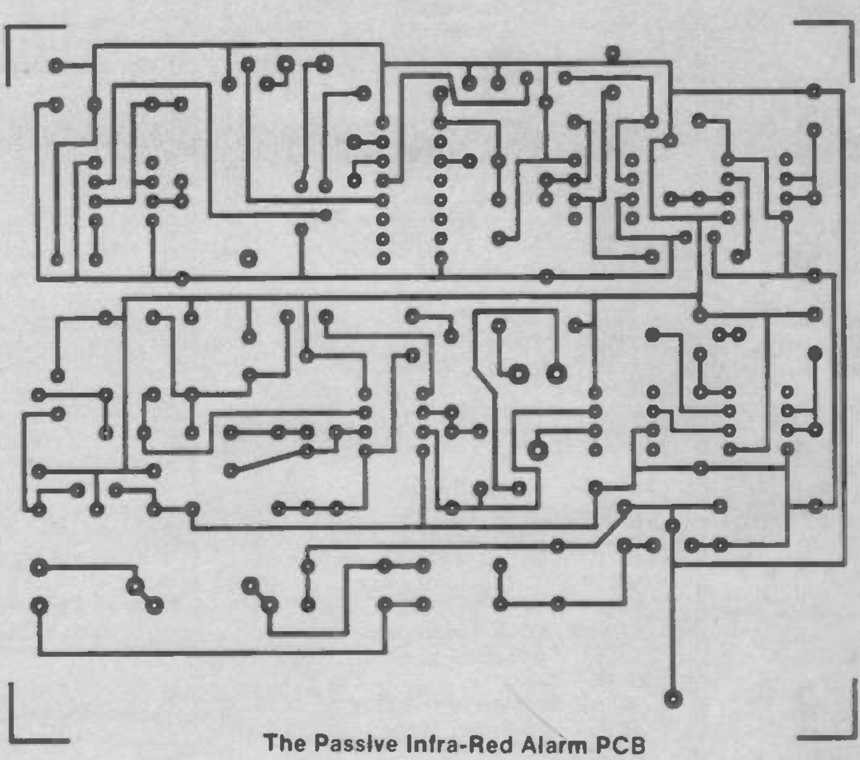

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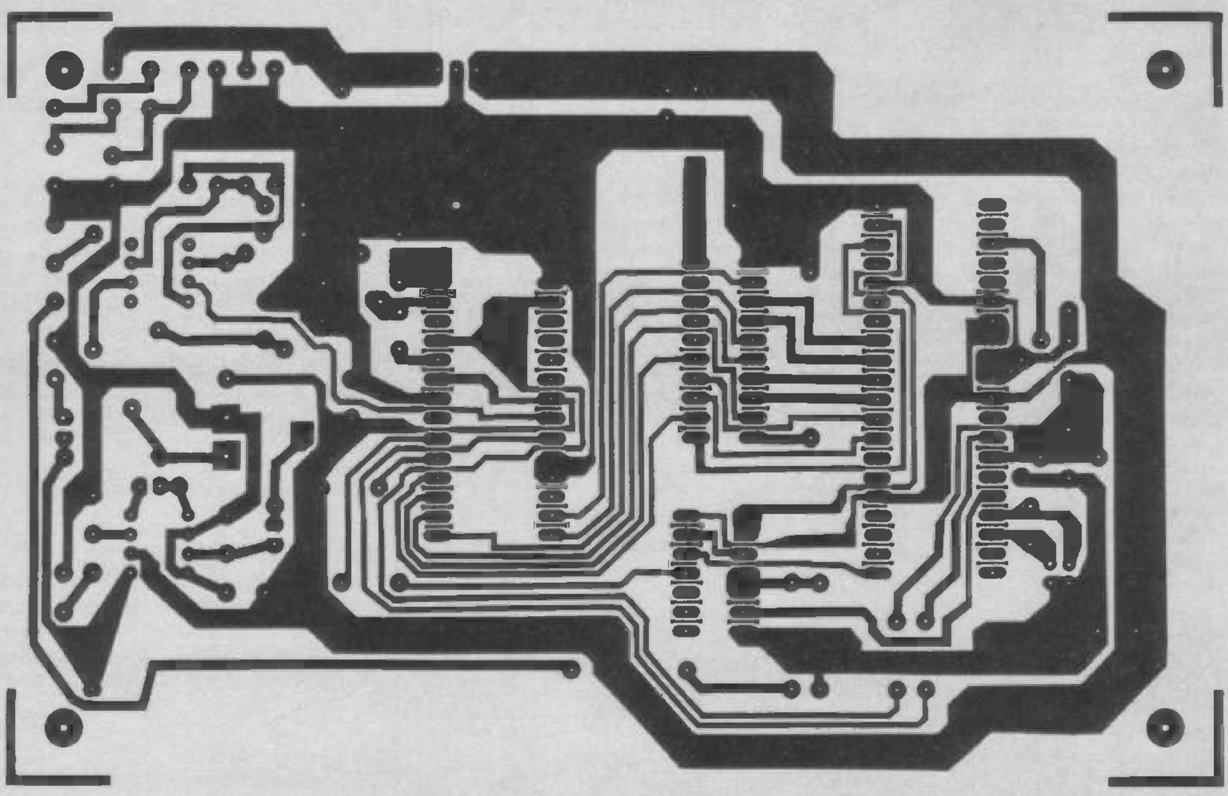

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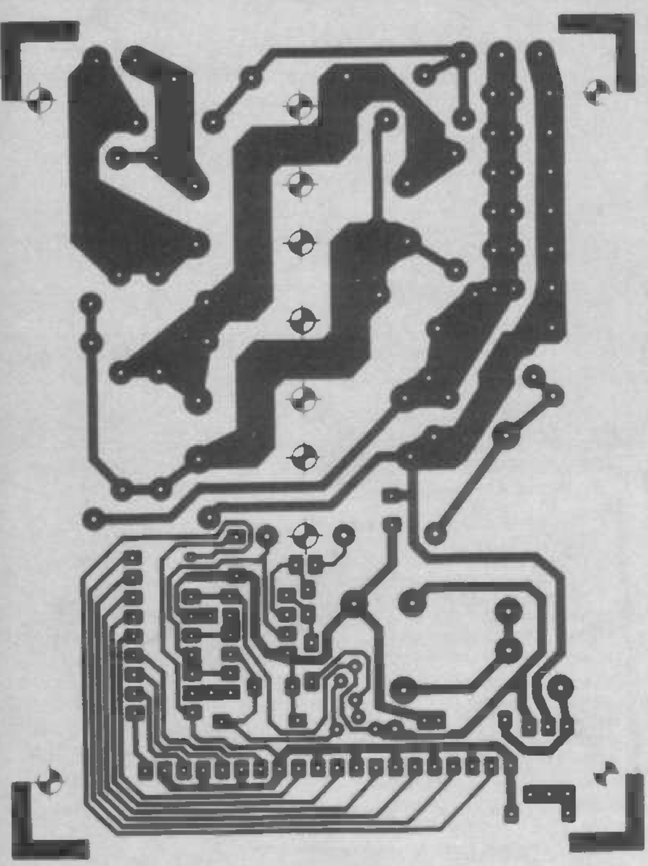

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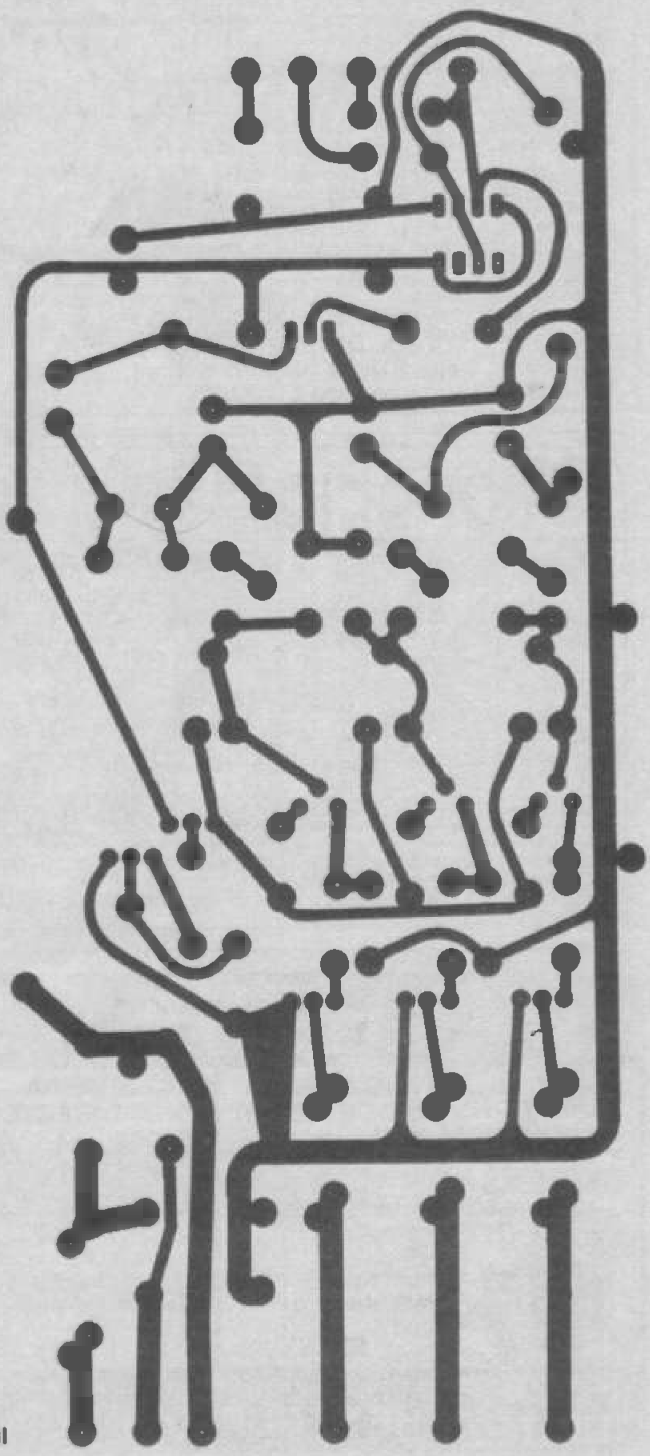

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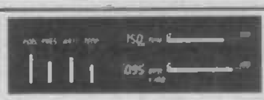

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