THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

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ELECTRONICS TODAY INTERNATIONAL

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TRANSISTORS
Inside The Silicon Sandwich

TREMBLER
Beginners' Motion Detector

TRA-LA-LA!
Polyphonic Programmable Doorbell

WIN!
JLH 80W (AUDIO DESIGN) MOSFET POWER AMPLIFIER KIT

MAPLIN LASER KIT

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AUDIO • COMPUTING • MUSIC • DOMESTIC

September

1989

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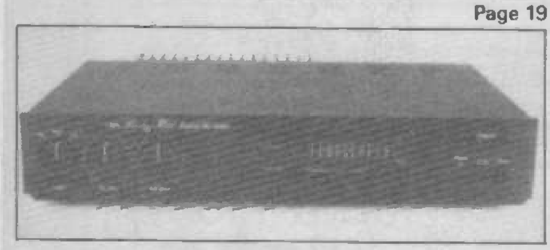

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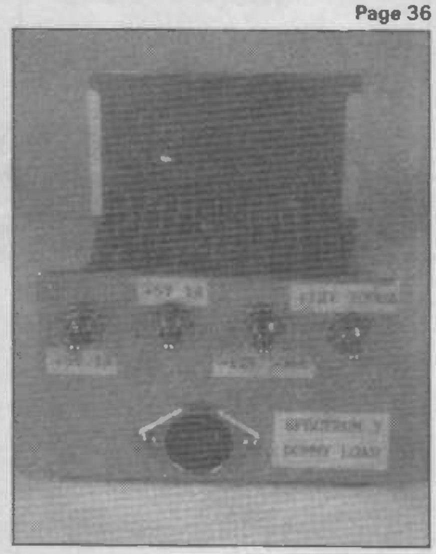

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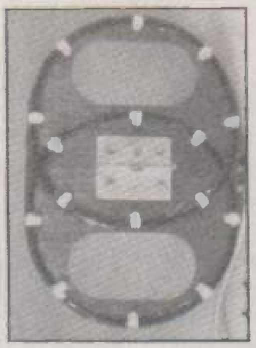
FEATURES/PROJECTS



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NEWS

NEW MERCURY PHONES

Amidst the growing despondency from City-bound mobile telephone users comes a further ray of hope that communication channels may ease. Lord Young, the Secretary of Trade and Industry, has decided that a licence should be given to a consortium led by Mercury Communications to provide the full range of telecommunication services (subject to them giving acceptable proposals).

Sales of mobile telephones have outstripped all expectations and the forecasts are that the number of subscribers will reach 1.2 million in the UK by 1992. Competition is now high amongst cellular telephone manufacturers and the race is on to reduce the weight, size, cost and power consumption.

This last aspect has led to designers to come up with more and more intelligent telephones to make those batteries hold out even longer. An example of this is that the cellular network can instruct the mobile phone to increase or decrease its signal strength to provide the bare minimum power for effective communication. This can be as little at 0.6W. Not only does this save energy but it also reduces interference.

Also easing any future congestion for the mobile telephone network will be the Telepoint or CT2 system, a system similar to cellphones except that outgoing calls have to be made within 150m of a public base station. The major disadvantage is that no incoming calls can be received, although carrying a radio pager with you would ease this problem. Four Telepoint consortia have been chosen (see Open Channel ETI July) and the first of these is expected to start service sometime this year.

MAINS FILTERS

A range of power-line filters designed to protect equipment against mains transients and other AC and DC power problems is now available from Highland Distribution.

The range includes plastic cased devices for both printed-circuit and chassis mounting. All are designed for use with a nominal mains voltage of 250V AC and DC, and current ratings from 0.6A to 30A are available.

For further information please contact Highland Electronics. Tel: (04446) 45021.

CHANNELS TO BE SCRAMBLED

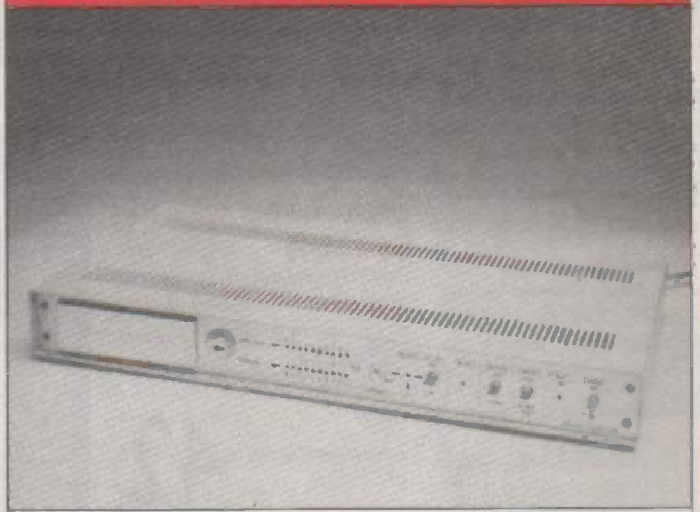
Now Sky Television has successfully completed and tested its videocrypt system, a system that scrambles a satellite TV signal before leaving the transmitter, it has given the go ahead for the production of decoders.

Videocrypt has been developed by Thomson Consumer Electronics and News Datacom to pave the way towards subcription TV. You pay to unscramble the satellite TV channels.

The system will consist of a decoder and a smart card, (a credit card with a micro-chip in it — see *Insight*). The cards will be send periodically to subscribers and programmes will only be seen if the card is slotted into the decoder. The subscriber is then charged regularly for each service requiring subscription. The decoders could be built into the satellite down-converters or even into new TVs in the future.

A French smart card manufacturer Gemplus hopes to make 1 million cards a month and Livingstone in Scotland has been chosen as the manufacturing base owing to its pool of computing skills, operational cost efficiencies and established electronics infrastructure. Sky Movies is expected to be partially scrambled towards the end of 1989 and totally encrypted by 1st January 1990.

HACKERS HACKED



Cream Communications, a security specialist, has launched *Com-lock*, a new device that claims to say goodbye to computer hacking. Hacking is the term given to the act of accessing computer information without permission.

The box amounts to being an interrogator, monitor and code keyswitch. It acts as a gate between the computer's modem and the telephone line. There are anti-hacking systems on the market that simply rely on giving a security code to obtain information and a standard method used by the hacker is the 'trial and error' procedure to find the code. This process can even be automated by a computer to save time.

This new box increases the odds against getting the code correct to one billion to one, and if the code is not correct the first time the box will cut the caller off. Any subsequent attempts will be monitored and after 10 incorrect codes the system blocks the computer for 30 minutes. After 90 attempts the system is permanently blocked and can only be 'opened' manually. During all this, a buzzer alarm sounds (assuming there is somebody around to hear) to notify the presence of a hacker. We are told that the information seeker is kept busy by the Com-lock to fool their intentions.

The system also incorporates a mains filter and a telephone operated relay to sever the computer from the mains. Com-lock costs £950. For further information call Cream Communications Ltd. Tel: (0268) 728577.

NEW SHOP FOR MAPLIN

Component shoppers mourning for the electronic decay of London's Edgware Road and Tottenham Court Road can find solace in Maplin's latest outlet in Edgware.

The shop is at 146-148 Burnt Oak Broadway, just up the hill and round the corner from Burnt Oak tube station. Whereas Maplin's Hammersmith shop is an 'order at the counter and wait while the man goes away' service system, the new premises adopt a self-service supermarket approach, with all the catalogue goodies on show to be perused before purchase.

The shop can be contacted on 01-951 0969 for advice on how to get there or what goodies are in stock (don't ring for mail order service — that's at Maplin's head office on (0702) 554161).

TV CALAMITY

The deregulation of broadcasting now looks set to become the disaster that many in the industry have feared, despite the initial hopes that the IBA's reply to the initial white paper would be heeded.

Early signs from the Home Office indicated that the IBA's proposals for selling ITV franchises would be accepted at least in part, and possibly in full (ETI News July 1989). The IBA's proposals would have removed excessively high bidders from the auction and make at least a passing nod to the need for a quality assessment. Even this was criticised at the time for placing over-emphasis on the price of the bid rather than the plans behind it.

Now Mr Douglas Hurd, the Home Secretary, has announced that unless circumstances are exceptional the Independent Television Committee (in control of the sales) will be required by law to accept the highest bid. Pleas from the IBA that stock exchange takeovers should be prevented have also been rejected.

The new white paper offers nothing to give hope to those who expect the quality of British broadcasting in the decades following the 1993 auction to descend to, or even below, American and Continental standards.

Indeed the 16 existing ITV franchises, now protesting loudly and promising to take the fight all the way to the House of Lords, are quick to point out that under the proposed sale, all 16 franchises could be owned by just eight companies, none of which needs to be British (bids are open to all EC comers). Mr Richard Dunn, MD of Thames TV, has written to the Financial Times arguing that the system "catastrophically destabilises a £1.5billion industry for at least two years before and and two years after an auction."

OB SAT LINK

BBC Radio's Outside Broadcast department now has a mobile satellite link which can be used to send high-quality stereo signals back to London for broadcasting over any of the BBC's networks.

The equipment allows a stereo circuit of the highest quality to be achieved from anywhere in the UK, provided the up-link dish can be placed in a position where it can 'see' Eutelsat 1.

Signals from the satellite are received via a 3m diameter antenna sited on the roof of Broadcasting House in London, where they can be routed to any of the BBC's four radio networks. The up-link equipment uses a transmit power of up to 300W and a dish antenna of 1.9m. It is planned to use the new equipment for an assortment of outside broadcasts.

MORE STAGE FREQUENCIES

An extra 22 radio frequency channels have been made available to theatres and concert halls who use radio microphones. This move comes in a bid to overcome outside interference.

The extra channels will remove the likelihood of interference from the high powered services, such as new private mobile radio services, which are to be introduced in the early 1990s on frequencies now used without authority by some theatre radio microphones. Such services are likely to make those radio microphones unusable.

Unauthorised theatre radio microphones tend to suffer serious interference from more powerful equipment used by legitimate users of these frequencies such as mobile operators.

The new channels will be shared with existing users but potential interference will be avoided by giving geographical allocations to theatrical use.

An information sheet giving details of the new and existing arrangements for authorised use of such radio microphones is available free of charge from: the DTI, Room 605, Waterloo Bridge House, Waterloo Road, London SE1 8UA. Telephone: 01-215 2140.

COMPUTALK

Vanderhoff, a British company, has produced a rather sophisticated telephone answering machine. It is a computer that amongst other things can store analogue voice recordings in digital form. This may be a message from company headquarters for any of the field sales team or service engineers out there hungry for information.

The machine will digitally record your message or query and then re-direct it automatically to the person concerned. It will also help out a busy switchboard by taking and re-directing calls (if there is no reply the computer will record the message and pass it on later). An interesting feature of the *Voice Server* (as it is called) is that it can convert typewritten information into speech. One wonders how accurately it phonetically handles the hundred of irregularities in the English language.

It will also respond to voiced or keyed set commands and then take the necessary action. This has been an area that has caused many headaches in speech recognition research — to say nothing of the interpretation of dialects, something of which this computer must have a limited understanding.

It is suggested the voice processor could be used in a wide variety of applications. This could be within financial institutions, advertising, tourism and shopping services.

Further information can be obtained from Vanderhoff Business Systems Ltd. Tel: (0252) 628018.

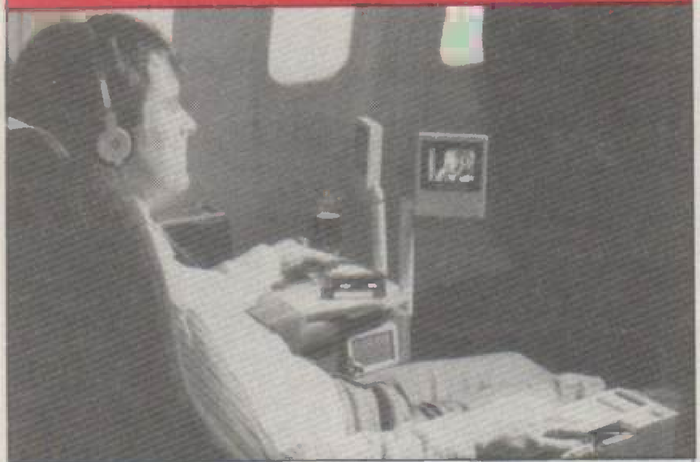
BREAKUP OF NETWORK

The Government intends to privatise the broadcasting transmitter network currently run by the BBC and IBA.

The sale of the IBA transmitter stock is likely to go first as the BBC has made it clear it does not wish to be privatised. However, this issue will be reviewed by the Government when the Corporation's Royal Charter ends in 1996.

This wish restricts the BBC from competing for any new business such as Channel 5, the new national television channel. The BBC will also be allowed to retain their night hours on two channels. This is a retraction from a proposal made in last year's white paper that one night-time channel should go to commercial broadcasting. The apparent change of mind is to give the BBC every opportunity to develop subscription services throughout the night.

INFLIGHT VIEW



If you've ever flown, particularly on a long haul journey, then you know how much of a bore programmed flight entertainment can be. However, a new personal in-flight video is under trial by British Airways.

It is called Skyview, and two major differences exist. The first is that you watch a flat screen colour liquid crystal display instead of the big screen. This lifts up from your armrest and gives you a picture measuring 80×60mm. Secondly, you have a personal choice of programmes from the on-board Video-8 library. The sound comes to you in the usual way through headphones and in PCM digital stereo.

The personal in-flight video is marketed worldwide by Fieldtech Heathrow Ltd. Tel: 01-897 6446.

LOW COST SIG GEN

A low cost RF signal generator is now available from Alpha Electronics. It has a range from 100kHz to 150MHz and can be internally or externally modulated. This oscillator could have uses in education, manufacturing industry and for the hobbyist particularly when aligning IF circuits in radio.

The generator has six frequency ranges and is accurate to within 3%. Crystal oscillator facilities allow crystals from 1-15MHz to be plugged into the front panel. Output is controlled via a high/low attenuator and fine level control. Internal amplitude modulation is at 1kHz. This frequency is also available as an audio output.

The price excluding VAT is £79.00. For further information contact Quiswood on (0756) 69737.

OPTO LINK TO JAPAN

British Telecom, together with six other international companies, has joined the Ministry of Posts and Telecommunications (MPT) of the Soviet Union on a project to study the feasibility of constructing a trans-Soviet fibre-optic telecommunications link connecting Europe and Japan.

The system could also access South-East Asia and Australia via other cable systems. The fibre-optic cables could carry up to 25000 simultaneous telephone conversations, something that BT has recently demonstrated on similar systems.

The lack of an optical link between Europe and Japan has meant that until now telecommunications has mainly been by satellite.

HOME SAFETY

Latest Government statistics from the Home Safety Unit show that fatal electrocutions are rising by 50% per annum. Lawnmowers and hedgetrimmers play a major role in this steep increase.

The survey also shows that many people are still not taking any preventative measures to safeguard against electrocution.

A good protective measure when using many electrical tools is to use a residual current device (RCD) or earth leakage circuit breaker. This detects any small current flowing down to earth and switches off the mains supply automatically.

One such device on sale in many DIY stores is the Power Breaker. Rather like an enlarged mains plug, it is wired up to the extension lead that is often used for outdoor work.

The Power Breaker sells for £15.95. For further information Tel: (0279) 34561.

APRS REPORT

June saw the 22nd annual APRS (Association of Professional Recording Studios) Exhibition, held for the fourth time at Olympia 2 in London.

This year over 180 exhibitors participated taking up three floors of the venue. Not surprisingly most of the stands were offering products costing about the same as an entire street in Stevenage but we did manage to find a few gems of interest.

Audio Design had a direct to disk system on show for the Atari ST which offers 30 minutes of stereo recording with full editing facilities at about £8000. Not cheap but the prices on this sort of technology can only come down.

Yamaha had its C-1 on display as well as a nice range of budget recording units to complement any home studio set-up. New additions to this range are the GSP-100 guitar preamp/equaliser (£129), the MV-100 four into two mic/line mixer (£129), the A-100 50W stereo power amp (£179), the Q-100 two-channel seven band graphic equaliser (£109), the S-100 50W loudspeakers (£129) and the FX-500 multi-effects processor £349. In the pipe line for the British Music Fair are several other products in this series including the TW-1000 power supply which will power up to five of these units from one plug. Price should be £79.

Roland sported a couple of new digital audio products plus a new keyboard.

The R-880 Reverb features some of the most comprehensive reverb-simulations going, combined with some very flexible control options. Just as well since for £2100 you could buy a very nice cave and make your own. In the same series is the E-660 parametric which also features a high degree of control over the sound. Price £1288 (a small cave).

On the keyboard front comes the U-20 which utilises some of the same technology found in the rack-mount U-110 but features quieter processing. It has 128 on-board sounds, 64 patches which include four drumsets. The sounds on board include D-50 type samples as well as classic patches from other Roland synths, plus it'll take U-110 ROM cards or cards designed specifically for the U-20 itself. No fixed price has been set as yet but it should be around the £1000 mark.

AKG the microphone manufacturer was showing several new products such as the Snakeless digital distribution system — a triaxial cable capable of carrying 32 audio channels including eight foldback, designed for use in more complex studios.

At the other end of the economic spectrum is the C525S (catchy name!) which is a vocal condenser microphone powered by a single 1.5V AA battery which should only need replacing twice a year. Sounds like just the thing for home or even disco use.

Citronic, probably best known for its disco equipment, launches a range of signal processors, namely the SPX3-51 dual expander, compressor and limiter, the SPX5-41 dual 4-way state variable crossover, the SPX7-21 dual 15-band graphic equaliser and the SPX7-27 31-band equaliser with parametric notch filter. All products come in 1U 19in rack format and are supplied with a 'tagged' security system.

Cue Systems was demonstrating the Cuedos automated mixing system. Cuedos software was there for use with the Yamaha DMP-7 and DMP-11 digital mixing desks plus the Cuedos controller which gives you motorised faders and a trackerball.

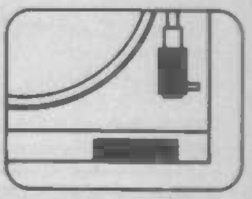
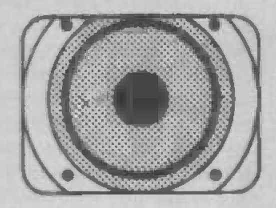
Harman UK (Fostex's UK distributor amongst others) proudly displayed its D-20 DAT format digital master recorder billed as the first fully professional four head R-DAT machine capable of transparent recording/playback of SMPTE timecodes within the subcode area.

Sound Technology had some nice pieces of hardware including the Alesis 1622 audio mixer featuring 'monolithic' technology.

Syco's stand had a few lodgers onboard, most notably Ensoniq who was creating quite a stir with its VFX keyboard. An all-in-one synth featuring sampled sounds is nothing new but this one features full programmability which puts it above most 'workstation' products. The sounds are excellent and the product is great value for money at around the £1200 mark.

Kevin Crosby

PLAYBACK

In July's *Playback* I introduced the concepts of bit-compression, noise-shaping and Pulse Density Modulation as utilised by Philips in their new 1-bit D/A conversion system. Dubbed Bit-Stream Conversion by Philips, this new method was in fact pre-empted by a parallel technology developed by NTT and Technics in Japan.

Technics' system is very similar to Bit-Stream but is known as MASH (Multi-Stage Noise Shaping), whereupon the final D/A reconstruction is effected using a PWM or Pulse Width Modulation DAC.

Odd as it may seem Technics actually introduced this new high-speed CMOS chipset (MN6471/MN6623B) around the beginning of this year, yet failed to tell anyone about it! Instead they retained the 4DAC 18-bit logo on their cheapest CD player and simply equipped it with the MASH/PWM convertor.

Even now, having introduced a totally new range of CD players, Technics have persisted in their use of 4DAC/18-bit and 4DAC/20-bit slogans despite the fact that all the players (bar the top SL-P999) utilise MASH/PWM convertors! Apart from contravening the Trades Description Act there appear to be at least two reasons why Technics is shunning publicity. The first seems to relate to problems concerning the patenting of this process, which has not yet been fully ratified.

A Bit Of A Problem

However there is another reason. In marketing terms the use of high bit logos such as 18 or 20-bit possesses substantial clout just as Philips' 1-bit banner is also likely to attract attention. Now here lies the rub, for despite the implication of Technics' development data, the MASH/PWM system cannot strictly be defined as either 16-bit or 1-bit in fact it is closer to 3.5-bits which, in the world of marketing, is about as useful as a chocolate fire-grate.

Technics' MASH chip employs two FIR interpolation filters together with a quantiser and two stages of noise-shaping. However, unlike Philips' SAA7320 chip the MN6625 processor only truncates the 16-bit digital words down to 3.5-bits. Less oversampling is utilised (×32 instead of ×256) together with a more sophisticated noise-shaper that combines both first and second-order digital low-pass feedback to yield a 3rd-differential (18dB/oct) characteristic.

In the same way as Philips' 2nd-order noise shaper, this time an averaging process is used to weight the quantisation noise (a by-product of truncation) towards the far end of the ultrasonic stop-band. By 'shaping' or redistributing the noise floor in this fashion the 16-bit s/n ratio of the original digital code is retained across the audio band.

So why only truncate down to 3.5bits? Well, the DAC incorporated in this LSI utilises the PWM principle and is required to generate a maximum of 11 different pulse widths (prior to integration) to describe the original analogue waveform. Hence the 3.5bit data stream which is equivalent to 11 different permutations of 1s and 0s. (0 to 1010).

There are a total of 11 positive pulse-widths plus one wait cycle (12 possible time periods) per clock cycle. Two clock cycles are required per pulse or wait period (one positive-going edge and one negative-going edge) so the maximum clock frequency is defined by 2 (44.1kHz × 32 × 12) = 33.8688MHz — three times faster than the 11.2896MHz clock used in Philips' PDM convertor.

Therefore in response to a logic zero the current source is held open for the shortest pulse period (2 clock cycles = 59.05ns) while in response to a maximum 1010 (binary 11) it holds open for 649.6ns (91.67% of total resampled time period). In which case the potential high frequency resolution of the PWM DAC should be superior to that of the PDM DAC, if only because there are more pulses per unit time to describe the analogue waveform.

On the debit side though, Technics' MASH noise-shaper operates over a more restricted 44.1kHz × 32 = 1.4112MHz band, producing a peak of quantisation noise at lower frequencies. Next month I'll discuss the measured and sonic differences of these parallel technologies and stick my neck out as to which sounds best!

Paul Miller

OPEN CHANNEL

Shock, horror! London shrinks! Residents of the second city — Birmingham — will have some cause to celebrate shortly — at 00:01am on 6th May next year to be precise. At that time they become the country's first city (at least as far as telecommunications are concerned). As of that date the existing telephone code for the London area (you know, 01) becomes defunct and will be replaced by two separate codes. The new codes will be:

071 — for inner London.

081 — for outer London.

This change is being brought about because of the demand for telephone services in the capital. The 7-figure number arrangement used in the public switched telephone network such as 01-123 4567 (a fictitious number used only for illustration purposes — not, incidentally, belonging to the editor — so don't ring it!), only allows for an absolute maximum of 10,000,000 different numbers allotted to any specific area code. Demand for telephones in London is now such that more than ten million people want a telephone.

So the changeover is required to allow a maximum of ten million lines in inner London and ten million more in outer London — doubling the previous limit. Only the code will change — individual numbers within inner or outer London will stay the same.

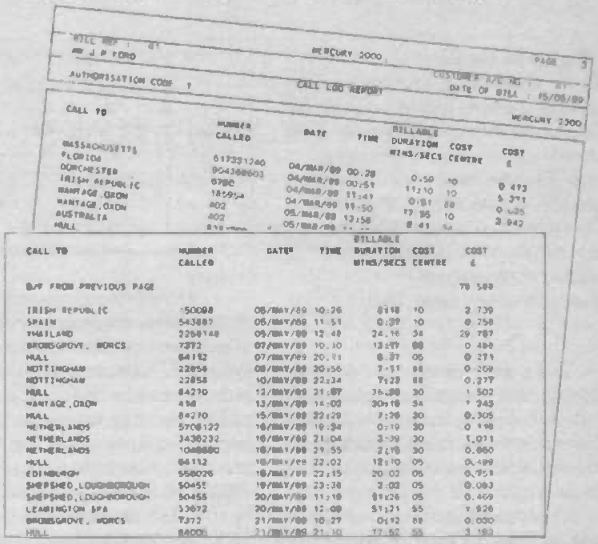
What this means to Birmingham is that Birmingham's area code, 021, now becomes the first area code in the list, while London's two codes are relegated considerably further down.

Calling For More

Long ago, a licenced monopoly existed in the operation of the PSTN. British Telecom was the sole operator of the national system. (An exception to this was, and still is, the local telephone system operator in Hull: apologies to it.) To clear up this unfair monopoly, Mercury was then licensed to compete with BT in the hope that benefits would arise for the customer. Initially this did happen, as Mercury was allowed connection to BT exchanges and some customers did benefit. Benefits have always been limited, however, to those who knew how to get them and whether BT allowed Mercury the required exchange access. Yours truly, in fact, connected to the Mercury network some two years or more ago (see the July 1987 issue of *Electronics Today International* for details). Since then, I've saved an estimated £150 or so in telephone charges.

However, the benefits of Mercury have not been extended to *all* telephone users yet, as BT is only slowly allowing Mercury the required access to BT exchanges. Nationwide Mercury coverage is still not available. For interested readers, the Mercury network available to private users and businesses is known as *Mercury 2300* and although it's not yet nationwide, it may be to your advantage to call Mercury's customer assistance number (0800 424 194 — a freephone number giving you the pleasure of knowing that BT is paying for the call) to see if your exchange is covered in the network. If it is, all you need to do is buy a new telephone with a Mercury access button on it, from either Mercury itself or a number of high street stores, pay the necessary connection charges and you're away.

Getting back to the gist of my argument though, even this duopoly of telephone network operators (apologies to Hull, again) is struggling to give an acceptable service in terms of price and quality. So much so in fact that it may be advisable for the powers that be to think again and perhaps authorize more network operators. In November next year, the current situation is to be reviewed in the light of recent knowledge about competition, or lack of it, in the telephone network. Let's hope that more operators *are* licensed, hence increasing competition and quality while lowering costs, ultimately ensuring the customer in general finally benefits.



CALL TO	NUMBER CALLED	DATE	TIME	BILLABLE DURATION MINS/SECS	COST CENTRE	COST £
B/F FROM PREVIOUS PAGE						78 580
IRISH REPUBLIC	150098	05/MAY/89	10:26	8:18	10	2 739
SPAIN	543887	05/MAY/89	11:51	0:39	10	0 258
THAILAND	2268140	05/MAY/89	12:48	24:16	34	29 787
BROMSGROVE, WORCS	7372	07/MAY/89	10:30	13:47	88	0 490
HULL	84112	07/MAY/89	20:11	8:37	05	0 271
NOTTINGHAM	22854	08/MAY/89	20:56	7:11	88	0 209
NOTTINGHAM	22858	10/MAY/89	22:34	7:23	88	0.277
HULL	84270	12/MAY/89	21:07	36:08	30	1 502
WANTAGE, OXON	418	13/MAY/89	14:02	30:18	34	7 243
HULL	84270	15/MAY/89	22:29	7:26	30	0.305
NETHERLANDS	5706122	16/MAY/89	19:34	0:19	30	0 118
NETHERLANDS	3438232	16/MAY/89	21:04	3:39	30	1,071
NETHERLANDS	1088880	16/MAY/89	21:55	2:18	30	0.860
HULL	84112	18/MAY/89	22:02	12:10	05	0.489
EDINBURGH	558026	18/MAY/89	22:15	20:02	05	0.751
SHEPSHED, LOUGHBOROUGH	50455	19/MAY/89	23:38	2:02	05	0.083
SHEPSHED, LOUGHBOROUGH	50455	20/MAY/89	11:10	11:26	05	0.469
LEAMINGTON SPA	33672	20/MAY/89	12:00	51:21	55	7 826
BROMSGROVE, WORCS	7372	21/MAY/89	10:27	0:12	88	0.030
HULL	84005	21/MAY/89	21:10	17:52	55	3 182

Example domestic Mercury 2300 billing showing itemised calls and the cost centre method of caller identification.

It's a Fair Cop, Guv

Not far from where I live, in Nottingham to be precise, an experiment is scheduled for 14th August to electronically tag criminal offenders. This is the first of three pilot schemes in the country to study the effectiveness of offender tagging. The other two take place in Tyneside in September and the Tower Bridge area in November. All three schemes are to run for six months.

The schemes use simple passive tags strapped around the offender's ankle. The fact that the tags *are* passive means that they cannot be used to monitor offenders' movements. Instead, a transmitter/receiver arrangement merely checks the tag, and hence the offender, is within operating distance. If not, say if the offender has gone to the shops for a packet of ciggies, the transmitter/receiver warns a central computer via telephone. In this respect, the systems are limited to offenders who are not likely to go walkabout — the passive tag does not allow an AWOL offender to be located once he or she has left the vicinity of the transmitter/receiver. So, the systems allow use with offenders who are effectively under house arrest.

Required legislation regarding electronic tagging has not yet been passed by Parliament. Further, it will be at least another year before it is (if it is) because the Bill to have introduced it last year was dropped due to lack of time in the last session of Parliament. Nevertheless, the pilot schemes will go ahead as planned.

Keith Brindley

BLUEPRINT

This column is a service to readers to provide electronic designs. Send your requirements, with as much detail as possible, to ETI Blueprint, Argus House, Boundary Way, Hemel Hempstead HP2 7ST.

Dear Blueprint,
I would like a circuit for a simple countdown timer able to be set for any time up to 99 minutes, after which it should sound a buzzer. Perfect accuracy is not necessary but it should be reliable to one minute if possible. I would like the counter to be set using the "0-99 event counter" circuit of which I enclose a copy.
Arthur Adams, Luton, Beds.

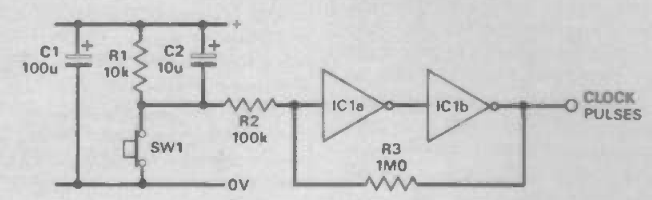


Fig. 1

The circuit which you enclose, from another electronics magazine (tut tut), is not easily adaptable for this purpose in part because it is only an up counter rather than an up/down counter as required for this purpose. One could, of course, start from this design and add the necessary components but the end result would be little like the original and clumsy to boot. In addition, aspects of the basic circuit are inelegant or plain bad practice.

For example, Fig. 1. shows the manual clocking circuit from this design. When the switch is closed, the 10μ capacitor is instantly charged via the switch. A small signal switch would only survive a limited number of clock pulses like this before its contacts burned too much to function. In addition, the sudden connection of an extra 10μ across a power supply decoupled by 100μ will instantaneously lower it by 10%, which could occasionally cause spurious counts.

Accordingly, I have started from scratch to design a new circuit for the function. The first step is to produce an approximate block diagram, shown in Fig. 2. All the boxes drawn here are implied in the requirement as stated. It must be possible to set the counter to a number from which it can count down, so the counter must be able to count up under manual control and then count down under the control of an internally generated clock pulse.

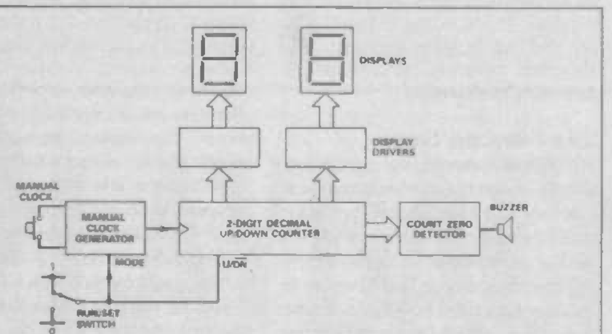


Fig. 2

The minimum counter requirements, assuming that a display of seconds is not needed, is a 2-digit BCD up/down counter. There must be displays, which means that there must be display drivers — unless this function is built in to the counter IC(s). There must also be some means of detecting when the counter reaches zero, in order to switch on the buzzer.

Counters

As the counter circuit forms the heart of the timer, this is a good place to start. The CMOS book offers only a few BCD counters and fewer which are up/down. Examination of the data shows that the 4510 is a good choice. It is an up/down BCD counter which can be cascaded simply and which includes an end of count detector. This will detect when the counter reaches 0 in the down mode and signal when the buzzer should sound. It also includes parallel load inputs which are not needed unless the counter is to be programmed by loading data from a second counter. This opens the possibility of an alternative design using the 0-99 counter to program the timer. This method is more complicated so it will be described after the main design.

The most commonly available CMOS display driver is the 4511 which drives common cathode displays, so this is the one chosen for use here. The next major requirement is to generate clock pulses at the rate of one per minute. Since the required accuracy of the circuit is approximately one per cent, a crystal oscillator is not required. An ordinary RC oscillator followed by a divider chain is probably the most convenient way of generating one cycle per minute. To generate this frequency directly would involve inconvenient component values.

A suitable IC for the job is the 4060, which includes an oscillator stage, and a 14-stage divider. Thus, a basic oscillator frequency of 273Hz will result in the divided-by-2^{14} output of one cycle per minute (0.016666Hz).

Finally, ordinary logic gates and other components are required to implement the functions of setting the counter, driving the buzzer and so on. The whole circuit is shown in Fig. 3. The counters are cascaded for synchronous clocking. The 4510 counter only counts when the clock enable input is at logic 0. Thus the least significant digit has its clock enable input grounded because it must count all the time. The next counter in the chain is only enabled to count for one

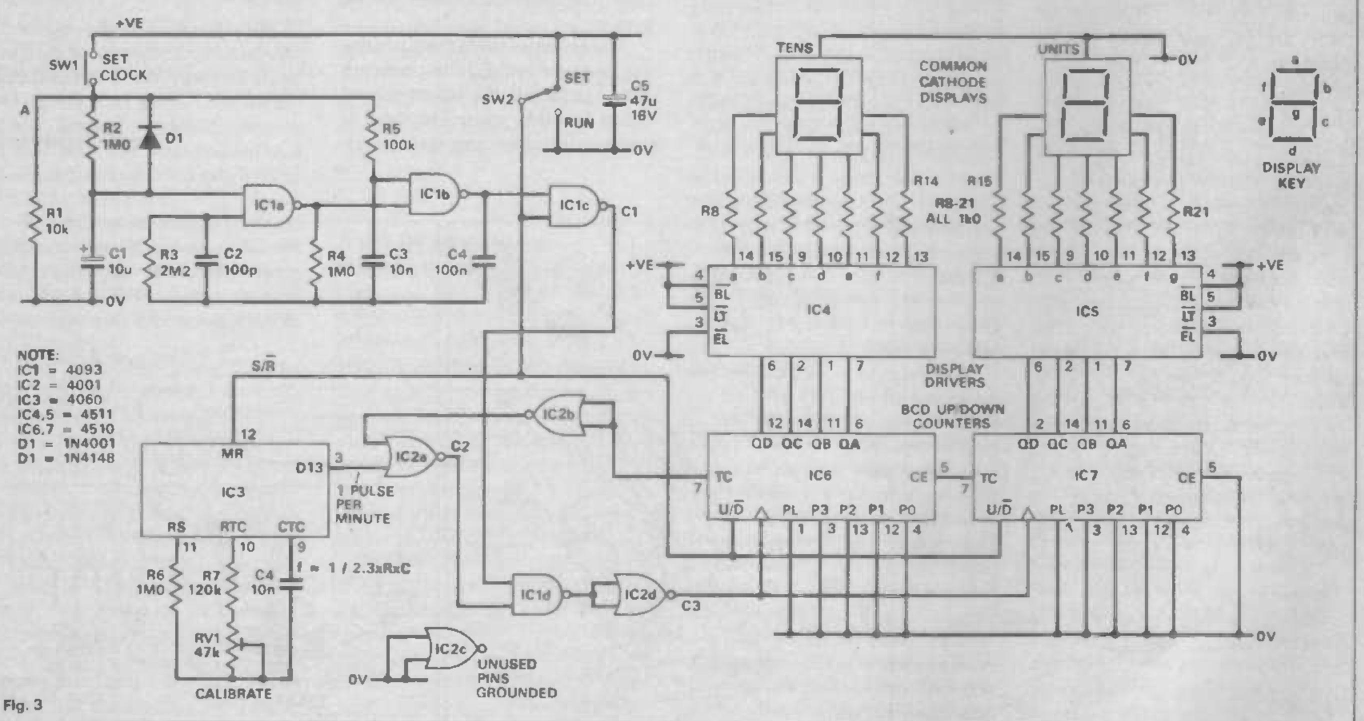
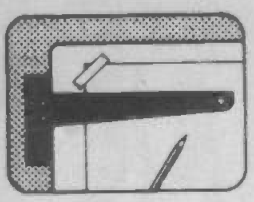
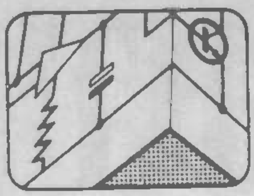
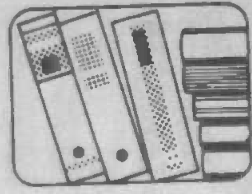


Fig. 3



clock pulse when the least significant digit reaches terminal count (nine when counting up or zero when counting down).

In the down-counting mode, when IC7 reaches zero the terminal count output switches to logic 0. This enables IC6 to count and on the next clock pulse IC6 counts down once, while IC7 counts back round to nine. When eventually IC6 has counted down to zero, its terminal count output will switch to logic zero as soon as its clock enable input is switched to logic zero. This means that the terminal count output of IC6 indicates unambiguously when the time period has expired.

The parallel load inputs of these counters are all connected to logic 0, as they are not required in this circuit. The BCD outputs of the counters are connected to the display drivers, which drive common cathode LED displays. The current per segment is set by the limiting resistors R8-R21 and the value chosen (1k) should provide adequate brightness. Any commonly available common cathode display would be suitable. The display drivers have lamp test, blanking and latch enable inputs. These inputs are connected so that blanking and lamp test are disabled, and the transparent latch passes BCD information straight to the decoder and output.

The Clock

The clock pulse to the counters is provided either by IC3, the clock oscillator, or by the manual clocking circuit using IC1. When the set/run switch is in the set position, IC3 is held reset so that it will always start at zero count and generate its first pulse after a minute rather than generating it at a point determined by the number in the counter at the moment the switch is switched to run. In the set position, IC1 is enabled so that any pulses generated by the clock circuit are passed via IC1d and the 4001 wired as an inverter to the counters. The manual clock generator itself, using two parts of IC1, combines a switch debouncer circuit with a variety of standard CMOS clock generator. If SW1 is pressed briefly so that C1 has not time to charge via R2, the time constant set by R5 and C2 is still short enough to pass the pulse on to IC1b. This time constant is just long enough to remove any switch bounce and provides a clean negative going pulse on the output of IC1b. This is inverted three times in the following gates to become a positive going pulse when it is fed to the counters.

If on the other hand SW1 is held depressed for approximately a second, C1 charges up and the clock oscillator circuit is enabled. This generates a frequency set by R4 and C3 and with the component values given is approximately 5Hz. If this frequency is not

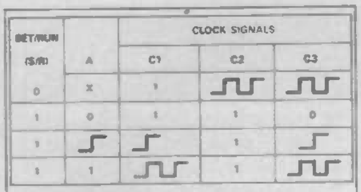


Fig. 4

suitable then different values for R4 or C3 may be tried. Thus the manual setting circuit provides a choice of individual step or fast advance to the counter. The set/run switch also controls the up/down line of the counters, so that they count up in the setting mode and down in the run mode.

When SW2 is in the run position, IC3 is permitted to generate clock pulses while any manually generated pulses are prevented from reaching the counters by IC1c. The only other piece of circuitry affecting the clock generation is the feedback from the terminal count output of IC6. This prevents further clock pulses from reaching the counters when they have counted to zero, so that they remain in this position, displaying 00 and holding the buzzer on.

The buzzer will of course go off immediately when SW2 is switched to the set position again. The functioning of the clock circuitry is illustrated in the truth table shown in Fig. 4.

Calibration

Because of component tolerance, it is possible to build the circuit using fixed value components and expect it to be accurate enough. Therefore, a calibration pot is included to set the time period accurately. If a frequency counter is available, then a measurement of the frequency on pin 9 of IC3 is a suitable means of calibration. RV1 should be adjusted to provide a frequency of 273Hz as previously mentioned. If a frequency counter is not available, then the circuit should be timed over increasing periods and RV1 progressively adjusted to provide an accurate count. In fact, a period of 5 minutes should be more than adequate for the final test, while initial calibration can be carried out over 1 minute intervals.

The long term accuracy of the timer depends on the stability of R7, C4 and RV1. Therefore, a pot with a good positive adjustment (which will not slip round on its own) must be chosen for RV1. A reasonable type of capacitor for C4 would be a polyester or polypropylene capacitor. Some cheap ceramic capacitors have a significant temperature coefficiant and would thus be unsuitable. If this is not accurate enough, and also for the interest of other readers who may want a more accurate circuit, a suitable crystal generated clock is shown in Fig. 5.

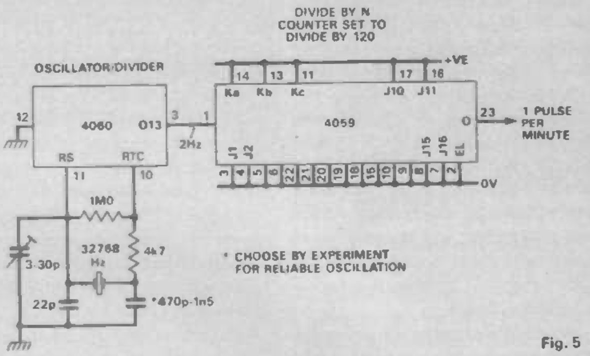


Fig. 5

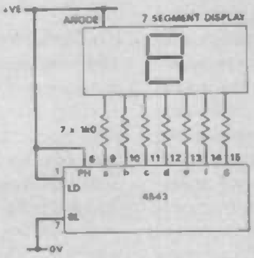


Fig. 6

Other Options

The tenor of the question suggests that components for the 0 to 99 event counter may already have been purchased, in which case common anode displays will be available. A CMOS decoder/driver from common anode displays is available, though it may be hard to track down. The IC to use for this function is the 4543 as illustrated in Fig. 6. In addition to the BCD inputs, this chip includes blanking, latch and phase input controls whether the outputs are active high or active low, and in the active low mode they can drive common anode LEDs. It is even possible, using this IC, to drive liquid displays. The necessary output waveform to avoid putting DC on the displays is provided by feeding both the back plane of the liquid crystal and the phase input of the 4543 from a square wave. This would be worth experimenting with if the circuit had to be battery powered.

So far the subject of the power supply has not been mentioned. Because CMOS ICs used, a highly regulated supply is not necessary. If batteries are to be used to power the timer, four cells in series giving a nominal 6V would be quite suitable and the circuit is liable to work until the voltage falls to under 4V. It is probably a good idea to use a regulated supply of 5V if the circuit is to be powered from a mains power supply in which case the 7805 regulator is suitable. Because of the current drawn by the LED displays, the regulator should be mounted on a heat sink.

Finally, how to use the original 0 to 99 event counter to program the counters in the timer. The resulting circuit is somewhat clumsy and complicated and mixes both TTL and CMOS devices but it is capable of being made to work and it does meet the original request more closely. The method of connecting the two circuits together is shown in Fig. 7. Unless it is a specific requirement to incorporate the event counter circuit, I would recommend that this design should not be used.

Andrew Armstrong

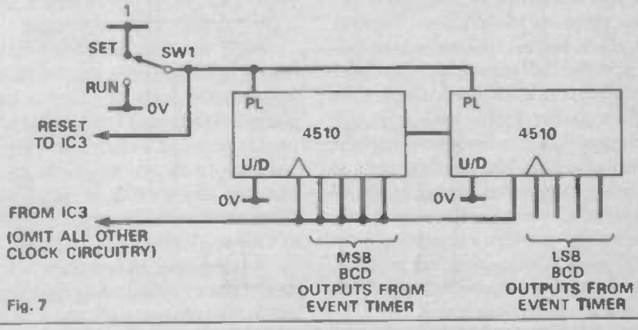


Fig. 7

INSIGHT SMART CARDS

In this plastic age it seems almost incredible to recall that as little as twenty years ago the credit card, or more precisely the 'charge card' as it is known to the issuing companies, was restricted to only a few top businessmen and the world's richest people. Those whose financial status qualified them to carry such a card gained a certain cachet by waving their AmEx cards at hoteliers and restauranteurs throughout the world, long before "that will do nicely sir" had been invented by the image makers!

We now have a situation where the ubiquitous world standard sized (ISO7810) plastic card is available to virtually everyone. Even if we don't want the automatic credit facility that many of the cards bring with them, they are a very convenient means of obtaining money from a hole-in-the-wall of bank, or for getting an up-to-date balance of your account even when the banks are closed. Cards are also used for many other purposes such as providing access to secure areas by means of card-activated security locks, and as telephone cards. The UK government has recently announced that it is considering a scheme whereby those people entitled to various types of social needs payments will be given cards which they can use to collect their cash. We are thus approaching the fascinating situation where *everyone*, from the long-term unemployed to millionaires, will be making use of a plastic card.

Plastic Carrier

It is not of course the piece of plastic that really matters, apart from its ability to carry information in a convenient format. The real heart of the current plastic card is a magnetic strip, just like a piece of audio magnetic tape, which runs down the whole length of the card. This carries information in digital form just as an audio cassette can be used to carry computer programs.

The strip is restricted in the amount of information which it can carry, typically less than 500 bits of data. Even this limited capacity is very useful however — it is quite sufficient to hold information about your bank account number which, when read in conjunction with the Personal Identification Number that you key into the automatic cash dispenser, will act as a security check to prevent unauthorised people from gaining access to your cash. Although in the early days enthusiastic 'hackers' were able to read the magnetic code on the strip, security coding has now been very much enhanced, and the banks claim that very little fraud occurs from this means. However, lost or stolen cards together with careless use of PINs still leads to massive losses.

Since 1974 a great deal of work has been done to try to increase the amount of useful information that a plastic card can hold. This has led to microchips being buried beneath the surface of the card but without increasing its thickness above the standard 0.76mm. These cards can thus contain semiconductor memory, logic circuitry and, in the latest generation of cards, even a full microprocessor and memory chip. We have effectively got a complete computer down to the size of the plastic card. It's not too surprising then to find that these latest cards with an embedded microchip have gained the name *smart cards*.

Pocket Phone

The simplest smart card is merely a *memory card*, which contains 512 bits of RAM and is fairly inexpensive to produce. This type of card has been used in France as a telephone card. The memory is filled with data after the card has been manufactured and then each time the card is used to make a telephone call part of the RAM is blanked out, which effectively subtracts the cost of the call from the credit originally available on the card. The card reading equipment communicates with the circuitry on the card either via small gold plated contacts, by means of an inductive loop, or even using very low powered radio transmissions.

This latter system gave rise to unfavourable comments in the public press when it was suggested that smart cards should be used to identify football fans, in order to keep hooligans out of the grounds. All sorts of scare stories have been put around suggesting that the radio signals from the card reader might be able to get the card to respond and give up its information whilst the card is still in your pocket, so that a card could be made to yield up confidential information about the card-holder without his even being aware that it has happened. This would certainly be worrying if it were true, but would require the fitting of a very powerful transmitter on to a card, which currently seems unlikely. The potential interference threat that millions of cards radiating high-power signals could present leads me to conclude that such a thing would never be allowed!

Note that the telephone cards issued by BT are not smart cards, but holographic cards in which a laser beam burns away a small area of the card as each unit is used. These single-purpose cards are evidently much cheaper and simpler to make than smart cards, but are much more limited in their applications.

A step further on from the memory card is the so-called *wired logic card*, which contains not only some 4.5Kbits of semiconductor memory but also some fixed-logic circuitry which is hard-wired at the factory for a specific purpose and which cannot therefore be programmed later on. The logic circuitry can be used, for instance, to check the validity of the PIN number that has been entered, before allowing any changes to be made to the information in the card's memory. Simple logical programs can be built in, such as to allow the usual three attempts at inserting a wrong PIN number before turning the card off altogether.

Plastic Gas

Such a card could theoretically be used as a portable bank. The owner would first go to the bank and have money from his account transferred to the card — using a special identification number known only to the bank, the cashier can put information into the card's RAM to represent the money deposited. Whenever the card user needs to make a payment, for petrol say, he then inserts the card into the card reader at the petrol station. This erases part of the RAM on the card, sends the payment to the bank account of the petrol company and then displays the remaining credit. The card can be 'refilled' by a further visit to the bank or by electronic funds transfer via a bank machine.

The security aspects of such applications worry some people and so most applications of this type are actually being carried out using the most sophisticated type of smart card — one that incorporates a complete microprocessor chip and currently up to 8K of memory, with 16K being promised for later this year.

Such cards are programmable for each individual application so there is no need for different logic circuitry to be manufactured for each different use and these microprocessor cards are therefore extremely flexible(sic).

It is the built-in 'intelligence' that these cards possess which gives them their advantages. All sorts of computer processing operations can be carried out on the stored data and special circuits prevent any modification of the data by anyone other than the authorised user. This makes it extremely difficult for the card to be used fraudulently, as PIN numbers are held in the memory in encrypted form and the microprocessor itself has to be utilised before the code can be decrypted. A trial is about to take place in various parts of the UK, where patients will have all their medical records committed to the microchip, so that doctors will have instant access, via their card reader, to such information as the drugs that a patient is currently taking, or the substances to which he is allergic. In the case of a road accident or sudden collapse, this information could prove to be a life-saver.

Students at Loughborough University are currently taking part in a trial, using smart cards for all their everyday on-campus shopping needs. The information that is gained from this trial should enable the banks concerned to highlight any snags in their systems before making them available to a wider audience.

Cards In Space

The introduction of satellite broadcasting in Europe has brought with it a need to scramble and encrypt the programmes, so that viewers will not be able to watch certain programmes, especially newly-released films, without paying extra for them. One method of payment, which will be used by some movie channels from the autumn of this year, will make use of smart card technology. Each month viewers who want to subscribe to various channels will either be sent a card through the post, or go to the Post Office and have their smart-card credit renewed. Plugging the card into the decoder unit at home will enable the receiver to decode the correct decryption keys to allow the receiver to unscramble the programmes which have been paid for.

Since each decoder will have chips containing its own individual keys, and the number concealed in the smart card will have to match the decoder's keys, the smart cards will not be interchangeable and should provide a fairly foolproof and convenient method of ensuring that the programme makers get their monetary rewards.

The one problem I can foresee with all these cards is the sheer bulk of all the different cards that we may need to carry in our wallets. Already it is not uncommon to see people shout 'Look at that plastic!' and display a dozen or so cards in special holders.

The smart card could hold the solution to this problem however. A card with a processor and 16K of memory has virtually the same processing power and storage as personal computers did three or four years ago. It should therefore be possible to have just one smart card that can act as a personal identify card, credit card, cash dispenser card, medical history card, and club membership card as well as a driving licence and national insurance card — even your front door key, surely the ultimate in convenience. There is just one snag. Such a card would contain virtually all the details of your life and loss or theft would be disastrous. You really would be lost without it!

Jim Slater

READ\WRITE

ETI LETTERS

RELATIVE MERITS

Congratulations to your magazine on the remarkably well presented explanation of Einstein's theories in Stephen Malone's article Relativity (July 1989). I am not really an electronics enthusiast (I heat my fingers more than the components) but was attracted to ETI by the colourful (if somewhat gaudy) Einstein cover (someone in your art department trying to be Andy Warhol for fifteen minutes?).

What surprised me most about the article was the level of mathematics that you were prepared to include. Are your readers capable of following six variable transform equations? I appreciate that a full explanation of relativity would be nigh on impossible without the Lorentz equations and your inclusion made the article far far more clear and precise than any others I have read. I just wonder how many readers will have run away when they got to the maths.

I will be checking your publication for other similar articles (unified theory, superstrings?) in the future.

Yours faithfully,
Brendon Palmer
Gravesend, Kent.

Never underestimate an ETI reader! It is true that the maths in Stephen Malone's article is a trifle above school level and might even give some graduates cause to crease their foreheads. However we did attempt to isolate the problem by putting the main transform maths in a tinted box leaving the main text skirting around the issue for those who turn green at the words 'integrate by parts'.

Regarding further articles, the subject of unified field theory might be best explained when there actually is one, although we covered most of what there is so far in our quantum physics article 'It's A Small World' (also by Stephen Malone) of September 1988.

MNEMONICS

The main reason for sending this letter is to tell you a resistor mnemonic that will hopefully meet your approval and beat Mr P Lefley's (July) to a free subscription.

It is: Be Big Reader Or You Get Bad Vocation With Gargantuanly Small Pay.

I would also like to comment on the new additions to your magazine, these being the Free Readers Ads (which are likely to be very popular) and the cartoons (especially the fusion one).

Both of these are a welcome sight.
Kirk Chapman,
Coventry.

Gargantuanly small? Yes OK, you win this month's free subscription. The second mnemonic you supplied in your letter was . . . er . . . rather rude, and we thought it best not to print it. Our mothers would be shocked. The Readers Ads are nothing new, but we are unable to run them every month for reasons of space.

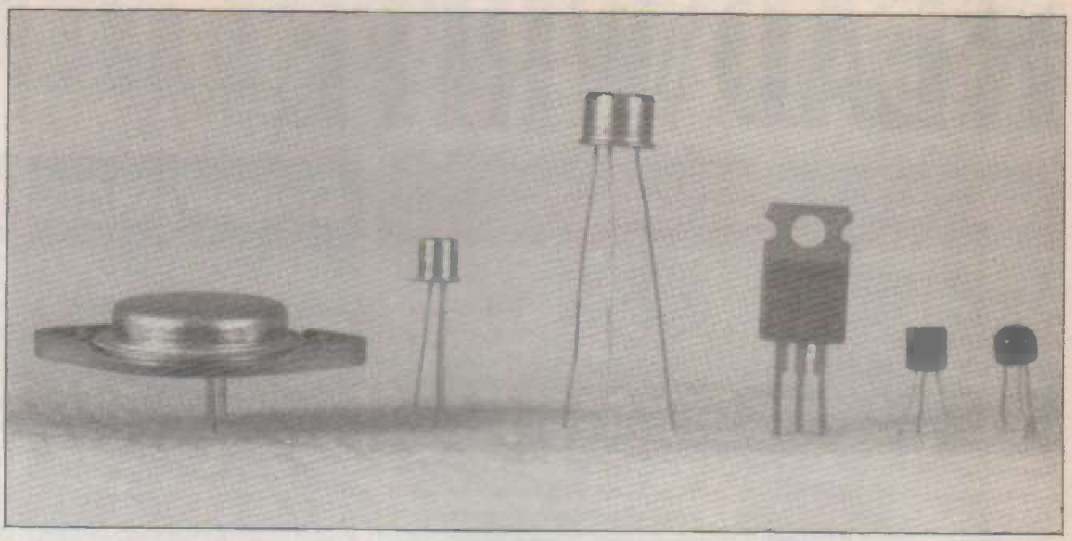
SAGE

When oh when are you going to do a full review of the Sage SuperMOS II modules? You did a news piece when they came out and promised a detailed review, but I have waited in vain. If they're as good as the spec in the ads then I want a pair, but would value ETI's judgement before parting with the money. How long?

Yours,
A Drew
Bristol.

Our apologies, the review and testing have taken longer than anticipated. The procedures are however approaching completion and we can say with something approaching certainty that the piece will appear in October or November.

. . . AND THEN THERE WERE



TRANSISTORS

John Linsley Hood leaves the venerated valve to take a look at less-dated diode and transistor theory

TRANSISTORS

For a would-be electronics engineer, seeking to learn his craft in the 1930s or 1940s, the way valves worked was a quite straight forward business to follow — the cathode got hot and emitted electrons and these were captured by the anode provided that the grid would let them through. In many ways, the transition from 'hot-cathode' to 'solid-state' has been a wonderful thing for electronics, but one must admit that the technology of semiconductors is a much more complicated business.

This has often meant that a first inquiring look at the theory of solid-state physics has been so discouraging, with its jargon of 'forbidden bands', 'Fermi levels' and 'minority carriers', that the reader has simply given up and adopted the approach of treating all semiconductor devices as black boxes which behave in a more or less predictable manner when one applies voltages or signals to their connecting wires.

I think that to take refuge in a black box approach is a bit of a pity, since the basics of semiconductor action is really quite simple. If one comes to terms with it, a lot of puzzling phenomena suddenly become quite obvious. So let us have a look.

Why And What Are Semiconductors

Electric current is the movement of electrons. These will travel, if they can, from a negative (electron surplus) terminal to a positive (electron deficient) one, provided that there is some path through which they can pass. Yes, positively charged ions can also migrate, through a gas or a conductive solution, from a positive terminal to a negative one, but this is not the normal form of current flow.

Electrons are one of the three major components of the atoms of all materials, the others being protons and neutrons that reside within the nucleus of the atom. These do not concern us much in this particular subject, but electrons do and they can be thought of (as a visually helpful though inaccurate model), as

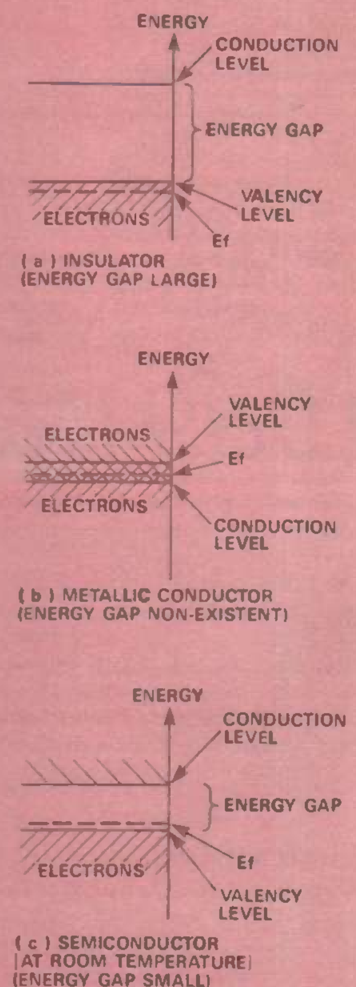


Fig. 1 Electron energy levels and distribution in insulators, conductors and semiconductors

being like tiny balls in planetary orbits around the nucleus, retained by the electrostatic attraction between the negatively charged electrons and the positively charged nucleus.

Whether any given material is a conductor or an insulator will depend on whether these electrons around the nucleus can move from atom to atom through the material. To understand why this should be, it is better to consider the electron structure of the atom in terms of its energy distribution, in which those electrons in the closest orbits to the nucleus are of low energy, while those in the outermost orbits have the highest energy.

Normally, all the low energy levels (orbits closest to the nucleus) will be filled, but this can leave the highest level with an incomplete quota depending on how many electrons the atom has. The number of electrons left over in this highest energy level will then determine the chemical relationships between dissimilar elements, or the crystal structure of any single pure material.

As the outer electron energy shell determines the chemical characteristics of the atom — what chemists refer to as its 'valency' — this shell is called the 'valency level' and it represents the greatest energy (largest radius and greatest orbital velocity) which the electron can have and still be held by the attractive force of the nucleus.

If the electron gains enough energy, through thermal agitation or some other agency, it can escape from the pull of the nucleus and join a wandering cloud of electrons moving from atom to atom. There is however a minimum energy level required for free electron movement and this is called the 'conduction level'. When there are electrons in this state, the material is to some extent a conductor.

Between the maximum captive electron energy at the valency level and the minimum mobile electron energy in the conduction level there is a no-mans-land where electrons do not exist. This is called the 'energy gap' or the 'forbidden band'.

A typical energy distribution diagram for the electrons within an insulator is shown in Fig. 1a. That for a good conductor, such as a metal, is shown in Fig. 1b. The obvious difference is that there is a wide energy gap between the valency level and the conduction level in an insulator, but none at all in the case of a conductor.

The semiconductors, as their name implies, are those materials which are half way between the metals and the insulators — chemically about halfway across (group four) in the periodic table of elements — and these have an electron energy distribution of the form shown in Fig. 1c.

In this the energy gap is small, and at temperatures above absolute zero (−273°C), some electrons will gain enough energy from thermal agitation to jump the energy gap and occupy the conduction band. This would represent the condition in an 'intrinsic' (ie pure) semiconductor material, which would be quite a good insulator at absolute zero, but slightly conductive at room temperature.

The Effect Of Doping

Many of the pure elements in group four of the periodic table, (such as carbon, silicon or germanium), which have four outer valency electrons, will crystallise in a near cubic lattice in which the outer valency electrons will be shared between adjacent atoms to make up the optimum outer orbital shell of eight electrons, as shown in Fig. 2.

However, there are chemical elements in group three and five, such as aluminium or phosphorus, which have a similar atomic size but with either three or five outer valency electrons.

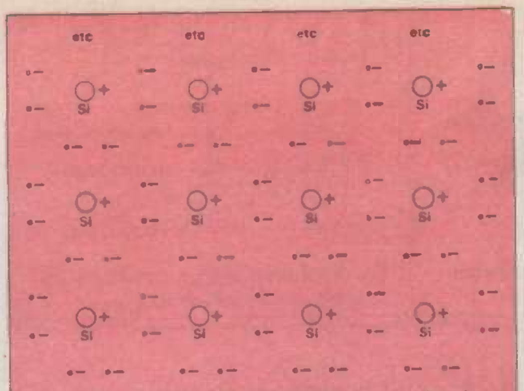


Fig. 2 Crystal structure of regular 'tetravalent' atoms showing shared valency electrons

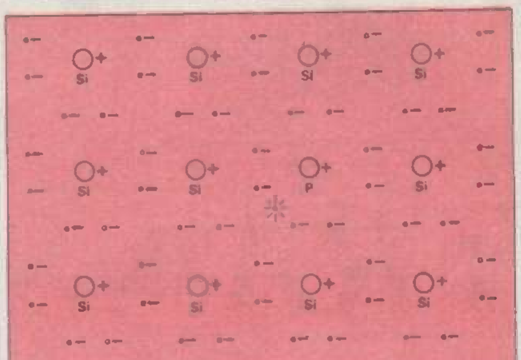


Fig. 3 Effect on electron distribution in silicon crystal lattice of an n-type type impurity in the crystal

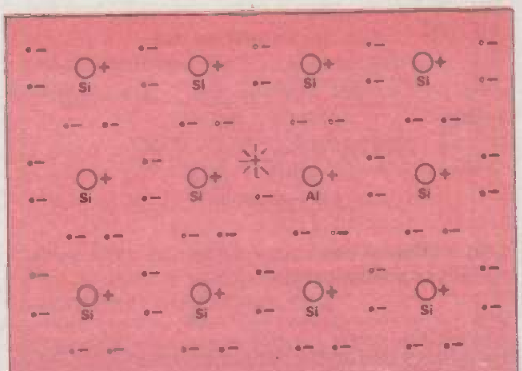


Fig. 4 Effect on electron distribution in silicon crystal lattice of a p-type inputity in the crystal

If these impurity elements are introduced (called doping) in trace quantities into the silicon crystal then the harmonious arrangements of shared valency electrons are disturbed, as shown in Figs. 3 and 4. This gives either a condition of electron surplus, called an n-type material, electron deficiency or called p-type, depending on whether the inpurity which has been introduced has five or three valency level electrons.

It is of course possible, though difficult and expensive, to persuade a mix containing an equal number of trivalent (3-electron) and pentavalent (5-electron) atoms to crystallise together to make a similar structure to that shown in Fig. 2, and gallium arsenide is a practical example of this. However, achieving the desired condition of a controlled small surplus or deficiency of either element in these 3-5 type crystals, to get a p-type or n-type resulting material, is very tricky.

In the case of an n-type semiconductor, the surplus orbital electrons in the crystal structure will be free to migrate from atom to atom, and are in consequence in the 'conduction band' so far as the

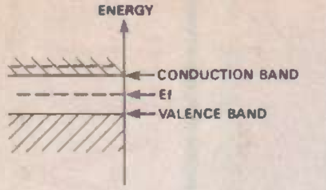


Fig. 5 Electron energy distribution in an n-type semiconductor

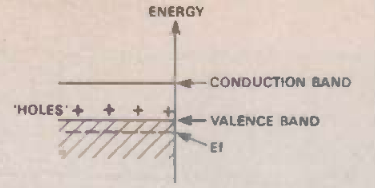


Fig. 6 Electron energy distribution in a p-type semiconductor

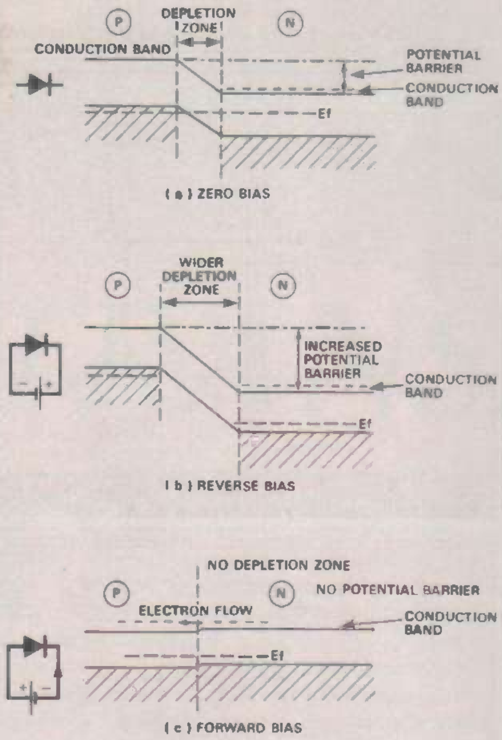


Fig. 7 Effect of bias in potential barriers and depletion zones at p-type junction

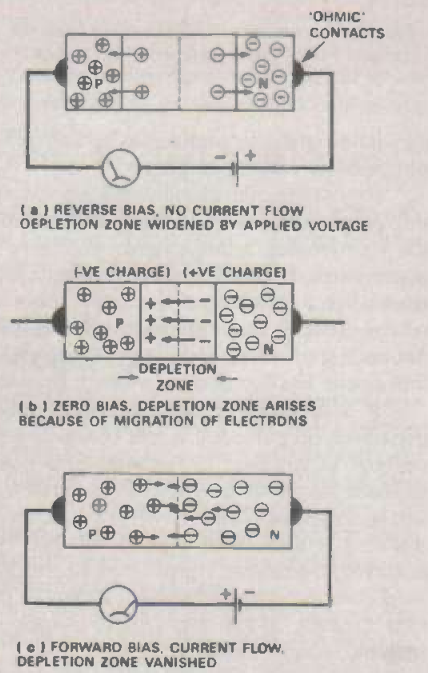


Fig. 8 Origins of 'depletion zone' and effects of forward and reverse bias

electron energy distribution is concerned. This leads to the type of energy pattern shown in Fig. 5.

On the other hand, a p-type semiconductor will not have any spare electrons to occupy the conduction levels, even allowing for thermal agitation. Indeed any which appeared at the valency level would simply fall into the 'holes' where electrons should have been. This gives the kind of electron energy distribution shown in Fig. 6, and this is where we come to 'Fermi levels' or 'Fermi energies'.

However, before leaving the subject of the effect of doping, it is necessary to note that both n-type and p-type doping greatly increases the conductivity of the semiconductor material, by comparison with the 'intrinsic' (undoped) crystal.

The reason for this is obvious in an n-type material, since the greater number of free electrons in the conduction band make it resemble the true metallic conductor of Fig. 1b. However, even in a p-type material, the presence of 'holes' allows electron movement, since under an applied electric field, electrons can move to fill holes, leaving other holes where they were, and so on.

For all practical purposes therefore, holes in a p-type material behave exactly like positive electrons, with the major reservation that because the flow of holes actually consists of a cascade of individual electron movements, it is much slower than the equivalent electron flow.

Fermi Energies

Enrico Fermi was an Italian physicist who proposed a theoretical model of the electron structure associated with a multi-electron atom, and one of the ideas he made use of was that of the average energy of the electrons within the atom. Consequently, this average energy is called the 'Fermi energy' (Ef).

Since the electrons in the conduction band have a higher energy than those of the valence band, an n-type material with quite a lot of conduction band electrons will have a higher average electron energy than an undoped material. An undoped material has fewer such electrons, and a p-type material has none at all.

This gives rise to the different levels of 'Ef' which I have shown as a dotted line in Figs. 1, 5, and 6. This leads to some interesting effects if an intimate contact (such as a single crystal structure) is made between an n-type and a p-type semiconductor.

In this case, electrons at different energies will migrate backwards and forwards across the p-n boundary much like a liquid in two interconnected tanks, until the energy levels on both sides are the same (Fig. 7a).

This has the effect of displacing the relative energy levels of the conduction bands on either side of the junction so that there is now an energy or potential barrier to prevent the continuous flow of the electrons in the n-type conduction band across to the other p-type side of the junction.

If a reverse voltage is applied across the p-n junction, the potential barriers will increase as shown in Fig. 7b, making it even more difficult for electrons to cross it. On the other hand, if a forward voltage is applied, it will reduce the size of the barrier until it disappears (Fig. 7c).

This is the cause of the well known characteristic of semiconductor junction diodes that a certain potential must be applied in order that any current can flow, even in the forward direction.

The Depletion Zone

Although no continuous electronic current will flow across a p-n junction in the absence of a sizeable forward potential (there are some exceptions to this, which I will come to later), thermal agitation will cause some electrons from the n region to diffuse across the junction to fill the holes in the p region. This will lead to a zone on either side of the junction which is completely devoid (depleted) of both holes and surplus electrons, shown in Fig. 8b.

When the electrons leave the n side of the junction they leave a positive charge on the atoms from which they have escaped. Similarly, when they occupy holes on the p side, they build up a negative charge as a result of their presence.

This accumulating charge developed across the junction discourages any further electron flow once it has reached some specific level, determined by the p-n junction 'potential barrier' of the semiconductor material in use. This determines the normal width of the depletion zone for any given value of voltage or doping level.

However, if a voltage is applied across the junction, this depletion zone will change in width, growing wider for a reverse bias and narrower with a forward potential as shown in Figs. 8a and 8c.

This is really just an alternative way of looking at the effect of a change in an externally applied junction voltage on the 'potential barriers' (Figs. 7a, 7b and 7c) though remember that electron energy diagrams will show 'potentials' as more negative at the top of the diagram.

Forward And Reverse Conduction Characteristics

In a perfect junction diode, no current will flow at any reverse voltage. In practice though, imperfections in the crystal structure and unwanted residual impurities in the material will always cause some reverse leakage current. As the reverse voltage is increased, leakage electrons will increase in velocity. These will then cause ionisation and more electron-hole pairs by collision with other atoms in the material.

This, together with the forward potential barrier, causes the type of conduction characteristics I have shown in Fig. 9, where once the voltage is reached at which reverse conduction occurs, the current flow then increases rapidly.

If the doping level is increased, the width of the depletion zone will be reduced, and since the electrostatic stress produced by a given voltage will increase as the separation between the two charged layers is decreased, the inevitable leakage electrons will be more highly accelerated and will cause more electron-hole pairs by collision. This occurs up to the point where an avalanche of current carriers is produced.

This causes quite an abrupt reverse breakdown effect to occur in highly doped materials at a voltage which will be determined by the doping levels of the material to give the sort of reverse voltage characteristics shown in Fig. 10.

These types of 'avalanche' diode come in very handy for voltage reference use, in the kind of circuit shown in Fig. 11. Moreover, they don't mind the reverse current flow provided that the resulting thermal dissipation is within their limits.

Excessive thermal dissipation, because of too much current, is normally the only reason why ordinary rectifier diodes will fail, owing to excessive reverse voltage being applied. Hence, diodes are designed with high breakdown voltages.

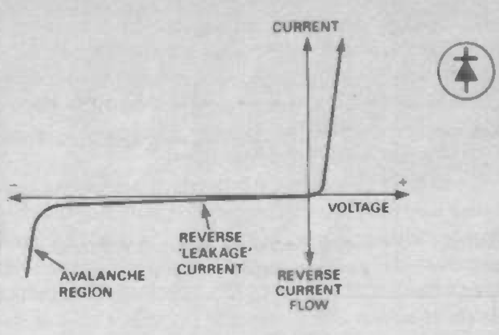


Fig. 9 Conduction characteristics of p-n junctions

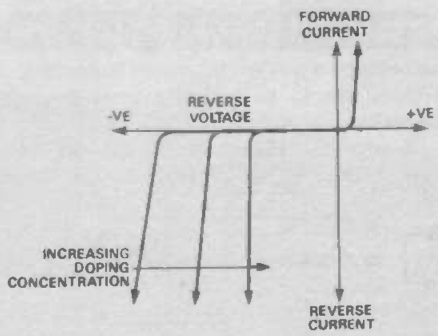


Fig. 10 'Avalanche' breakdown characteristics of diode for three different doping levels

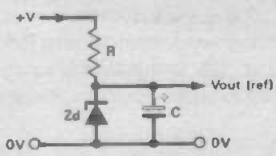
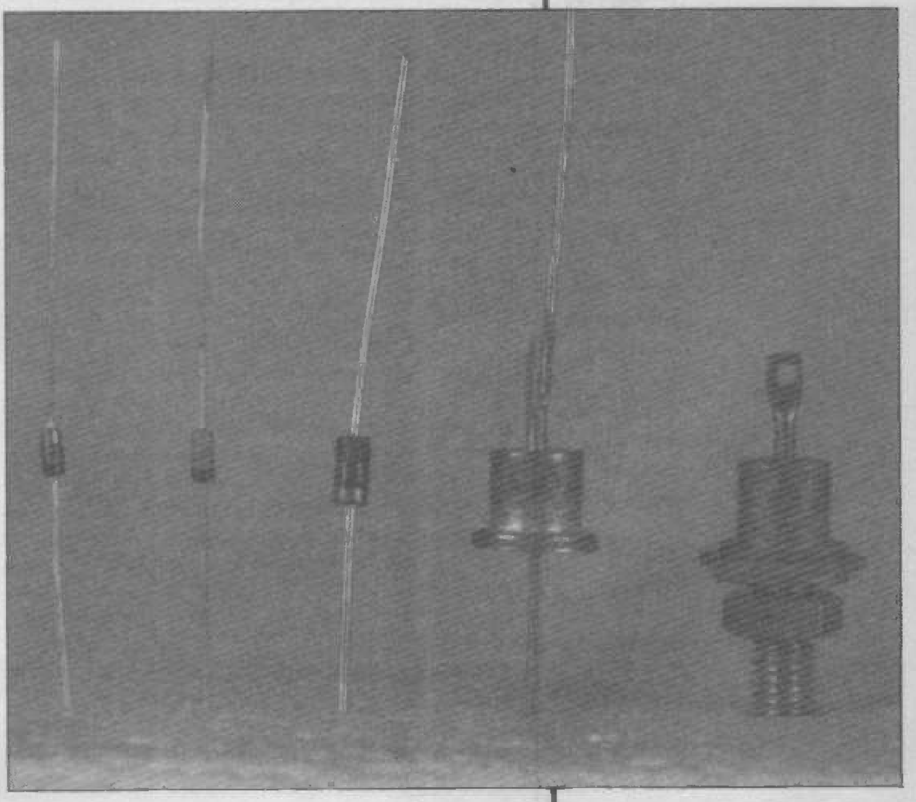


Fig. 11 Simple voltage reference circuit using avalanche or zener diode



Zener And Tunnel Diodes

The voltage reference diodes which I have just described are normally called 'Zener' diodes, as a convenient term, but really this name should only be used to describe a rather different kind of device having a much higher doping level and a rather different way of working.

To understand this, it is necessary to have a look at the way the potential barrier diagram is affected by higher doping levels, in the manner which I have sketched in Fig. 12. The situation at zero forward bias is as I have shown in Fig. 12a, with the two energy levels at which electrons exist on either side of the junction and separated by a very narrow energy gap.

If the negative bias is increased, the resulting increase in the potential, barrier brings these two energy levels opposite each other, shown in Fig. 12b. If the depletion zone separation is small enough, the electrons can move from one side of the junction to the other by a process known as 'tunnelling'. This also gives rise to an abrupt reverse breakdown characteristic.

Clearly, this reverse conduction process will continue with an increase reverse voltage, the effect of which is shown in Fig. 12c. True Zener diodes only exist at breakdown voltages in the range 2.5 - 5.5V. Above this voltage level, such diodes will be avalanche types.

This distinction is worth remembering, since avalanche breakdown is a very noisy business. Indeed, a diode operated in reverse breakdown conditions makes quite a good wide-band 'white noise' source. By contrast, electron tunnelling is relatively noise free.

If the extent of the doping is increased still further, the energy bands in which electrons exist can be at the same energy level, even at zero forward voltage as shown in Fig. 12b. In this kind of junction, electrons can flow easily in both directions, even at very small potentials.

On the other hand, if the forward bias is increased, the energy levels at which tunnelling can occur are separated and the current flow is reduced, shown in Fig. 12c. Finally, if enough forward bias is applied, the diode will conduct as a quite normal p-n junction. The energy diagram for this is shown in Fig. 12d.

The combination of these modes of operation causes the kind of conduction characteristics sketched in Fig. 13. This allows the device to be used as an oscillator if just enough bias is applied to cause it to operate at the point 'X' on its conduction curve. This reduction in voltage across the diode will cause an increase in current flow, otherwise known as 'negative resistance'.

Ohmic Contacts

A standard requirement is to be able to make non-rectifying (otherwise known as 'ohmic') contacts with pieces of semiconductor material in order to be able to connect them into external circuitry. The fact that electrons can easily tunnel backwards and forwards through the thin depletion layers between very highly doped regions provides a simple method of doing this.

Aluminium is used to give a p-type inpurity within silicon, so if a layer of aluminium is deposited on a heavily doped n+ layer and then heated, enough aluminium would diffuse inwards to cause a very heavily doped p++ layer in contact with the n+ region. This will make a bidirectional tunnel-type junction.

On the other hand, if the aluminium is deposited on a region which is already p+ doped, all that will happen is that the impurity concentration, and hence the conductivity, will increase up to the point of contact with the metal. The contact p++/aluminium is a non-rectifying junction.

In the second part of this article I will look at the ways in which the basic p-n junction technology has been extended to provide a whole family of amplifying and switching devices.

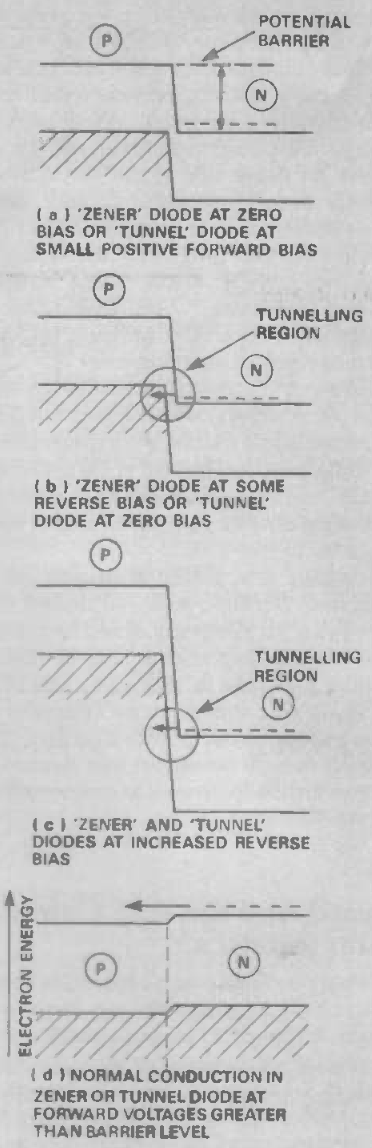


Fig. 12 'Tunnelling' effects in highly doped p-n junctions

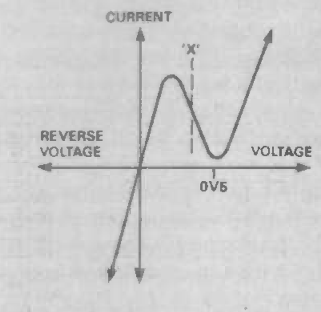


Fig. 13 Tunnel diode characteristics

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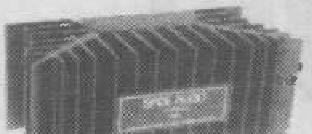

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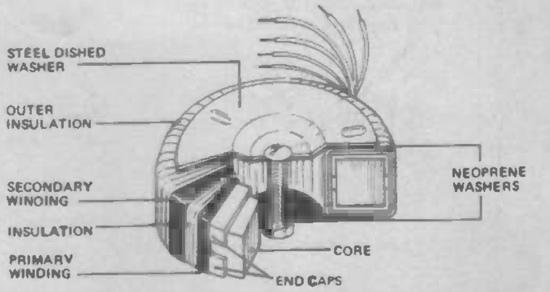

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MAKING TRACKS

REVIEW

Dave Bradshaw examines two PCB design packages and makes his choice between tape and dis

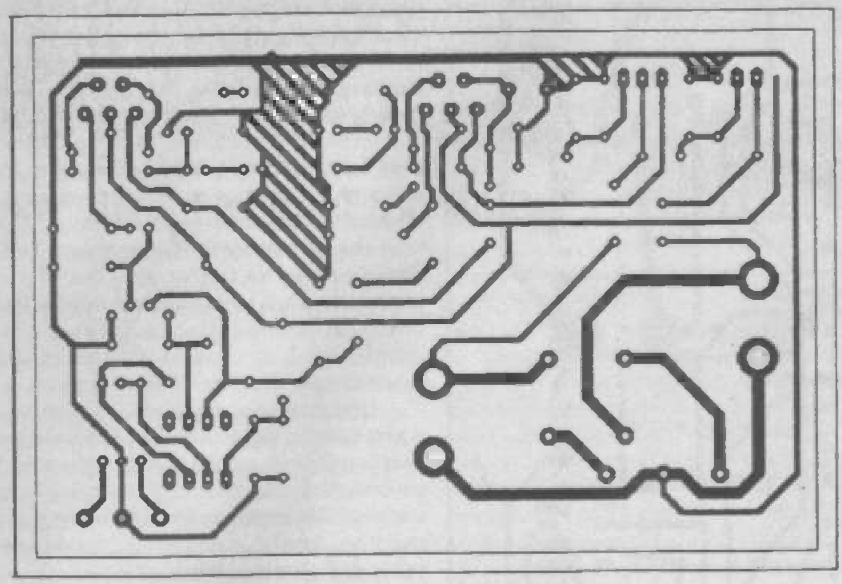

Fig. 1 Example board output from Easy-PC

Using crepe tapes and pads to make PCB foil masters is a time-consuming and occasionally messy business (especially if your scalpel falls blade-first into your leg, as happened to me once). Computer software packages for PCB design have been around for quite a while — so why do people still use tape?

The answer is that computer programs do not solve all the problems by themselves. I have used tape for many years and I know I can get usable results even at 1:1, and if I've access to a suitable camera my 2:1 patterns are close to professional level (quite a number have appeared in the august pages of ETI).

However, the lure for a PCB package has always been the ease of re-jigging patterns after they've already been part-designed. It is a real pain to do this with tape. Besides the waste of the tape and pads (and they are not of negligible cost), it always leaves smears on the film so that sooner or later you have to start again.

So let's set out the criteria that an ideal PCB design package would have. Obviously for amateur or semi-professional use it has to be cheap. You can buy some wonderful packages if you've got £20K around for software and a graphics workstation to run it on, but that's certainly well outside my budget.

It has to be easy to use - unless you're earning your living by it, you'll only want it occasionally and time spent re-learning or ploughing through the manual is time completely wasted.

There has to be some means of getting a usable output from a dot-matrix printer. Whilst plotters are gradually coming down in price, they're still very hard to justify on the budget we're talking about here. An alternative could be some sort of plotting service, but it would have to be very quick and cheap.

Finally, and most importantly, the software has to offer some real advantage over tapes. It must be more than a gimmick!

The two packages reviewed here are *Easy PC* from Number One Systems and *PC-B* version I (there is also now a version II) from Labcenter Electronics. These two packages illustrate the range of low-cost PCB design packages admirably. They were reviewed on an Amstrad 1640 with an EGA monitor.

Easy-PC

When loaded up, an initial menu offers four items — design PCB, design PCB symbol, design schematic, and design schematic symbol. Selecting design PCB moves you straight on to the design screen where, but for an outline square, three hashed pads at the top and some rather meaningless (at first) numbers at the bottom, there's nothing to help you.

In fact the central square represents an area 17in square, which is the maximum working area of the program. Hitting the Z key zooms into the area (U zooms out) or the required level of magnification can be directly accessed just by hitting the appropriate number key (1 gives a screen area equivalent to 0.5in by 0.3in across the screen; 7 displays the full 17 × 17in area in the middle of the screen). Pressing the 'pan' key, P, moves the layout so that the current cursor position moves to the centre of the screen.

Clicking the left-hand mouse button with the cursor (a small white cross or full length cross-hairs) on any of the hashed pads pops down a menu. The main menu contains such items as edit track, lay track, edit pad, lay pad, edit symbol and so on, plus access to the filing system and library system. Selection is made by clicking the mouse on an item or via the function keys (which don't require the menu to be shown).

Laying a pad requires two clicks of the mouse buttons, once on the left to put it in position and a right click to fix the pad. Pads can be set to 'snap' to grids of 0.1, 0.05 and 0.25in, or can be laid completely freehand. There are 16 different pad sizes (one size for automatic via holes) and 12 different pad shapes.

After fixing, pads can be edited through the menu command or by positioning the cursor and pressing F3. The cursor snaps to nearest pad, which can then be moved, changed in size or shape, or deleted.

EASY-PC retails at £98+VAT. A simpler version of the program, TINY-PC, costs £49 including VAT. For details contact:
Number One Systems (ref ETI),
Harding Way,
Somersham Road,
St Ives,
Huntingdon,
Cambs PE17 4WR.
Tel: (0480) 61778.
PC-B retails at £69+VAT. There are also two more powerful versions: PC-B Pro at £229+VAT and PC-B AR (auto-route) at £399+VAT.
For details contact:
Labcenter Electronics,
14 Marriner's Drive,
Bradford BD9 4JT.
Tel: (0274) 542868.

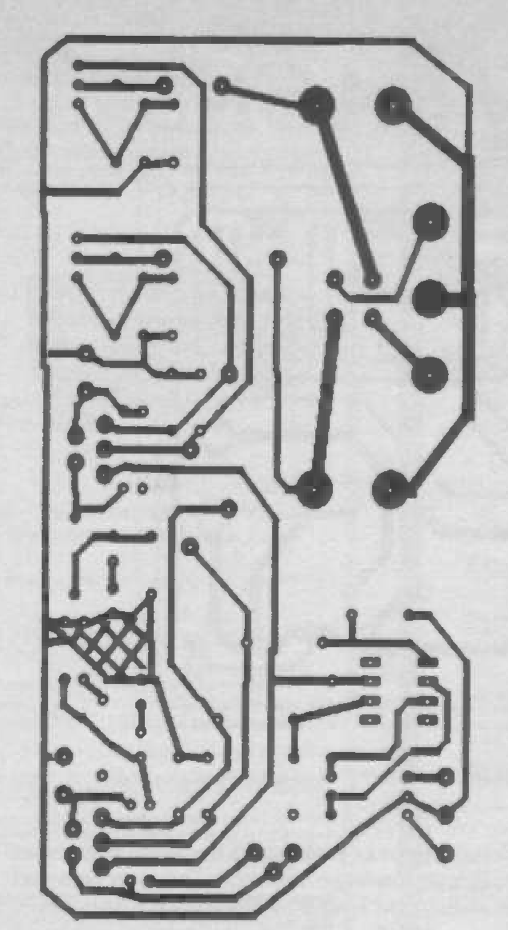

Fig. 2 The same board produced by PC-B

An alternative to laying pads one at a time is to use symbols — collection of pads with a silk-screen layer pattern added. The program came with a very limited number of these in the library for different sizes of DILs, but there is no reason why the user shouldn't build up this library considerably to cover objects as mundane as resistors through to complex patterns for connectors.

Tracks are positioned by selecting F2 then clicking left once to start and again to insert a node (fixed point). There are eight widths of track. The program introduces 45° angles automatically into the track if the two points are not along the same axis or a diagonal, although it always seems to put these in the opposite way to which you want. You can 'flip' the angle, but I found it easier to define the bending points where I wanted them by putting nodes there.

A single track can have over 100 nodes. The delete (D) direct command deletes successive nodes starting with the most recent one. Clicking right on the mouse fixes the track.

One very nice feature is that if a track is laid over a pad (or a pad on top of a track) the central hole of the track is automatically left open. Selecting the 'rubber band' option shows the possible positions of the track with a dashed line as the cursor is moved around: without this option the track section is not shown until the next node is selected.

Editing tracks is achieved by selecting F1 — the cursor will move to the nearest track end node. There is a way then of moving along the track and deleting individual nodes; however I found this rather fiddly and usually ended up deleting the entire track and starting again. In other respects, I found this function easy to use.

There are block functions which allow you to copy, move, flip rotate or delete a rectangular area of the layout in one go. It is possible to separately manipulate the pads and the tracks from the box. You can also print out the area in the box on its own.

I could carry on for some time describing further features of this program such as the saving prompt or the symbol handling, but the point is made: this is a very powerful package, almost bewildering in its complexity. I found that when I first booted it up, I really did need to diligently work through the tutorial section of the manual! This program is not over-friendly and it wasn't possible just to start laying pads and tracks. I suspect that it is going to be very hard to pick up and use again in a couple of months time, although if you're using it fairly frequently you will obviously have far fewer problems.

The programs allows you to output either to an Epson-compatible printer or to an HP compatible plotter, although I was unable to test the last part. At double-scale on my Epson LX-800, the foil pattern was of usable quality, provided the tracks were not thin in which case a 'staircase' effect appears.

One thing the program does have, which I feel is a bit over the top, is the ability to handle multi-layer boards with up to eight track layers. I would think that anyone designing boards of this complexity should use a full CAD system with auto-routing, design rule checking, simulation and so on. Mistakes can be very costly at that sort of level.

A final small criticism is that the mouse is a bit 'draggy' using my Amstrad. Obviously a faster computer would speed up the mouse response time considerably — I'm presently considering adding a maths coprocessor or swapping the 8086 for an NEC V30 and we'll let you know if that makes any great difference.

In summary, this is a very good, professional program which passes on all points except the user interface, which lets it down. Admittedly, writing a friendly interface will not be easy with a package which supports so many features, but it would convert a good program into a superb one.

PC–B

PC-B is almost a complete contrast, being so easy to use that minimal reference to the manual is necessary. There is a start-up screen, with layout editing as one of the options. Choosing this brings you straight into editing.

There are five sections to the layout screen. The main part is occupied by the layout work area itself, there is an over-view of the whole layout (the work area can represent either the full area of 12 × 10in, or 5 × 4, or 2.4 × 2), there is the 'icon' table where actions to be carried out are selected by clicking on them, and two final sections — the current symbols list and the message panel.

Clicking on one of the pad icons (there are three sizes of circular and one DIL-style oval pad) makes this the current object, and clicking left at any position on the grid drops it there, successive left clicks dropping more of the same object. Clicking right deletes the most recent pad, and clicking right again deletes the previous pads starting at the most recently dropped, so everything can be erased. However, some other actions block this un-dropping and a message will eventually appear to say that there is nothing to delete even though there may be pads still on the work area.

Faster results are obtained using symbols, a method encouraged by a wide range of pre-designed symbols covering resistors, connectors, DIL ICs, transistors and so on. You make use of these by setting them up in the symbol table, which can contain up to eight symbols at any one time. The symbols include pads and tracks on one or both of the two track layers that the program permits (as well as an outline on the silk screen layer).

To lay tracks, you select the track size from a choice of four on the icon table. One left click fixes the start of the track at the current cursor position and a green line 'rubber-bands' to the new cursor position as it is moved (always a straight line going directly between the two points). A subsequent left click fixes the other end of the track and it is then drawn in. The track can be at any angle, and between any two points — there is no 'snapping' to any points on the grid or to any angle. The ends are either vertical or horizontal, depending on which gives the least acute angle with the sides.

A 'right angled' option in the menu extends any tracks which are *exactly* horizontal by half a track width so that any right angled bends do not a 'hole' in them at the exterior corner. This helped a little but I found that few of my tracks were horizontal.

Overall I found that the tracking was much the weakest part of this program. It was very hard to produce neat results, and I didn't have the patience to try. In some respects, this is accentuated because in every other respect the program is so easy to use. Another problem is that it is very hard to keep the centre-holes of pads clear — the program doesn't do this automatically.

There are three block options: copy, move and delete. Using the block delete is the only way to edit an area after it has been laid for some time and the 'undropping' function is blocked. This is a somewhat hit and miss procedure at best.

Once the layout has been saved and the main program left, it can be dumped to an Epson compatible printer or to a HP compatible printer using routines called from MS-DOS. The printer routine seems fairly limited in the area it can cope with — it could only print a layout 4.1in deep by 2.7in wide at 1:1. Labcenter Electronics offers a laser printing service (onto drafting film).

In general, I found this program exceptionally easy to use and the symbols made it possible to get going very quickly on a layout. It is really let down by the tracking and the editing facilities could usefully be more powerful. However, for its price it still represents good value.

Conclusion

Neither of these programs lived up to all the criteria I set at the beginning but both have something to offer. PC-B is so quick and easy to use, it's probably worth getting for use as a rough guide for subsequent taping. Easy-PC gives an exceptionally neat finish, but in the form it was reviewed (and particularly in comparison to PC-B) it is laborious to use. Obviously, prolonged familiarity would help overcome this to some extent.

A niggling doubt remains with me as to whether it is worth an amateur using a package at all. The layouts shown here took me about a day and a half with Easy-PC and about half a day with PC-B. It's hard to do a direct comparison with tape because the process is rather different — for instance, I usually do a succession of pencil sketches before beginning taping, an unnecessary stage using the programs. However, the original from which these patterns were modified took me less than a day to tape and needed several trips to a photocopier at intermediate stages.

The problem that is the hardest to solve is the dot matrix printer output is only just adequate at 2:1 and unsatisfactory at 1:1. In both cases, it still needs to be turned to film for use. Really, output from a plotter is needed and that is going to be expensive no matter how cheap the package is.

Dave Bradshaw is Editor of Test magazine

ETI

DC MOTOR CONTROL CIRCUITS

Ray Marston presents the second and final part of his mini-series of stator-the-art designs

In this month's selection of circuits to help you keep a hand on the tiller of DC motors, we start with a variety of DC motor speed control and regulation circuits, then delve into servomotor control to close this mini-series.

Motor Speed Control

The rotational speed of a DC motor is directly proportional to its mean supply voltage value, and speed can thus be varied by altering this voltage. Figure 1 shows a simple variable voltage speed control which uses compound emitter follower Q1-Q2 to vary the motor's DC voltage from 0-12V. This type of circuit gives fairly good speed control and self-regulation at medium and high speeds but very poor low-speed control and slow-start operation.

Far better speed control can be obtained by using a switched-mode or pulse-width modulated (PWM) variable voltage circuit such as that in Fig. 2.

Here IC1 acts as a 50Hz astable multivibrator that generates a rectangular output with a mark-space ratio fully variable from 20:1 to 1:20 via RV1. This waveform is fed to the motor via Q1 and Q2. The motor's *mean* supply voltage (integrated over a 50Hz period) is thus fully variable via RV1) but is applied in the form of high-energy pulses with peak values of 12V. This gives excellent full-range speed control and generates high torque even at very low speeds — its degree of speed self-regulation is proportional to the mean value of applied voltage.

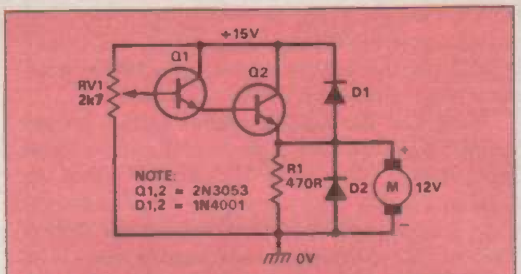

Fig. 1 Variable-voltage speed control of a 12V DC motor

Model Train Speed Controller

Figure 3 shows how the switched-mode principle can be used to make an excellent 12V model train speed controller. The maximum available output current is 1.5A but the unit incorporates short circuit sensing and protection circuitry that automatically limits the output current to a mean value of only 100mA if a short occurs on the track.

The circuit operates as follows. The power line voltage is stepped down via T1 and full-wave (bridge) rectified via BR1, to produce a raw (unsmoothed) DC supply for the model train (via the track rails) through the series-connected SCR and direction control switch SW3.

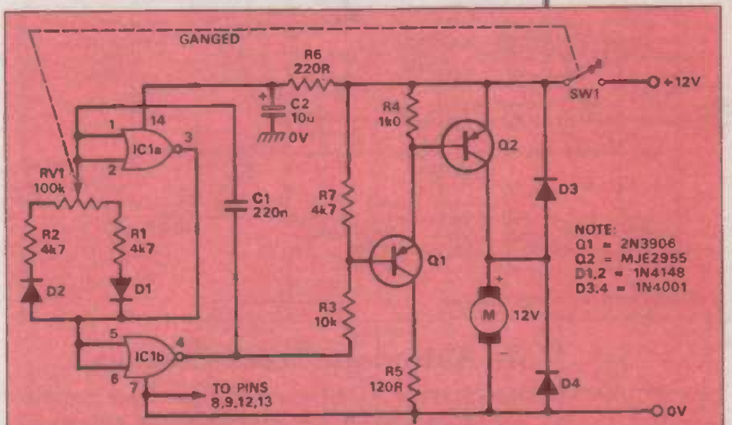

Fig. 2 Switched-mode speed control of a 12V DC motor

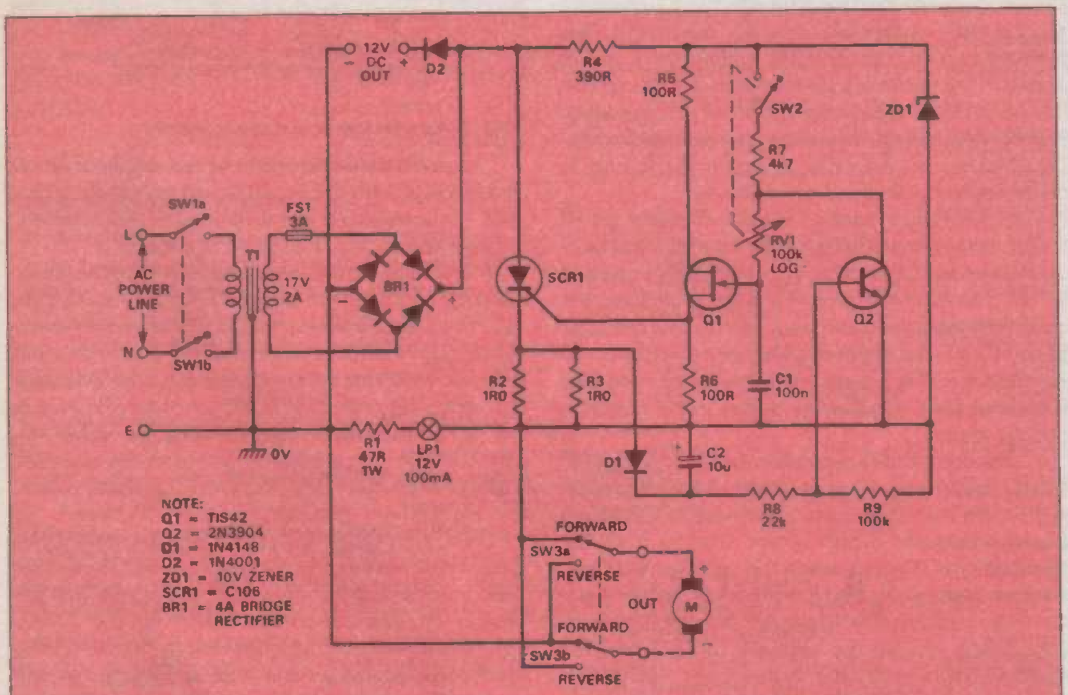

Fig. 3 Model train speed controller circuit with automatic short-circuit protection

At the start of each raw DC half-cycle the SCR is off, so DC voltage is applied (via R4 and ZD1) to UJT Q1 and its associated C1-RV1 timing circuitry. Eventually the UJT fires and triggers the SCR which saturates, removing power from Q1 (which thus resets) and feeding the rest of the power half-cycle to the model train via R2, R3 and SW3.

This timing/switching process repeats in each raw DC half-cycle (so at twice the power line frequency), giving a classic phase-triggered power control action that enables the train speed to be varied over a wide range via RV1.

Note that the circuit's output current passes through the parallel R2-R3, generating a proportional output voltage that is peak-detected and stored via D1-C2 and fed to Q2 base via R8-R9. The overall action is such that, because of the voltage storing action of C2, Q2 turns on and disables the UJT's timing network for several half-cycles if the peak output current exceeds 1.5A. Thus, if a short occurs across the track the half-cycle output current is limited to a peak value of a few amps by the circuit's internal resistance, but the protection circuitry ensures that the SCR fires only once in (say) every fifteen half-cycles, thus limiting the *mean* output current to only 100mA or so.

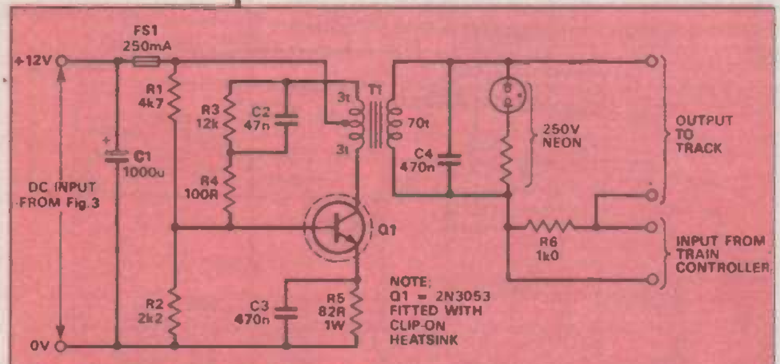

Fig. 4 Model railway track cleaner

An Automatic Track Cleaner

Note that the raw DC output of the above circuit is available (via isolating diode D2) to power accessories such as an automatic track cleaner to maintain electrical contact between the train pick-up wheels and the track, susceptable to dirt and oxidisation. This problem can be overcome by feeding train control signals to the track via a load-sensing high-frequency low-power high-voltage generator, which harmlessly cuts its way through any existing dirt or oxidisation. Fig. 4 shows an example of such a circuit and its controller-to-track circuit connections.

It is basically a modified blocking oscillator, tuned to operate at about 100kHz by the inductance of step-up transformer T1 (wound on a small ferrite core) and by the values of C2 and C4 (which minimise the unwanted effects of track capacitance). The oscillator generates several hundred volts peak-to-peak on T1 secondary, but at a fairly high impedance (and thus harmless) level. Oscillation ceases if the output is heavily loaded.

Transformer T1's secondary is wound with fairly heavy gauge wire, through which the train control signals are fed to the track. When electrical contact is made between a train motor and the track the resulting low impedance kills the oscillator and only the train control signals reach the track. If the contact is interrupted by dirt, however, the resulting high impedance enables the oscillator to work and the resulting high-frequency high-voltage (plus train control) signals rapidly break through the interruption and re-establish electrical contact.

A neon lamp (plus resistor) is wired across T1 secondary and illuminates when the track cleaner is active, indicating loss of track contact. R6 ensures that only a very small part of the oscillator output voltage can be fed to the train controller terminals when the cleaner is active.

Motor Speed Regulation

Motor speed regulators are meant to keep motor speed fairly constant in spite of wide variations in the control circuit's supply voltage and in the motor loading conditions. Figure 5 shows an example of a regulator circuit designed to simply keep the motor's applied voltage constant in spite of such variations in voltage and temperature.

The 317K 3-terminal variable voltage regulator IC when fitted to a suitable heat sink can supply output currents up to 1.5A and has an output that is fully protected against short circuit and overload conditions. With the component values shown, the output is fully variable from 1.25V to 13.75V via RV1, provided that the supply voltage is at least 3V greater than the desired output value.

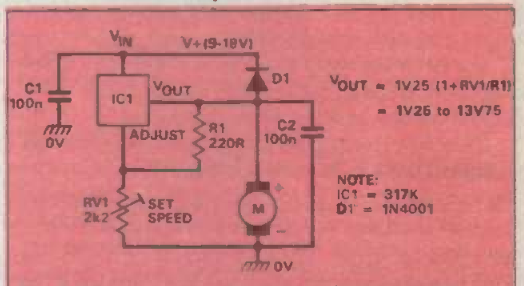

Fig. 5 Simple motor-speed controller/regulator

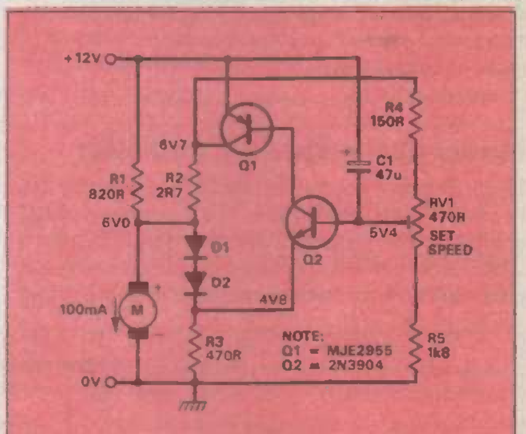

Fig. 6 Popular motor-speed regulator

Figure 6 shows a popular type of regulator circuit widely used (with minor variations) in cassette recorders, compensating for variations in both battery voltage and motor loading conditions.

The motor current is controlled via series transistor Q1 and is monitored via R2. Q1 is controlled via Q2. The diagram shows the circuit voltages obtained when the motor is operating at 6V and is drawing 100mA. Note that Q2's emitter is biased 1.2V below the motor value via D1-D2-R3, and that Q1's base is set at a fraction of the Q1-collector value via R4-RV1-R5. All changes in motor or Q1 collector voltages thus effect Q2's emitter and base bias values, but the changes are always least on the base.

Thus any drop in the circuit's supply voltage tends to decrease the motor's voltage and make Q2's emitter fall further below its base value, driving Q2 and Q1 harder on and self-compensating for the supply reduction. Similarly, any increase in motor loading tends to slow the motor and increase the motor current and the R2 voltage drop, thus raising the relative value of Q1's collector voltage and making Q2's base voltage rise further above that of the emitter, driving Q2 and Q1 harder on and increasing the motor drive to self-compensate for the increased motor loading. Some thermal compensation is also given via D1 and D2. The motor speed can be varied over a limited range via RV1.

Figure 7 shows a high-performance regulator circuit that can be used in wide-range variable-speed applications such as controlling 12V DC mini-drills and so on.

Here the motor is again powered via the output of a 317K 3-terminal variable voltage regulator IC but in this case the motor current is monitored via R5-RV2, which feed a proportional voltage to the input of the IC2-Q1 non-inverting DC amplifier. This generates a Q1 emitter voltage directly proportional to the motor's load current.

Now, the output voltage of this circuit equals the normal output value of the 317K IC (which is variable from 1.25-13.75V via RV1) plus the voltage on Q1's emitter. Consequently, any increase in motor loading makes the circuit's output voltage rise to automatically increase the motor drive and hold its speed reasonably constant. To initially set up this circuit, simply set the motor speed to about one-third of maximum via RV1, then lightly load the motor and set RV2 so that the speed remains similar in both loaded and unloaded states.

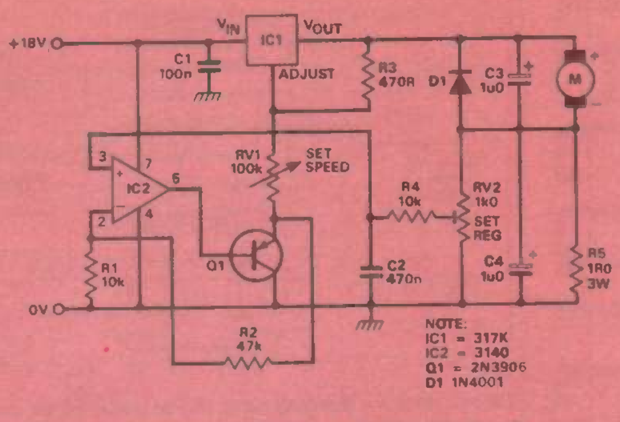

Fig. 7 High performance variable-speed regulator circuit

Two-phase Motor Driver

Two-phase (AC) motors are synchronous machines and low-voltage versions are sometimes used as precision phonograph turntable drivers. Figure 8 shows a circuit that can drive 8R two-phase motor windings at up to 3W each, at frequencies between 45Hz and 65Hz. The circuit is designed around an LM377 dual 3W audio power amplifier IC, driven from a split supply.

It operates as follows: The IC's left half is wired as a Wien bridge oscillator, with frequency variable between 45Hz and 65Hz via RV1, and with amplitude stabilised via RV2 and the filament lamp. The output is fed directly to one motor phase winding and to the other via the IC's right hand half which acts as an 85° phase shifter (C6-R6 shifts the phase by 85° but attenuates by a factor of ten at 60Hz — the IC half gives unity phase shift and a gain of ten at 60Hz).

Circuit stability is assured via decoupling networks C3-R4-R5, C4 and C5, and the motor windings are tuned to a mid-frequency value via C8 and C9.

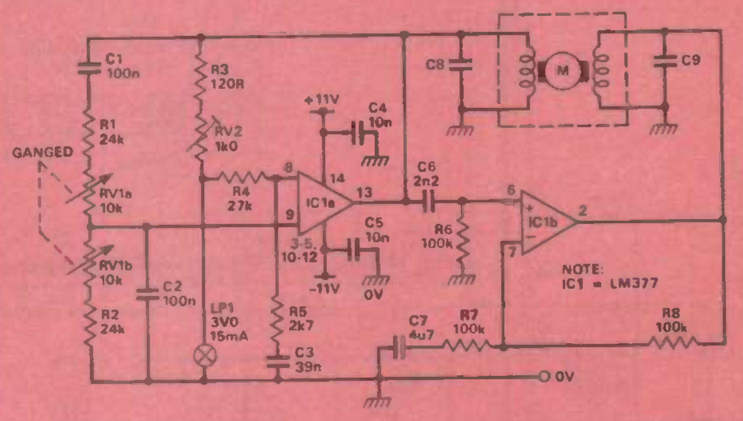

Fig. 8 Two-phase motor driver

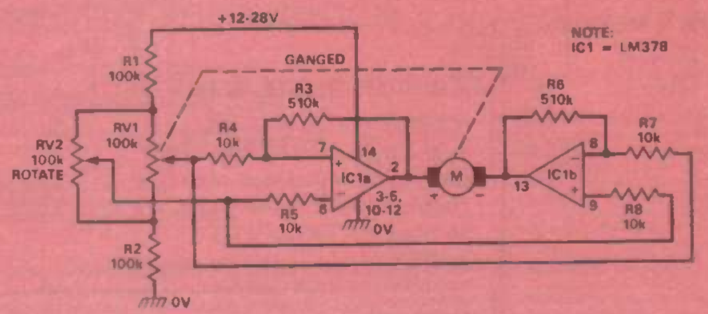

Fig. 9 Proportional movement (servomotor) controller

Servomotor Systems

A servomotor is a conventional electric motor with its output coupled (usually via a speed-reduction gearbox) to a movement-to-data translator such as a potentiometer or a tachogenerator.

Figure 9 shows a controller that can be used to give proportional movement (set via RV2) of a servomotor with a pot (RV1) output. The motor can be any 12-24V type that draws less than 700mA of current. Here RV1 and RV2 are wired as a Wheatstone bridge and the IC (a dual 4W power amplifier) is wired as a bridge-configured motor-driving difference amplifier. The circuit action is such that any movement of RV2 upsets the bridge balance and generates a RV1-RV2 difference voltage that is amplified and fed to the motor, making its shaft rotate and move RV1 to restore the bridge balance. RV1 thus tracks the movement of RV2, which can be used to remote-control the shaft position.

Figure 10 shows, in block diagram form, how a

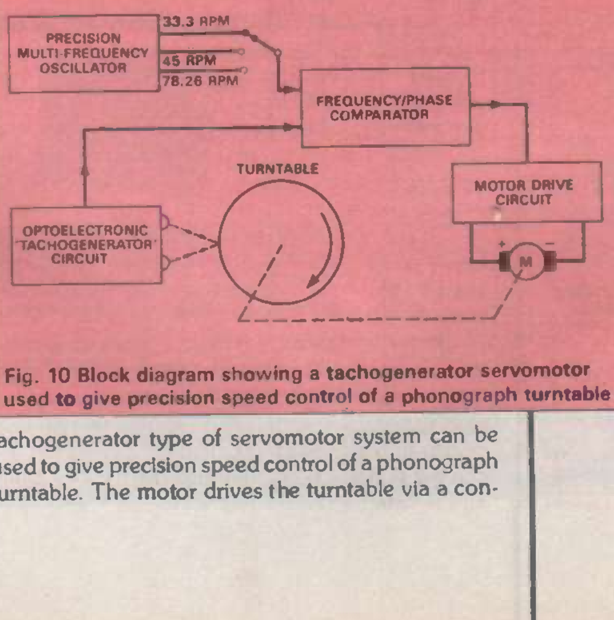

Fig. 10 Block diagram showing a tachogenerator servomotor used to give precision speed control of a phonograph turntable

tachogenerator type of servomotor system can be used to give precision speed control of a phonograph turntable. The motor drives the turntable via a con-

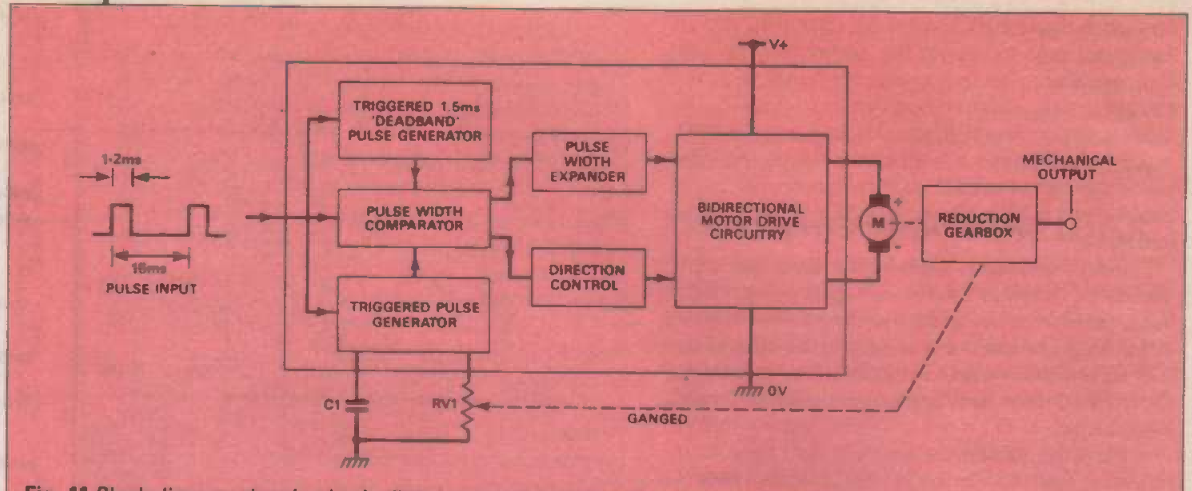

Fig. 11 Block diagram showing basic digital proportional-control servomotor system

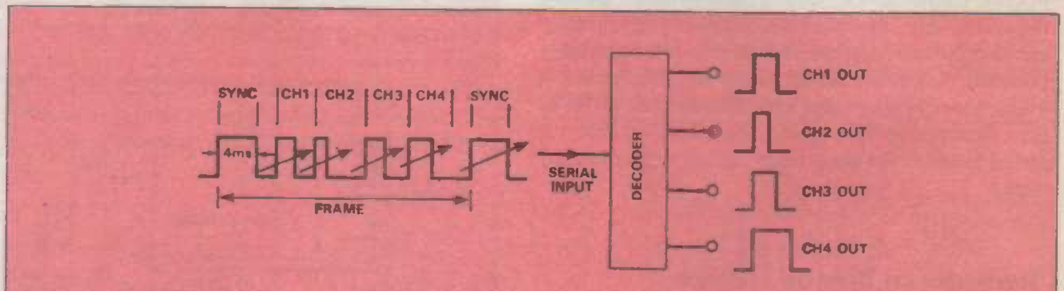

Fig. 12 Waveforms of a 4-channel digital proportional-control system

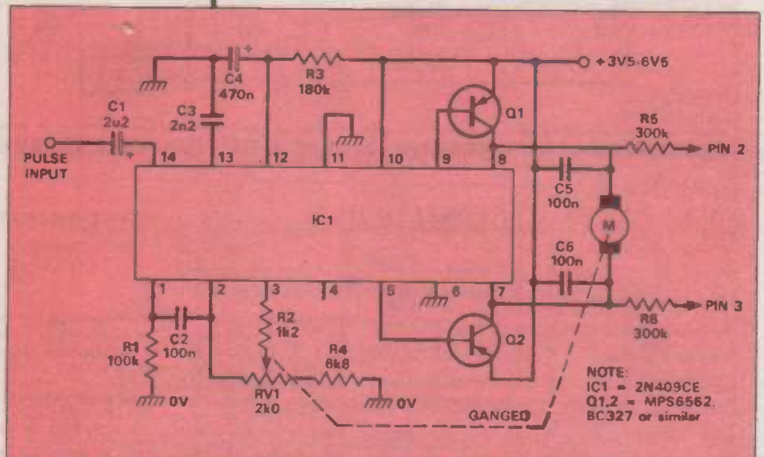

Fig. 13 Digital proportional servo driver using the ZN409CE IC

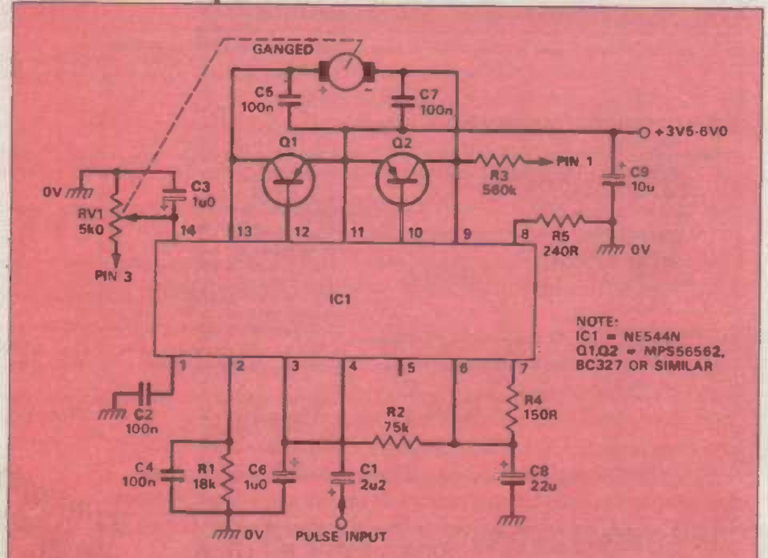

Fig. 14 Digital proportional servo driver using the NE544N IC

ventional belt drive mechanism and the turntable edge is patterned with equally-spaced reflective strips monitored by an optoelectronic tachogenerator producing an output signal proportional to the turntable speed. The phase and frequency of this signal are compared with that of a precision oscillator to give an output that is used to control the motor drive circuit, thus holding the turntable at the precise speed selected by the operator. Several manufacturers produce dedicated ICs for use in this type of application.

Digital Proportional Servomotors

One of the best known types of servomotor is that used in digital proportional remote control systems. These devices actually consist of a special IC plus a motor and reduction gearbox that drives a pot and gives a mechanical output. Figure 11 shows the block diagram of one of these systems, which is driven via a variable-width (1-2ms) input pulse repeated once every 15ms or so (the frame time).

The input pulse width controls the position of the servo's mechanical output. At 1ms the servo output may (for example) be full left, at 1.5ms neutral and at 2ms full right.

Each input pulse triggers a 1.5ms 'deadband' pulse generator and a variable-width pulse generator controlled (via RV1) by the gearbox output. These three pulses are fed to a width comparator that gives one output specifying direction control of the motor drive circuitry and another that (when fed through a pulse-width expander) controls the motor speed, making the servomotor's RV1-driving mechanical output rapidly follow any variations in the width of the input pulse.

Servomotors of the above type are usually used in multi-channel remote control systems as shown in the basic 4-channel system of Fig. 12. Here a serial data input is fed (via some form of data link) to the input of a suitable decoder. Each input frame comprises a 4ms synchronisation pulse followed by four variable-width (1-2ms) sequential 'channel' pulses. The decoder simply converts the four channel pulses to parallel form, enabling each pulse to be used to control a servomotor.

Digital Servomotor Circuits

Digital proportional servomotor units are widely available in both kit and ready-built forms and are usually designed around either the Ferranti ZN409CE or the Signetics NE544N servo amplifier ICs. Figures 13 and 14 show practical application circuits for both of these IC types, with component values suitable for input pulse lengths in the 1-2ms range and frame length of about 18ms nominal.

Finally, to complete this series, Figure 15 shows a general purpose tester for use with the above types of servo. This unit is powered from the servo's supply battery (nominally about 5V) and simply feeds normal input pulses to the servo via a standard servo socket. The frame length is variable from 13-28ms via RV1, and the pulse length is variable from 1-2ms via RV2. It can be trimmed to give a precise 1.5ms mid-scale value via RV4. The output pulse level is variable via RV3.

The circuit is designed around two 7555 ICs, the CMOS versions of the 555 timer chip giving stable operation at supply values down to 3V.

IC1 is configured as a free running astable multivibrator and generates the frame times. Its output triggers IC2, which is configured as a monostable multivibrator and generates the output test pulses.

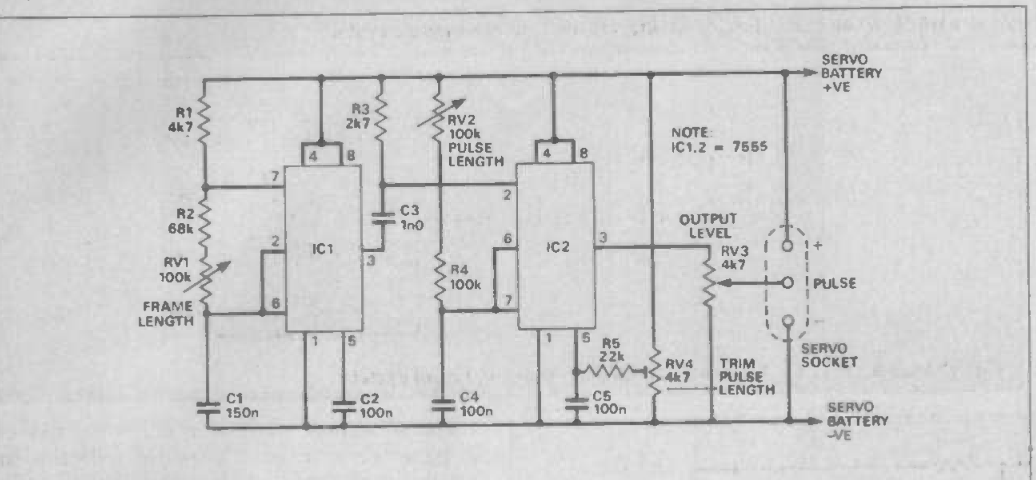

Fig. 15 Digital proportional servo tester circuit

CIRCUITS

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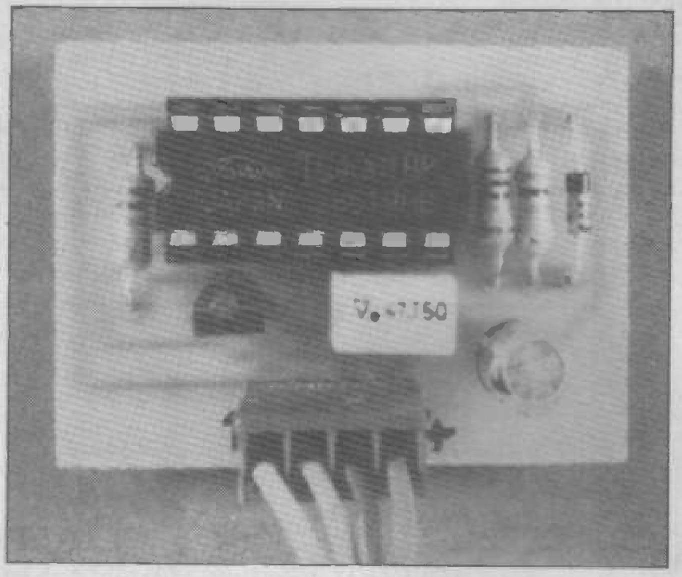


Paul Brow aims to please with this auto-reset addition to last year's fire-power project

UPDATE

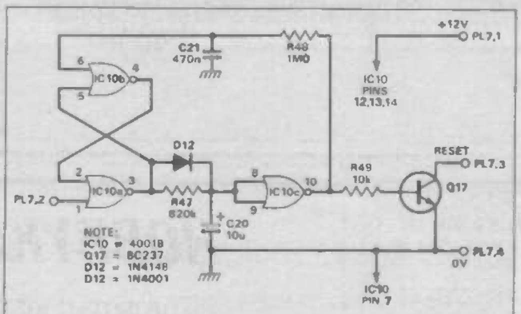


Fig. 1 The circuit diagram for the auto-reset board

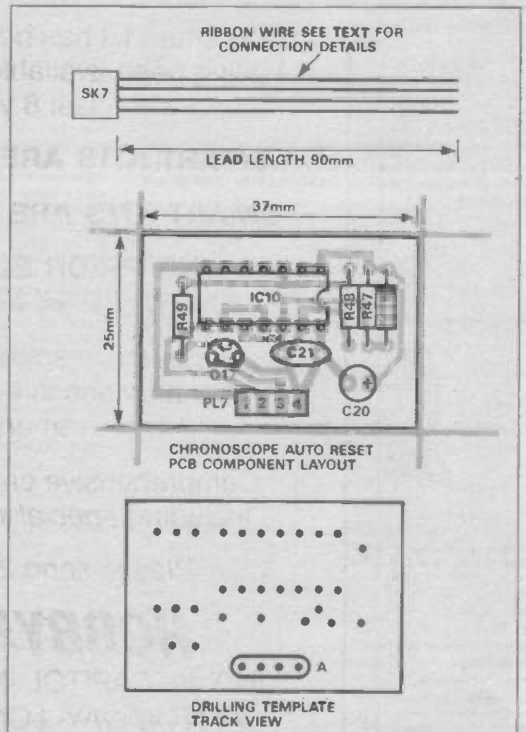


Fig. 2 The component overlay for the auto-reset board

It was last November that the complete design for the Chronoscope was published. It functioned as a self-contained unit that measured the velocity of an air pellet fired through the project case — preferably through the specially designed holes.

It was built on three PCBs: one for the counter, one for the display and the third for the sensors that had to reliably spot something travelling faster than . . . well as fast as a speeding bullet.

All well and good. However, while using the Chronoscope, I found that having to press the *reset* button after every shot was getting on my 'wires'! I had to do something about it, hence the circuit diagram in Fig. 1. Its function is to provide a reset pulse eight seconds after the shot was fired. This allows sufficient time to note the display reading and prepare to shoot again.

Construction

The circuit is constructed on a PCB about 25mm square and has a detachable lead, which is soldered to the other boards. After testing it can be stuck down inside the Chronoscope with double sided tape pads.

Connections

The new board has four connections to the existing Chronoscope boards. These are as follows:

Auto board pin 1 wire to C15 +ve on sensor board.

Pin 2 wire to R40 (end near D10) on sensor board.

Pin 3 wire to SW5 pins nearest edge of display board.

Pin 4 wire to C15 −ve on sensor board.

Solder the wires to the component side on the sensor board and to the track side of the display board.

After testing, stick the auto reset board down with double-sided tape in the space available.

HOW IT WORKS

When a pellet is fired through the Chronoscope, it is initially detected by D4-D6 and IC7b goes high momentarily, setting bistable IC8a.

The new board connects to the output of IC7b so this pulse also sets the bistable formed by IC10a and IC10b.

Prior to a trigger pulse, C20 would be fully charged keeping Q17 turned *off* via inverter IC10c. When the pulse sets the bistable, C20 slowly discharges into IC10a via R47 (taking about eight seconds to reach the switching threshold of IC10c). IC10c output now goes high, turning *on* Q17 (which resets the unit).

However IC10c output (delayed by half a second by R48/C21) also resets bistable IC10a/IC10b and recharges C20 via D12. The result of this is a short (0.5s) negative pulse on the reset line about eight seconds after a pellet is fired.

PARTS LIST

Component numbering continues from that used in the original article.

R47	820k
R48	1M0
R49	10k
C20	10µ 16V radial electrolytic
C21	470n miniature polyester
IC10	4001B
Q17	BC237 (BC107 or similar)
D12	1N4148
PL7	4-way pin header
SK7	4-housing and terminals

PCB, IC socket, 4-way ribbon cable.

TREMBLER MOVEMENT DETECTOR

Rashid Adat has a simple circuit to ward off thieves

Here is a simple design for a movement detector with possibilities when used as a security device. It could protect expensive electronic apparatus, personal documents or indeed anything in a container that might be carried away by an unauthorised person. To protect documents in a filing cabinet, the detector could simply be placed in the drawer and when the drawer is opened, a high intensity sound results.

The main sections of the device are: motion detector (a mercury tilt switch), control logic and a high intensity audible buzzer. All parts are mounted in a small plastic box. The box has an LED to show the setting time and battery condition, a keyswitch socket to enable and disable the detector and several holes to allow the sound to leave.

So, to set our sentinel, here is what you do. Place or attach the box to the piece of apparatus you want to protect (preferably out of sight) and withdraw the jack plug. The jack plug functions as part of the switching device that enables the circuit when it is removed from the socket. When this happens, the LED turns on for approximately 10 seconds. After this time, the LED goes out and the circuit enters standby mode.

Thereafter, any motion imparted to the box is sensed by the mercury tilt switch. The angle of the switch to the circuit board was set at about 15 degrees (Fig. 1). This provides detection when the box is tilted slightly. The angle can be adjusted for maximum sensitivity. If movement in the horizontal plane is required, the angle should be made as small as possible. The mercury switch could also be pointed at a corner of the box thus providing a detection of tilt in two planes. Any tilt or movement results in the triggering of the buzzer. The circuit is designed to sound a 90dB tone continuously and can only be silenced by inserting the key (jack plug) into the socket. This cuts power to the circuit.

If you wanted extra security you could use a keyswitch. With the jackplug it is just possible to shove a paper clip into the socket, short it out and reset the circuit. However this takes a fair amount of time to work out (as the ETI cleaning staff have discovered much to their chagrin), particularly if you're an alarmed burglar. In the meantime, the high intensity buzzer really is very loud.

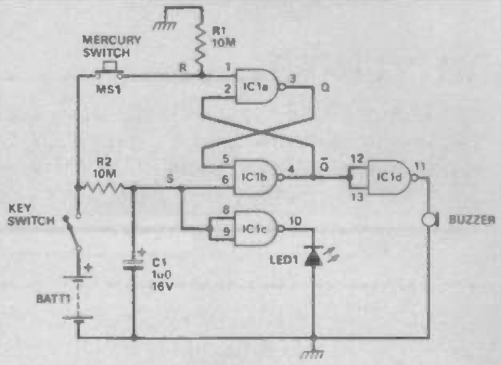


Fig. 1 Circuit diagram of movement detector

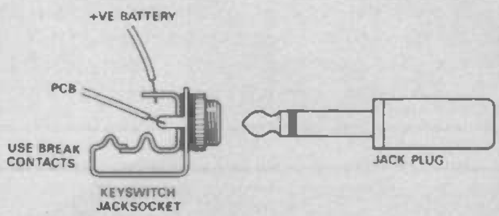


Fig. 2 Keyswitch jack plug and socket

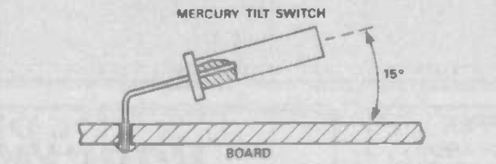


Fig. 3 Mercury switch

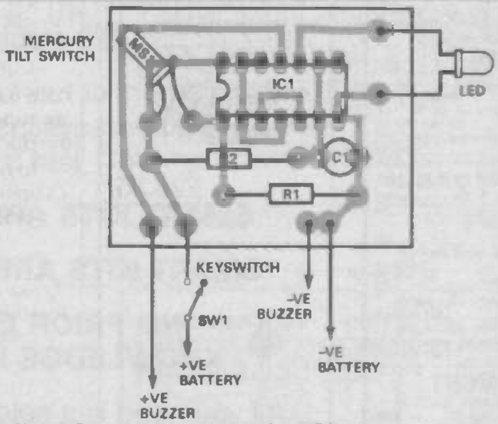


Fig. 4 Component overlay for PCB

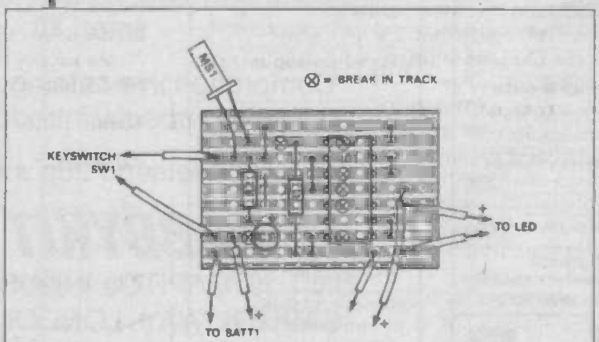
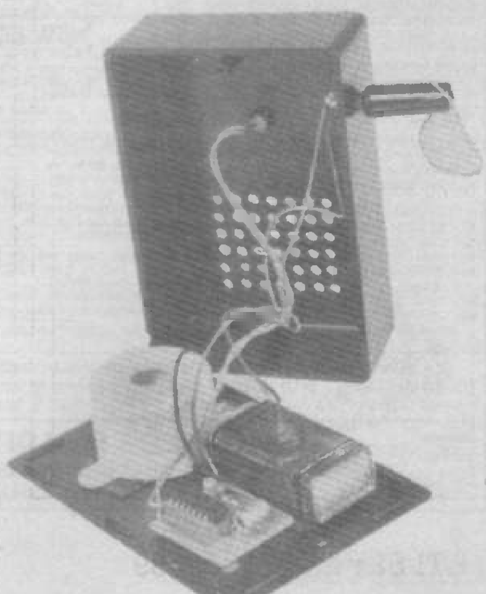


Fig. 5 Component overlay on stripboard



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ETI

Construction

Construction is fairly simple for this project. When using the PCB, mount and solder a 14-pin dual-in-line socket first. Then solder the two resistors, capacitor and mercury switch as shown in Fig 4. Next solder the wires in for the connections to the battery, keyswitch, buzzer and LED. The wires to the LED and switch must be long so that the two halves of the box can be separated easily.

As the IC is a CMOS device, care must be taken when handling and inserting it into the socket. Make sure your body is earthed when carrying out this operation.

All the circuitry is then housed in a plastic box of suitable size. The one used in the prototype measured 114×76×30mm. The PCB, buzzer and battery can be mounted by simply sticking them inside the box with double-sided foam tape.

When constructing the movement detector on stripboard (Fig. 5), cut the copper lines first using a sharp drill bit. Then mount and solder the socket. Place the wire links in next and solder the components in as before. Finally, a matrix of holes was drilled in the plastic box to let the sound out.

BUYLINES

All components are easily available. The buzzer is available from Maplin, cat no. FK84F and the mercury tilt switch also available from Maplin, cat no. FE11M. The PCB is available at £2.50 or the complete kit at £11.99 from the author at 20 Highview St, Bolton BL3 4DQ.

HOW IT WORKS

Once the key is removed, the LED is switched on for a period of about 10 seconds. This length is determined by the values of C1 and R2 (see Fig. 1). When the voltage on C1 reaches the threshold value of 3.6V, the input to NAND gate c (connected as an inverter) goes high resulting in a low output from pin 10. The LED switches off.

ICa and ICb are connected as an R/S flip flop and when the key switch is first removed, S sets to logic 0 (low) and R to logic 1 (high) because the mercury tilt switch is normally closed in its relaxed position. The output from ICb (pin 4) adopts a logic 1 state. This output remains at logic 1 even when C1 has passed its threshold voltage making S go high. The circuit is now in its standby mode.

If the box is moved, MS1 will open. R will now go low (logic 0) and the bistable will flip making ICb output go low. ICd serves as an inverter and its output will change at this point supplying the voltage to trigger the buzzer. The circuit can then only be switched off by re-inserting the jack plug in the key switch.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,2	10M
CAPACITORS	
C1	1µ 16V electrolytic
SEMICONDUCTORS	
IC1	4011BE quad 2 i/p NAND
MS1	mercury tilt switch
SW1	2.5mm jack plug and break contact socket
X1	buzzer piezo-electic type
LED 1	5mm LED and holder
BATT 1	9V PP3 type and clip
Plastic case and printed circuit board.	

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W	£37.90
X	£40.70

PCBs

E8305-3	Dual Audio Power Supply, Linsley Hood	G
E8305-3	Balanced Input Pre-amplifier	F
E8308-1	Graphic Equaliser ⅓ Octave	M
E8404-2	Mains Remote Control Receiver	F
E8405-2	ZX81 EPROM Programmer	N
E8405-3	Mains Remote Control Transmitter	H
E8405-4	Centronics Interface	F
E8406-3	Audio Design RIAA Stage	G
E8406-4	AD Buffer/Filter/Tone	H
E8406-5	AD Headphone Amp	F
E8406-6	AD Preamp PSU	K
E8406-7	AD Power Amp	H
E8406-8	AD Power Amp PSU	J
E8406-9	AD Stereo Power Meter	F
E8406-10	AD Input Clamp	C
E8407-1	Warlock Alarm	M
E8408-2	EPROM Emulator	N
E8410-1	Echo Unit	F
E8410-2	Digital Cassette Deck	N
E8410-3	Disco Party Strobe	H
E8411-5	Video Vandal (3 boards)	N
E8411-9	Stage Lighting Interface	F
E8412-1	Spectrum Centronics Interface	F
E8412-4	Active-8 Protection Unit	F
E8412-5	Active-8 Crossover	F
E8412-6	Active-8 LF EQ	F
E8412-7	Active-8 Equaliser	F
E8501-3	Digital Delay (2 bds)	T
E8502-1	Digital Delay Expander	N
E8502-2	Data Logger	J
E8503-1	Combo Pre-amplifier	F
E8503-2	THD Meter mV & oscillator boards (2 bds)	K
E8503-3	THD Meter Mains PSU	F
E8504-1	Framestore Memory	M
E8504-3	Framestore Control	N
E8504-4	Buzby Meter	E
E8504-5	CCD Delay	F
E8505-5	Stereo Simulator	F
E8506-1	Audio Mixer Main	J
E8506-2	Audio Mixer PSU	F
E8506-3	Audio Mixer RIAA	D
E8506-4	Audio Mixer Tone Control	D
E8506-5	EPROM Prog MKII	O
E8507-1	Noise Gate	H
E8508-1	RCL Bridge	N
E8508-2	EX42/BBC Interface	E
E8508-3	EPROM Emulator	L
E8509-1	Spectrum EPROM Card	F
E8509-2	Direct Injection Box	E
E8510-9	Sunrise Light Brightener	K
E8511-1	MTE Waveform Generator	H
E8511-2	Millifaradometer	H
E8511-3	Cymbal Synth	J
E8511-5	Chorus Effect	H
E8511-7	Enlarger Exposure Meter	F
E8511-9	Second Line of Defence	M
E8512-1	Specdrum Connector	F
E8512-2	MTE Pulse Generator	H
E8512-3	Specdrum	L
E8601-2	Walkmate	L
E8601-3	MTE Counter-timer	M
E8602-1	Digibaro	O
E8603-2	Programmable Logic Evaluation Board	H
E8603-3	Sound Sampler Analogue Board	R
E8604-1	JLLH PA PSU	H
E8604-2	Matchbox Amplifier	C
E8604-3	Matchbox Amp Bridging Version	C
E8604-4	MTE Analogue/Digital Probe	M
E8605-1	Microlight Intercom	E
E8605-2	Baud Rate Converter	M
E8605-3	Baud Rate Converter PSU Board	C
E8605-4	Portable PA	H
E8606-1	MIDI-CV Converter Board	H
E8606-2	MIDI-CV Converter PSU	D
E8606-3	Trogiograph	F
E8606-4	80m Receiver	H
E8606-5	Sound Sampler	R
E8607-2	Upgradeable Amp, MC stage (Stereo)	G
E8607-3	BBC Motor Controller	F
E8608-1	Digital Panel Meter	G
E8608-2	Upgradeable Amp, MM stage (mono)	H
E8609-1	Mains Conditioner	E
E8609-2	Experimental Pre-amp	F
E8609-3	Upgradeable Amp, Tone Board (mono)	H
E8609-4	Upgradeable Amp, Output Board (mono)	F
E8610-1	Audio Analyser Filter Board	L
E8610-2	Audio Analyser Display Driver	K
E8610-3	Audio Analyser Display	H
E8610-4	Audio Analyser Power Supply	F
E8611-1	Audio Switcher (2 bds)	H
E8611-2	PLL Frequency Meter (4 bds)	Q
E8611-3	Upgradeable Amp PSU	J
E8611-4	Call Meter, Main Board	O
E8611-5	Call Meter, Interface Board	N
E8612-1	Bongo Box	J
E8612-2	Biofeedback Monitor (Free PCB)	E
E8701-1	RGB Converter	F
E8701-2	Mains Controller	D
E8701-3	Flanger	H
E8701-4	Audio Selector Main Board	M
E8701-5	Audio Selector PSU	H
E8701-6	Tacho-Dwell	F
E8702-1	Ratemeter Main Board	K
E8702-2	Ratemeter Ranging Board	F
E8702-3	Photo Process Controller (3 bds)	O
E8702-4	LEDline Display Board (2 off)	K
E8702-5	LEDline PSU and Controller (2 bds)	G
E8703-1	Capacitometer	F
E8703-2	Geiger Counter	L
E8703-3	Credit Card Casino	E
E8704-1	BBC Micro MIDI Interface	L
E8704-2	ETIFaker Patch Box	H
E8705-3	MIDI Keyboard Keyswitch Boards (3 bds)	W
E8705-4	Batlite	C
E8705-5	Budget Power Meter	E
E8706-1	Hi-fi Power Meter	N
E8706-2	MIDI Keyboard CPU	U
E8706-3	MIDI Keyboard Front Panel	O
E8706-4	Flame Simulator	G
E8707-1	MIDI Keyboard PSU	H
E8707-2	Telephone Alarm	J
E8708-1	Remindalite	F
E8708-3	Rev Counter	F
E8708-4	Car Alarm	F
E8708-5	Knight Raider	J
E8709-1	Boiler Controller	G

PCBs

E8909-1	Twin Loop Metal Locator	H
E8909-2	Trembler movement detector	D
E8909-3	Field power supply (spec 3)	C
E8909-4	Micro monitors active filter	F
E8909-5	Chronoscope auto-reset	C

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

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

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

E8709-2	Amstrad Sampler (2 bds)	P
E8709-3	Portable PA	G
E8709-4	EEG Monitor (2 bds)	L
E8710-1	Concept CPU Board	N
E8710-2	Concept Power Board	K
E8710-3	Concept Display Board	G
E8710-4	Hyper-Fuzz	F
E8711-1	Quiz Controller	E
E8711-2	256K Printer Buffer	N
E8712-2	SWR Meter	H
E8712-3	Dream Machine (free PCB)	D
E8801-2	Passive IR Alarm	H
E8801-3	Deluxe Mains Conditioner	G
E8801-4	RGB Dissolve	L
E8802-1	Electric Fencer	E
E8802-2	Telephone Intercom	L
E8802-3	Transistor Tester (2 bds)	L
E8802-4	Spectrum Co-processor CPU	N
E8803-1	Co-processor RAM board	N
E8803-2	Beeb-Scope (3 bds)	O
E8804-1	Spectrum Co-processor Interface Board	N
E8804-2	Combo-Lock	E
E8804-3	Kitchen Timer	E
E8805-1	Virtuoso 2U PSU	M
E8805-2	Virtuoso 3U PSU	N
E8805-3	Bicycle Speedometer	F
E8805-4	Dynamic Noise Reduction	E
E8806-1	Universal Digital Panel Meter	L
E8806-2	Universal Bar Graph Panel Meter	K
E8806-3	Virtuoso Power Amp Board	N
E8806-4	Virtuoso AOT Board	G
E8806-5	Metal Detector	E
E8806-6	Bicycle Dynamo Backup	D
E8807-1	Bar Code Lock (2 bds)	N
E8807-2	Analogue Computer Power Board	L
E8807-3	Bell Boy	F
E8807-4	Logic Probe	C
E8807-5	Updated FM Stereo Decoder	J
E8807-6	Breath Rate Display Board	F
E8808-1	Breath Rate Main Board	H
E8808-2	Breath Rate Switch Board	C
E8808-3	Telephone Recorder	D
E8808-4	Analogue Computer Main Board (2 bds)	M
E8809-1	Spectrum EPROM Emulator	M
E8809-2	Frequency Meter (2 bds)	P
E8809-3	Travellers' Aerial Amp	E
E8810-1	Gerrada Marweh Bikebell	E
E8810-2	Peak Programme Meter (2bds)	N
E8810-4	TV-to-RGB Converter	E
E8810-5	Electron RGB Buffer	C
E8811-1	NiCd Charger	E
E8811-2	Chronoscope (3 bds)	P
E8811-3	Digital Transistor Tester	G
E8812-1	Doppler Speed Gun (2 bds)	K
E8812-2	Small Fry Mini Amp	D
E8812-3	Thermostat	E
E8812-4	Burglar Buster Free PCB	D
E8812-5	Burglar Buster Power/relay Board	E
E8812-6	Burglar Buster Alarm Board	C
E8812-7	Burglar Buster Bleeper Board	C
E8901-1	EPROM Programmer mother board	M
E8901-2	Variat-Ion updated Main Board	H
E8901-3	Variat-Ion Emitter Board	E
E8901-4	In-car Power Supply	C
E8901-5	Granny's Hearing Booster	E
E8902-1	Compressor/Limiter/Gate	L
E8902-2	Ultrasonic Horn	D
E8902-3	Stepper Motor Driver Board	L
E8902-4	Quest-Ion (2bds)	K
E8903-1	Intelligent Plotter Solenoid Board	H
E8903-2	MIDI Programmer	L
E8903-3	Balanced Disc Input Stage	F
E8903-4	Digitally Tuned Radio	G
E8904-1	Camera Trigger	E
E8904-3	Intelligent Plotter Main Board	O
E8904-4	Kinetotie Tie Board	N
E8904-5	Kinetotie Control Board	E
E8905-1	Guitar Tuner	H
E8905-2	Camera Trigger Ultrasonics (2 boards)	F
E8905-3	Bench Power Supply (2 boards)	H
E8906-1	PC edge connector	F
E8906-2	MIDI converter CPU	N
E8906-3	MIDI converter keyboard	N
E8906-4	MIDI converter control	M
E8906-5	AF signal generator	G
E8906-6	Mini bleeper	C
E8906-7	Caravan heater controller	G
E8907-1	MIDI Patch Bay	G
E8907-2	Priority Quiz Switch	E
E8907-3	Camera Trigger Infra-reds (2 boards)	G
E8907-4	Aerial Amplifier main board	E
E8907-5	Aerial Amplifier power supply	E
E8908-1	Intercom master station	L
E8908-2	Intercom slave station	F
E8908-3	Intercom power mixer	E
E8908-4	Digital joystick-to-mouse conversion	H

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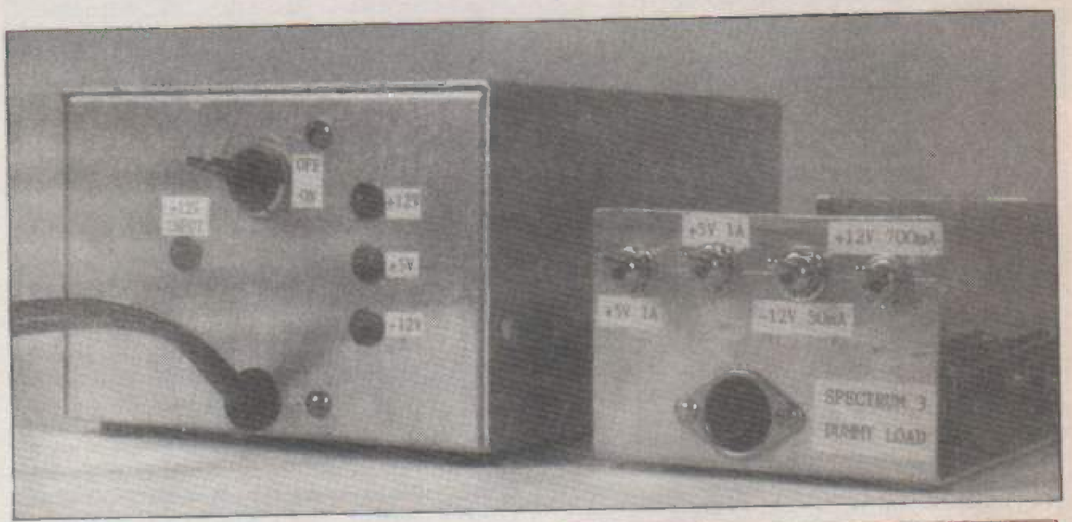
FIELD POWER SUPPLY

FOR THE SPECTRUM 3 COMPUTER



Don Scarrott's computer can operate in the open air with this switched mode supply project

PROJECT

The Spectrum 3, with its disk drive, is a very useful computer giving considerable power at a very reasonable price. The idea for this project arose when it was required to take the Spectrum 3 out into the field to process the results from a sporting event. This meant running it from a car battery which would also be driving a black and white television set. It was important to have an efficient power supply unit to avoid wasting power.

The Spectrum 3 needs three supplies: +12V at 700mA, +5V at 2A, and −12V at 50mA. The +12V can be taken straight from the battery but the +5V and the −12V need to be generated. A switched mode power supply offers the best efficiency.

Basic Principles

Figure 1 shows what we want — a basic converter running at 25kHz. When running, C6 holds the output voltage roughly constant at 5V so that when the switch is closed there is a steady voltage of 7V applied across L1. The rate of change of current is therefore $V/L = 7/.0002 = 35mA/\mu s$. When the switch opens, the inductance produces a back emf which drives point P negative until D3 opens. The collapsing magnetic field continues to drive current into C6, but the voltage across L1 is now −5V so the rate of change of current is $-25mA/\mu s$.

In the steady state the rise must equal the fall, so the on/off ratio must be 5/7. So at 25kHz (a period of 40µs), the switch is on for 16.6µs and off for 23.3µs, giving the waveforms shown in Fig. 1b. The current rise is $16.6 \times 25 = 580mA$, and the fall is $23.3 \times 25 = 580mA$, say 0.6A.

The load current remains virtually steady at 2A so the inductor current ramps up from 1.7A to 2.3A while the switch is on and ramps down from 2.3 to 1.7A when the switch is off. The input current thus rises from 1.7 to 2.3A while the switch is on but falls to zero while the switch is off. The mean input current is only 5/12ths of the output current, that is 0.83A (theoretically).

By providing a secondary winding on the inductance, we can generate a larger AC voltage. This can be rectified and used to supply a standard −12V regulator. The one supply can be made to give two outputs.

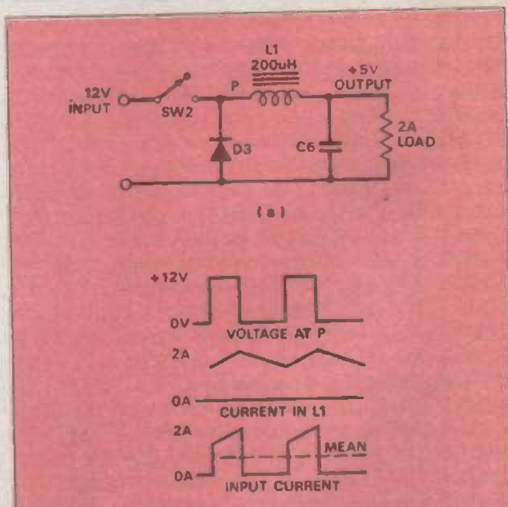


Fig. 1 Basic circuit of the required forward converter circuit and circuit waveforms

The Real World

This sounds good in theory but is difficult to achieve in practice. Special components have had to be developed to make it practicable. Ordinary diodes and electrolytics just won't do. You need a schottky diode with a low forward voltage drop (for efficiency) and quick recovery time (to work at high frequencies). The electrolytic specification must include the impedance at 10kHz or above. The output transistor must also switch cleanly and it is best to use one of the special chips designed for this purpose, especially as it includes a voltage reference and the quite complex control circuits.

The better your components, the sharper your edges, and the more trouble you have getting rid of spikes. The main components must be arranged with

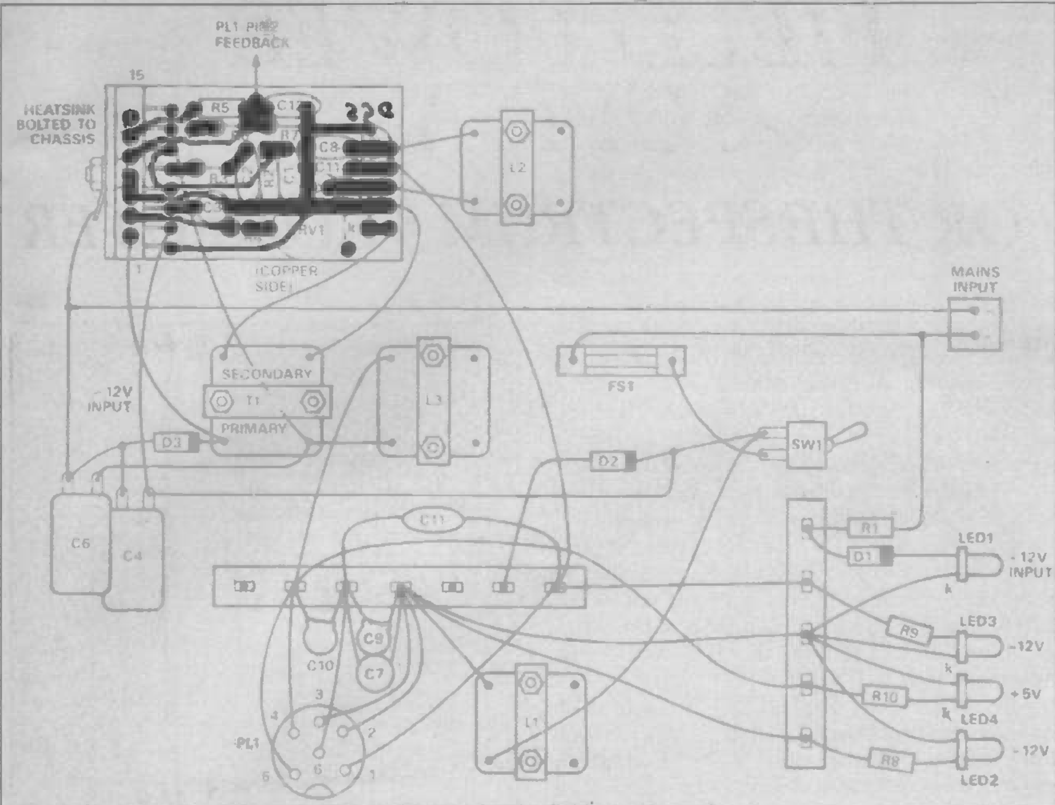
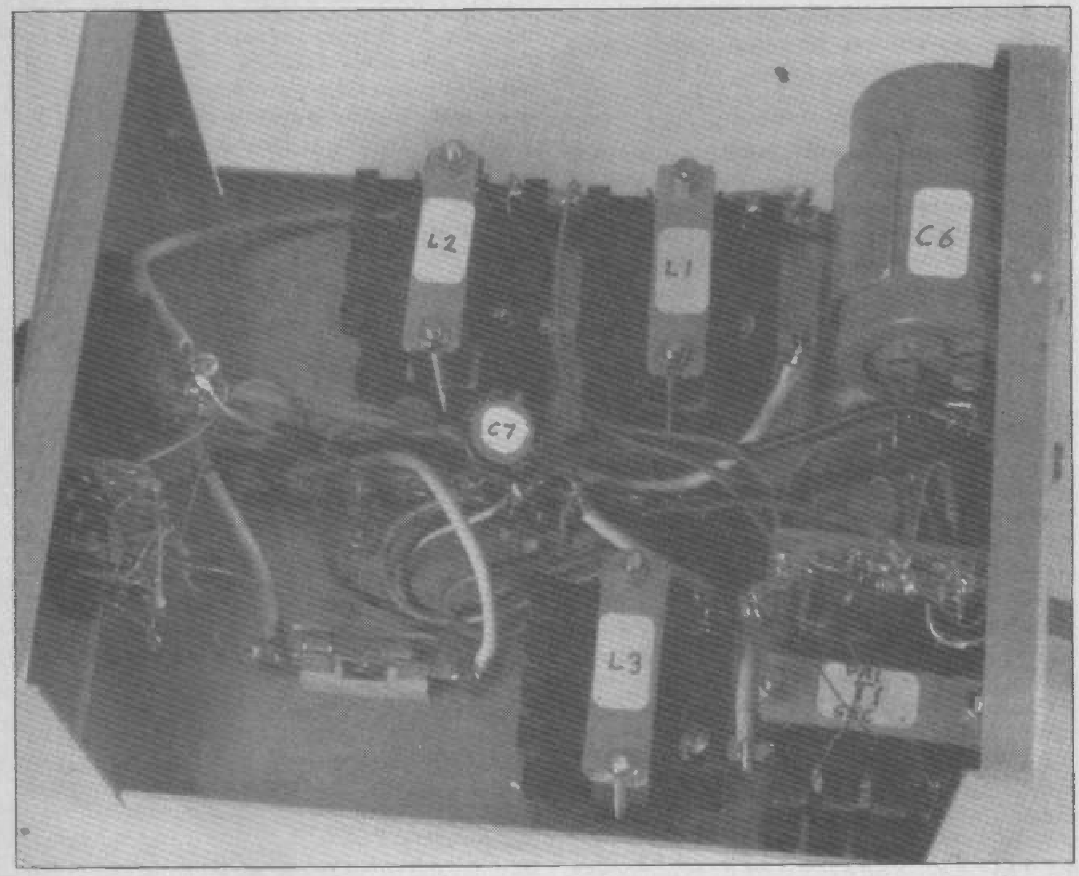


Fig. 2 Component overlay and off-board wiring for the field power supply



care, more like a UHF receiver than a PSU, with careful attention to earthing.

Then there are the inductances which must not saturate at the maximum DC load. Ferroxcube cores are ideal but there must be an adequate gap to prevent saturation. Gaps mean stray inductance with all its undesirable side effects and unwanted coupling.

Winding The Coils

It is best to improvise some arrangement for holding the bobbin while winding the coils, such as a carved wooden former mounted in a hand-drill. They can be hand wound by your average dexterous octopus — three pairs of hands are needed! One turns the bobbin and counts the turns, one feeds the wire and controls the tension and a third pushes things into place.

The inductance is not very critical, so you can manage by just providing the specified number of turns and the right gap. Start with the chokes where there is plenty of space, and finish with the transformer which must be wound neatly or there may not be room on the bobbin.

The voltages are not excessive, so the enamel insulation should be adequate, unless it gets scratched. It is always worth putting a bit of sticky tape over the start of the winding where it goes down the side of the bobbin, to protect it from subsequent layers, if any.

On the transformer, separate the two windings with a layer of thin insulation folded up slightly at the edges to stop any secondary turns slipping down into the primary. The secondary will need about four layers and it is good to put another layer of insulation between the second and third layers of wire. Paper will do. Cut it a ¼in wider than the bobbin and nick the edges every eighth of an inch so that they can bend up. Mark the start of each winding with a spot of corrector fluid as you will need to know this later.

The gaps are achieved by putting spacers of the right thickness between the outer two legs of the E cores. There is nothing in the centre. Pieces of card-board will do but you will need a micrometer to measure the thickness. The gap should not be less than that specified to avoid saturation. It can be up to 5thou thicker, though this will reduce the inductance slightly.

Try to get some M2 studding to clamp them together. You could use 6BA but it is a little too thick and you have to file the sides down to fit, which is a nuisance on four of them. A strip of aluminium along the top is better than just washers, as it stops the studding slipping sideways.

When finally assembled, put a tiny spot of clear adhesive between the bobbin top on one side and the core, to stop it rattling.

Board Assembly

The small components associated with the L296 chip are mounted on the small board (Fig. 2) which is supported on the pins of the chip itself. Assemble the resistors and capacitors first, then fit IC2 and then IC1. The high current connections to pins 2 and 3 will be made directly and do not go through the PCB.

RV1 can be used to set the current limit down to 4A to 2.5A. This is not critical in this application, so we will not attempt to set it accurately. Just set RV1 to the middle of its range and leave it there.

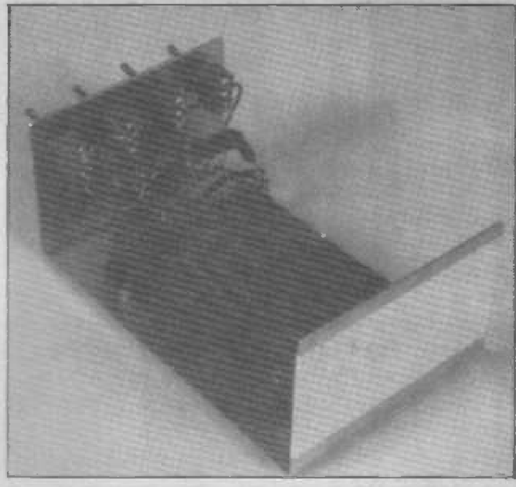
Component Layout

A metal case is essential for screening and is also used as the heat sink. In practise it hardly gets warm. The L296 chip is mounted at one end on its side just above T1, so that the lead from T1 to pin 2 is as short as possible. Indeed, this lead can be made from the end of D3, bent up to suit.

The two large capacitors C4 and C6 are mounted close by. I found it best to mount them with the terminals horizontal and to have the −ve terminal of C6 and the +ve terminals of C4 closest to the metal chassis. Thick wire (at least 18 swg) should be used to connect these capacitors to the other components and to an earth tag bolted to the L296 heat sink. You need a 75W soldering iron with a ¼in bit to make these connections quickly. The L296 heat sink does not need insulating but a little conducting compound between it and the chassis is useful (though messy).

The cables enter at the bottom. The battery leads go straight to their destinations but a tag strip down the centre provides a convenient place to terminate the Spectrum cable. Another tag strip on the front panel supports the LED resistors. The chokes have been placed with a view to minimising coupling via the leakage from the gaps.

There is one (and only one) connection to the chassis and that is on the L296 heat sink. It is



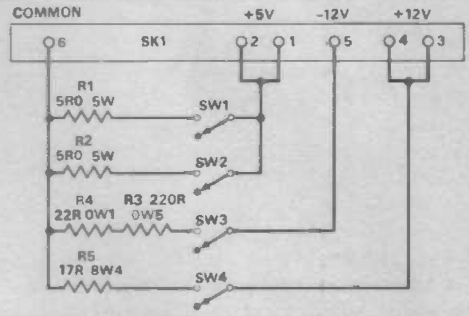


Fig. 3 Circuit diagram for the test dummy load circuit

important that the common return from the Spectrum should have a low resistance, so the cable screen should be connected to the common wire at both ends of the cable. The filter capacitors can conveniently be attached to the screen connection on the tag strip.

Testing

It is best to try the PSU out on a dummy load before connecting it to a Spectrum. A circuit like that shown in Fig.3 will be required and it is not easy to find resistors of suitable wattage. However, constantan wire of 28swg provides some 4R2 per meter and I find it can take up to 1A provided it is suspended so that air can circulate freely.

There are many ways of suspending it but a compact method is to coil the wire tightly round a ¼in diameter rod to form a spring and then stretch it between two tag strips. A meter of wire can be suspended between strips some three inches apart. R1 and R2 need just one coil each but R5 needs to be split into four coils if you are to use a three inch spacing.

To wind these coils, it is worth fixing a hand-drill horizontally either in a vice or by screwing it to a bench. Cut a slot in one end of a 3in length of ¼in rod to hold the wire at the start and mount it in the chuck. Scrape and tin the ends of the wire, then coil them close wound. The resulting coil is about one inch long and spaces all the turns evenly when stretched to 3in.

The photographs show a suitable assembly. The various power lines are arranged on the top of the switches and pieces of wire are left projecting so that a voltmeter can be attached easily without shorting anything out.

Testing can then proceed as follows:

- Connect the PSU to its dummy load with all its switches on.
- Check the PSU switch is off and connect it to the car battery the right way round. Check that the green LED lights. If not, check polarities.
- When the green LED does light, switch on and check the three red LEDs light.

HOW IT WORKS

The complete circuit diagram is shown in Fig.4.

The 12V DC input is supplied from a car battery. If it is connected the right way around, the green LED1 lights. If not LED1 will not light, and D1 protects it from excessive reverse voltage. If you do switch on in this condition, D2 conducts and blows the fuse FS1 to prevent damage to the PSU and Spectrum.

Normally the +12V goes straight through to pins 3 and 4 on PL1, but IC1 generates spikes which are filtered out by L1,C7 and C9. Unlike the other supplies, this one is not stabilised and lead resistance must be kept low to avoid excessive voltage drop.

The L296 chip has been specially designed for switched mode PSU operation up to 4A. It contains the output transistor needed to switch cleanly and all the other components needed to control the switching. There is a sawtooth oscillator the frequency of which is set by C1,R2 to about 25kHz. There is a 5.1V reference which is compared with the voltage fed back to pin 10, and R3,C2 stabilise this feedback loop.

There is provision for soft start with a time constant set by C3. There is a current limiter which can be reduced from 4A to 2.5A using R4 and RV1. The short circuit current is kept well below the 4A maximum. There is also a crowbar circuit and a reset circuit which are not used.

The output transistor is effectively a switch connected between pins 2 and 3. The primary of T1 provides a load inductance of 200µH. C6 is the output capacitor, normally charged to a steady 5V. When the swich is *on*, some 7V appears across T1 primary and the inductive current ramps up some 0.6A (see main text). When the switch is *off*, the inductance generates a back emf which drives pin 2 negative. However, D3 opens and clamps it with −5V across the inductance. The inductive current ramps down some 0.6A and the cycle repeats.

With a steady load current of 2A, the inductive current never falls to zero and everything is very efficient, provided the inductance does not saturate due to the DC current.

The output from the secondary winding on T1 is rectified by D4,C5 to produce about −16V for input to a −12V stabiliser chip. Should the load on the +5V line fall below 0.3A, the inductive current will hit zero, the transformer action will be impaired and the −12V supply will collapse. This is not a problem in this application because the SPECTRUM always takes enough current from the +5V line.

The switching edges are very fast and are at a low impedance. They generate spikes which are filtered out by L1,C7 on the +12V line, by L2,C8 on the −12V line, and by L3,C10 on the +5V line. Every care must be taken to keep the spikes out of the earth circuits, otherwise you will never get rid of them. Hence C4 and a single earth point on the heat-sink of the L296. The thick line connections on the circuit diagram must be as short and straight as possible.

L1 must not saturate at 700mA DC and must have a very low resistance to avoid voltage drop. L3 must not saturate at 2.3A but its resistance is less important because it is included in the feedback loop. The +5V current flows from pin 2 through T1, L3 and the cable resistance to PL1 pins 1 and 2. It is the voltage on PL1 pin 2 which is fed back to IC1 pin 10 and which is kept constant at 5.1V regardless of the load current. R6 and R7 provide a default feedback path in case the external one should be lost for some reason. C12 provides local smoothing and R5 merely holds an unused input steady.

L2 has only to handle 50mA of DC and its resistance is unimportant. It is placed before IC2, a −12V regulator, to prevent input spikes finding their way onto the output. As a result, the output needs little extra smoothing.

The three red LEDs indicate when the three outputs are present.

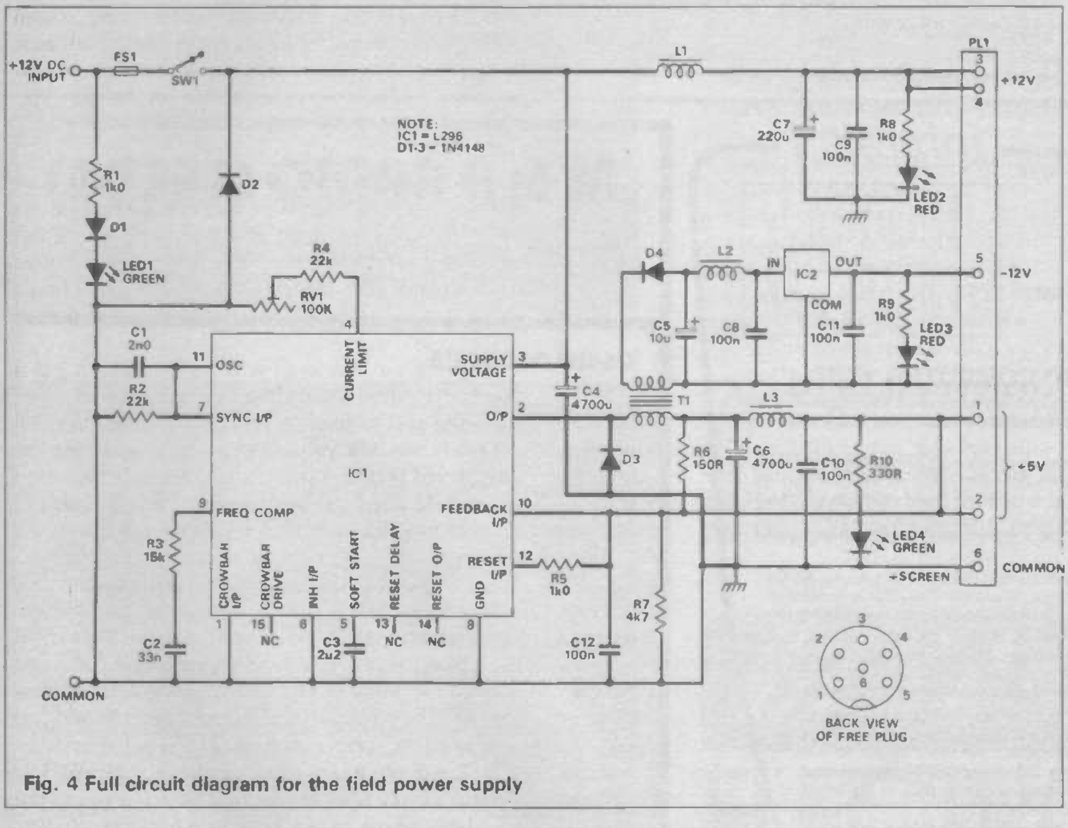


Fig. 4 Full circuit diagram for the field power supply

- Check the voltages on the dummy loads. The +12V should not be more than 0.3V less than that across the battery. The +5V and −12V should be within 0.2V of their nominal value. Also check the voltage across C5 is about 16V on load and about 17V when SW3 is open.
- If you have a scope, check the spikes are less than 0.2V pk to pk and that the ripple is less than 50mV measured at the dummy load.
- Halve the load on the +5V line by opening SW2 and repeat the voltage checks.
- Switch off, reverse the battery, switch on again and check the fuse has blown. Check D2 is still intact, either by resistance measurement or by repeating this test. Replace the fuse and reverse the battery.
- The +5V and the −12V supplies have short circuit protection built in but you will probably prefer to leave this to an inadvertent test. The +5V may tick audibly when short circuited as it

keeps trying to do a soft start. The +12V has no protection apart from the fuse.

If you have a current meter, you may wish to check some of the currents but many meters need about 0.5V to drive them and this is significant at these low voltages. Moving the meter from one point to another can give misleading results because of the changes it makes.

If you measure the input current, it should be about 1.75A at full load. When you take the meter out of circuit, the L296 gets an extra half volt, adjusts its on/off ratio and takes a little less current. The +12V load takes a little more.

ETI

BUYLINES

The constantan wire can be obtained from Maplin, part code BL64U. The copper wire can also be obtained there in 2oz reels.

The schottky diodes, the tag strips, the L296 and the special condensers were obtained from Electromail. The 50W ferroxcube kits are available from both these suppliers. The Electromail kits come in little yellow cardboard boxes which are just 13 thou thick and can be used for the spacers. On the other hand, the Maplin kits include 16 solder spills which can be inserted in the bobbins to terminate the winding neatly.

The case was a Maplin AB31.

The PCB is available from the ETI PCB service (see centre pages).

For Maplin telephone (0702) 554161.

For Electromail telephone (0536) 204555.

PARTS LIST

RESISTORS

R1,5,8,9	1k0
R2,4	22k
R3	15k
R6	150R
R7	4k7
R10	330R

CAPACITORS

C1	2n0 polyester
C2	33n polyester
C3	2µ2 25V electrolytic
C4,6	4700µ 25V electrolytic impedance 50mR @ 10kHz
C5	10µ 16V electrolytic
C7	220µ 16V electrolytic
C8-12	100n ceramic

SEMICONDUCTORS

IC1	L296
IC2	79L12
D1,4	1N4148
D2,3	3A schottky
LED1	5mm green LED
LED2-4	5mm red LED

MISCELLANEOUS

FS1	chassis mounting fuse clip + 2.5A fuse
L1-4	Ferroxcube transformer kit
PL1	6-pin DIN plug
SW1	Single pole switch, 3A at 12V DC

Case. Wire (2oz 18swg, 2oz 22swg). Tag strips. 6 core cable. Solder tags. Nuts and bolts. P-klips.

WIN A LASER!

PLUS TICKETS TO THE LONDON LASERIUM

FREE COMPETITION

Can it be true? Yet another competition to challenge, charm and channel the talents of the great ETI readership of the world?

Yes it can. Together with Maplin we are offering the chance to win one of Maplin's laser and controller units described below. Plus the winner and the runner-up will receive a pair of tickets for the show of their choice at the Laserium in the London Planetarium.

Just answer the five questions to the right on the back of a postcard and send them together with your name and address to the address below.

The closing date is September 4th when the winning entry will be drawn from the ETI Competition kettle drum. Please indicate on your entry if you would be unable to attend the London Laserium — a year's subscription to ETI will be awarded in recompense.

You can buy Maplin's laser as an easy-to-build kit but for the competition we'll be giving away fully constructed version with a light output power of 2mW. The tube comes complete with a 1.8kV power supply and protective aluminium case. The laser emits randomly polarised waves in the red end of the spectrum. Its low output power makes it completely safe, provided the light beam is not directed into the eye.

The controller will turn your laser into a light show. This trip of the light fantastic is performed by two motorised mirrors which move the beam in two dimensions. The controller has three operating modes; manual, auto and audio input. This is an essential item if the user intends to go in for beam bending Lissajous and spiral Graphic effects that will be displayed upon a wall.

The Laser and PSU kit (LM 72P) normally sells for £99.95 including VAT and the controller kit (LM73Q) for £69.95 including VAT.

London's Laserium uses the most advanced laser projectors in the world to present nightly laser spectaculars from its base in Marylebone Road, one minutes walk from Baker Street tube. Current shows include the music of Michael Jackson, U2's greatest hits, and the 'London Rocks' spectacular. For full details call the Laserline on 01-486 2242.

1. For what is LASER an acronym?

A Low Amplitude Serially Emitted Radiation
B Large Antelope Sends Everyone Roses
C Light Amplification by Stimulated Emission of Radiation
D Los Alamos Synchrotron Energy Research
E Light Acting Sideways on Energised Ruby

2. One light year is approximately

A 9.46073×10^{15} *km*
B 3ft 9ins
C 20000 leagues
D 9.46073×10^{18} *mm*
E 3×10^{8}*m*

3. Which one of these gases is not commonly used in lasers?

A Helium
B Carbon Dioxide
C Neon
D Xenon
E Boron

4. Which one of the following statements is not true?

A Lasers are illegal in Norway
B Wavelengths of red light are longer than those of blue light
C Clocks go forward at the start of British Summer Time
D As you approach the speed of light, your mass increases
E The first operational laser used ruby as its lasing material

5. Which one of the following wavelengths appears as red light?
A 63nm
B 570nm
C 635µm
D 800nm
E 6.3×10^{-6}m

LASER COMPETITION
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ARGUS HOUSE
BOUNDARY WAY
HEMEL HEMPSTEAD HP2 7ST.

Maplin

ELECTRONICS TODAY INTERNATIONAL

LASERIUM

PLENTY OF SCOPE RESULTS

We received a record number of entries to the *PLENTY OF SCOPE* competition from our July issue. Even more surprising, about half of you got the correct answers. What a clever bunch you are.

The lucky winner is P. Austin of Thame in Oxfordshire, who was first out of the hat with the correct answers.

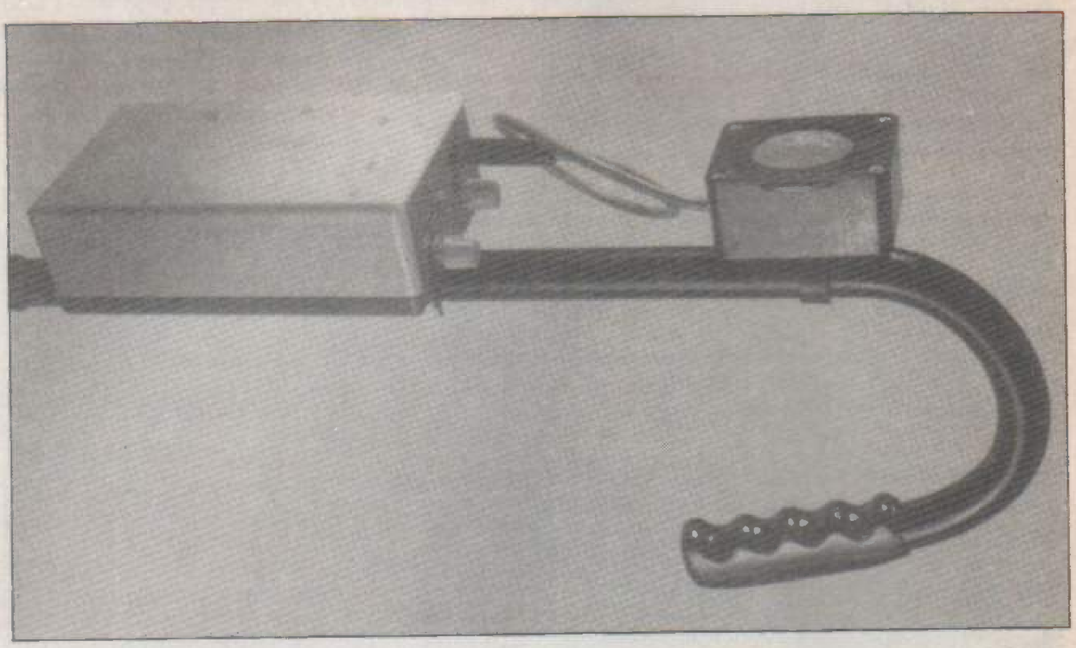
For those who require enlightenment, the answers were as follows:
AETHRIOSCOPE definition E
CHRONOSCOPE definition I
DIPLEIDOSCOPE definition M
EBULLIOSCOPE definition B
ELECTROSCOPE definition H
MEGASCOPE definition G
OSCILLOSCOPE definition K
PSEUDOSCOPE definition D
STETHOSCOPE definition A
ZENOSCOPE definition X

All those who answered C, F or J fell into our silly definitions trap. Our thanks to Maplin and to all who took part.

TWIN LOOP TREASURE SEEKER

Robert and David Crone present their snouted seeker that exposes the treasure other detectors cannot reach

PROJECT



Pulse metal detectors are powerful and versatile machines but in their basic form they suffer from ground effect and radio interference. However a very simple modification can almost entirely eliminate these two problems.

The principle of the pulse metal detector is very easy to understand. A large pulse of current is transmitted through a coil of wire and the resulting magnetic field induces eddy currents in nearby coins or metal objects. The eddy currents continue to flow after the transmitted pulse has ended and they in turn induce small voltages back into the coil. These voltages are amplified and detected in a receiver which operates an audio indication, usually a click generator.

A problem with this is that the transmitted pulse induces eddy currents in mineralised ground causing a ground effect signal Secondly the coil acts as a good aerial for long and medium wave radio broadcasts, producing interference. So what can be done about these problems?

The ground effect comes from a large area and is almost constant over a flat surface like a wet sandy beach after the tide has gone out. If we were to position a second search coil about 100mm from the original then it would pick up the same amount of ground effect. Now if we were to subtract the outputs of the two coils the ground effect from each would cancel out. However the system would still pick up coins because the distance between the coils is large compared with a coin. By similar reasoning, medium and long wave radio broadcasts will cancel out as the field strength of these signals does not change significantly in 100mm and each coil will receive the same amount of interference.

So the second coil is a modification to the pulse

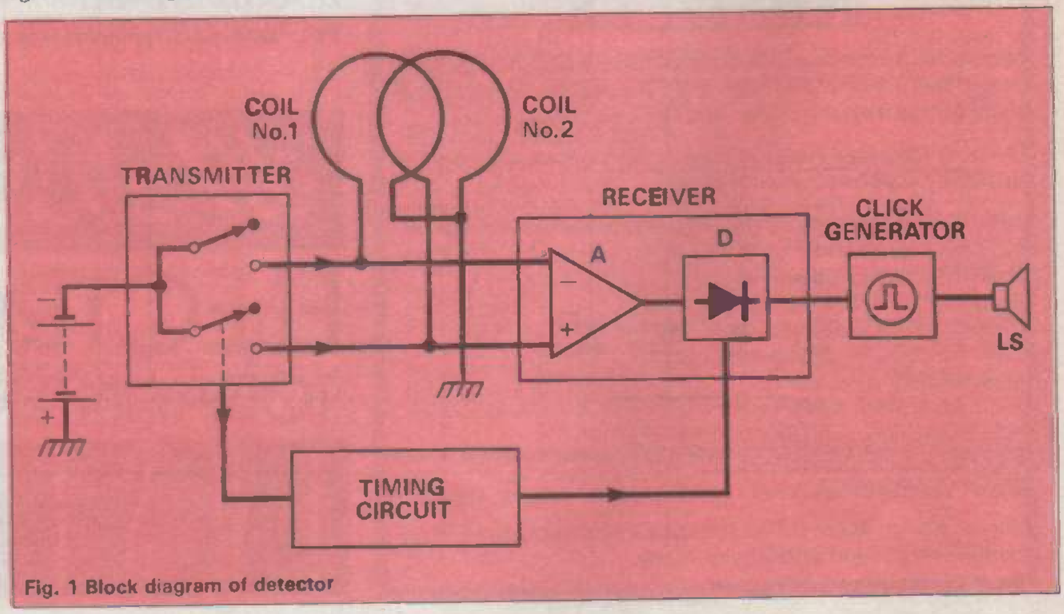


Fig. 1 Block diagram of detector

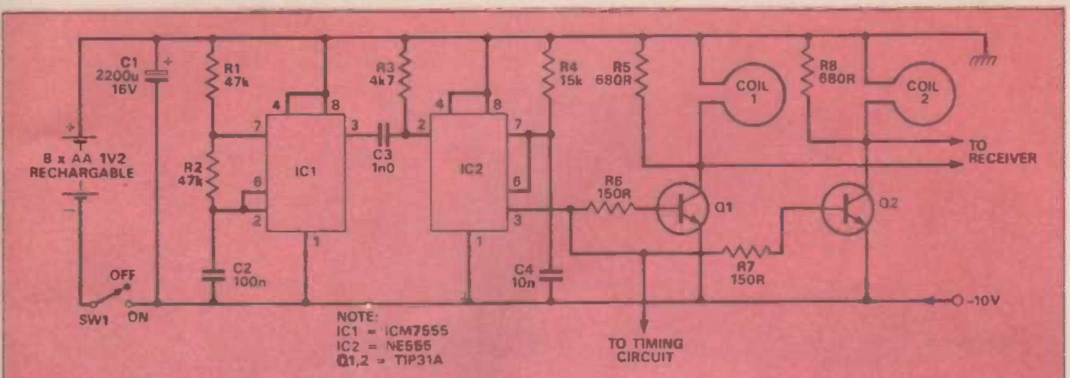


Fig. 2 Circuit diagram of transmitter

detection system. Figure 1 shows a block diagram of the unit. The central feature is the search coil assembly which in practice consists of two coils each of 200mm diameter and overlapping by 100mm.

The Transmitter

Figure 2 shows the circuit diagram of the transmitter. IC1 is wired as an oscillator running at 100Hz. IC2 is triggered 100 times per second from IC1 via the differentiating network of R3 and C3. Each time IC2 is triggered its output goes high for 165µs and drives the two power transistors hard on into saturation. The full battery voltage is now applied across the coils and the current in each one builds up to about one amp.

The Timing Circuit

Fig. 3 shows the circuit diagram of the timing circuit. IC3 is triggered from the transmitter at the end of the 165µs current pulse. Its output goes high for 36µs and then IC4 is triggered via C8 and R11. IC4 runs for 50µs and its output goes to the receiver where it switches on the detector for 50µs.

The Receiver

Fig. 4 shows the circuit diagram of the receiver. The outputs from the coils are fed to the inputs of the difference amplifier IC5. Here the ground effect and interference cancel out but the coin signals are amplified and passed on to the next stage. The 709 is used in the IC5 position because its noise figure is good enough for the job. Diodes D1 to D6 protect the op-amp inputs and are configured so that IC5 does not go into an indeterminate state when the diodes are on. Q3 is switched on for 50µs by the timing circuit and allows the coin signals to pass on to the detector and amplifier IC6. When constructed, set pin 6 of IC5

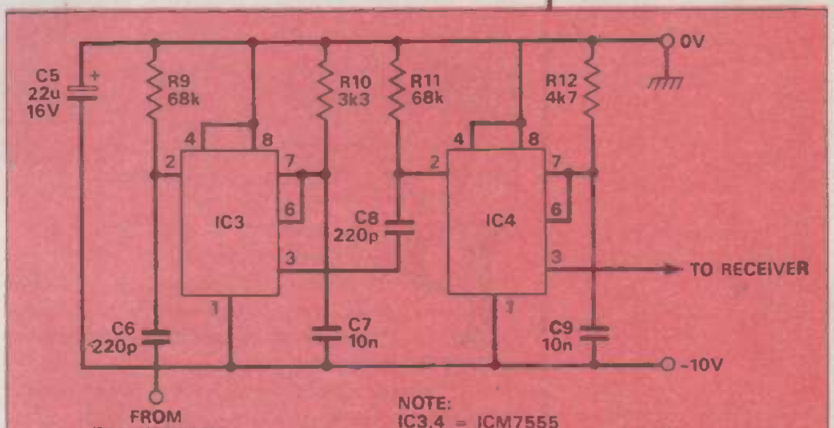


Fig. 3 Timing circuit

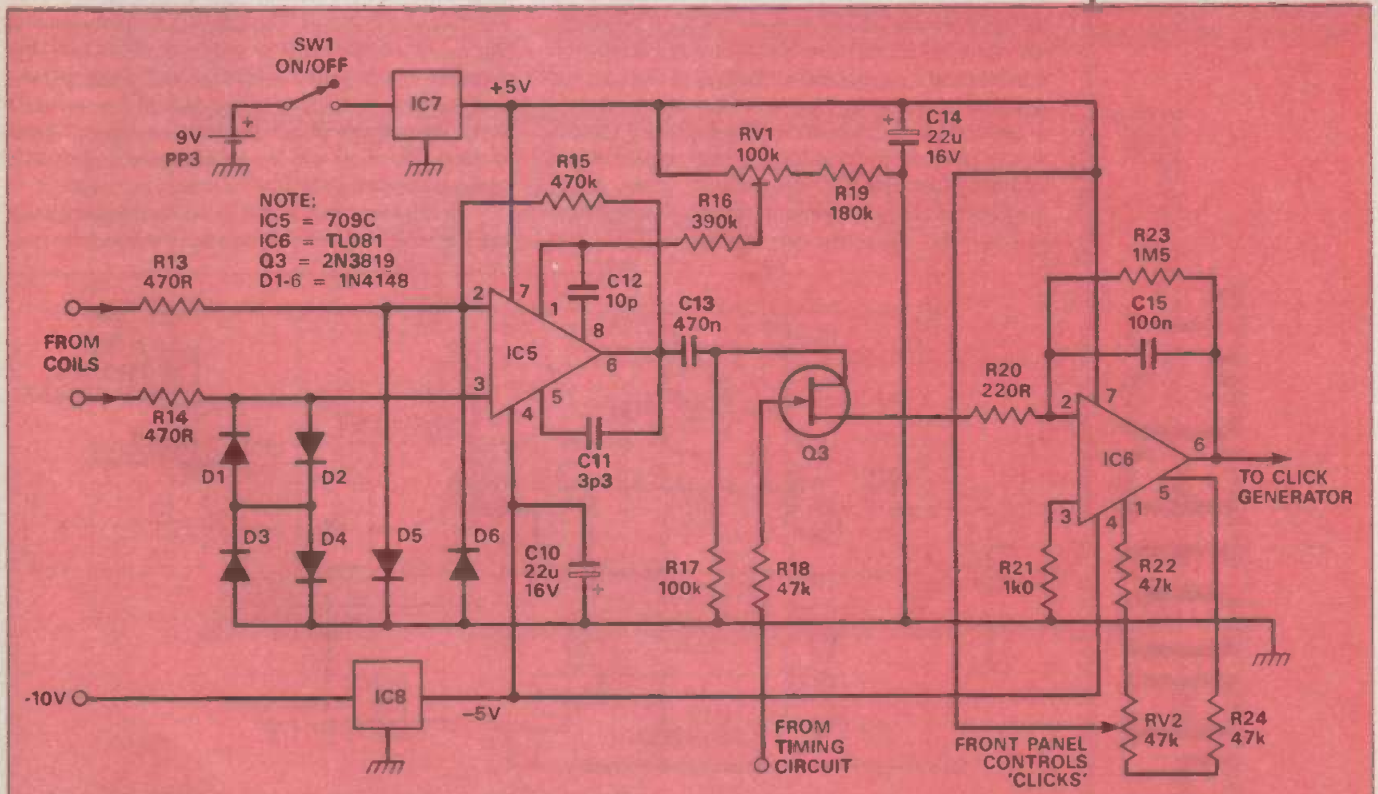
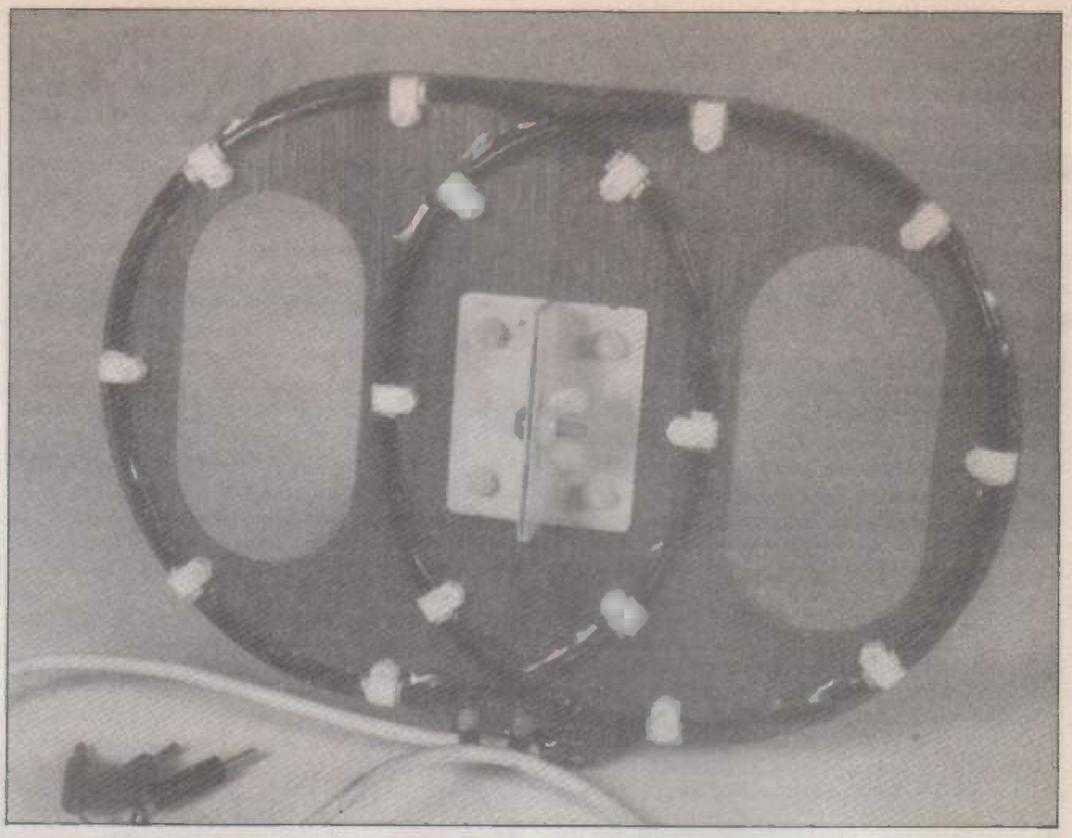


Fig. 4 Circuit diagram of receiver



to −1V by adjusting RV1 and set the receiver output to −0.3V by the front panel control RV2.

The Click Generator

Fig. 5 shows the circuit of the click generator. With no input at all, Q4 is off and the circuit is inoperative. However with −0.3V coming in from the receiver, Q4 starts to conduct very slightly and the circuit starts to click slowly. The clicks rapidly turn into a high pitched whistle as the search coil approaches a coin.

Construction

The circuit is built on a single PCB and the components should be mounted according to the component overlay in Fig. 6. The usual precautions should be taken with the ICM7555s as these are CMOS devices. You need to keep yourself earthed when handling these chips.

Once all the components have been mounted on the PCB, the board can be drilled in the four corners. The board is held firm in a plastic control box by four nylon cuts and bolts. Terminal pins were used on the PCB for external connections to the switches, potentiometers, sockets and battery connections.

Drill the required holes in the plastic control box. You will probably have to do a little additional filing for the volume, click control pots and the audio socket.

To make the search coils, first obtain a piece of scrap 25mm chipboard and hammer into it a 200mm diameter circle of nails, wind 30 turns of no 26swg enamelled copper wire around the nails and secure the windings with string or cotton ties. Pull out a few nails, remove the coil and then wind a second coil. Then mount the coils, overlapping by 100mm as in Fig. 7 on a suitable piece of 6mm plywood and fasten them down with plastic cable clips and plastic screws. Connect the coils up to a few feet of 3-core cable terminated at the other end in 4mm plugs. Alternatively you could use 2-core screened audio cable and use the screen for the common connection.

At this stage you would be advised to bench test the machine to check that you have wound the coils

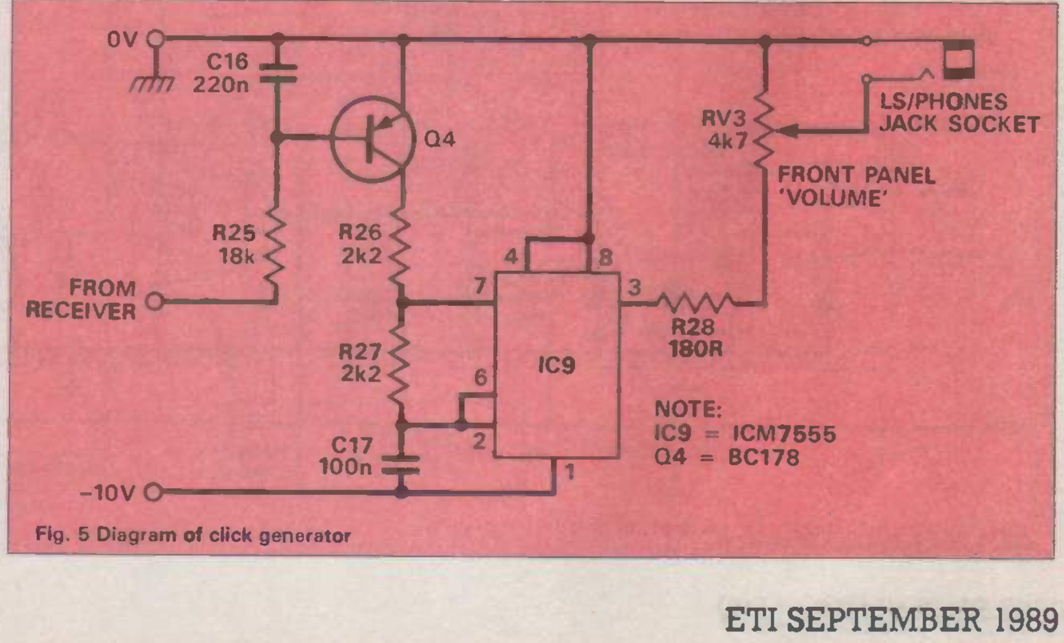


Fig. 5 Diagram of click generator

PROJECT

correctly so that the current in each coil flows in the same circular direction. A method of testing the phasing or current direction in each coil, apart from inspection, would be to pass a small direct current through each coil and then detect the magnetic field produced with a small compass. The coils would need to be placed in the vertical plane with the compass positioned at the centre of each ring. If the currents are in the same direction, the compass will indicate that this is so.

The Printed Circuit Board

Fig. 6 shows the component overlay. Make sure the components are placed in the correct positions. Once the 165μs pulse has finished, the reservoir capacitor C1 starts to charge up with a large current. This causes a voltage drop in the wiring. If any voltage drop gets on to the earth rail, it will be amplified and interfere with the system operation. For this reason separate wiring for the two battery supplies must be used and nothing but the battery may be connected to the left of C1.

The Coils

Fig. 7 gives the details of the coil assembly. Mount the coils on a plywood frame and cut away as much wood as possible to reduce the weight. A few feet of 3-core mains cable is suitable for connecting the coil assembly to the 4mm sockets on the plastic control box. Everything must be plastic or wood. Finally keep in mind that the current in each coil is flowing in the same direction ie they are driven in phase.

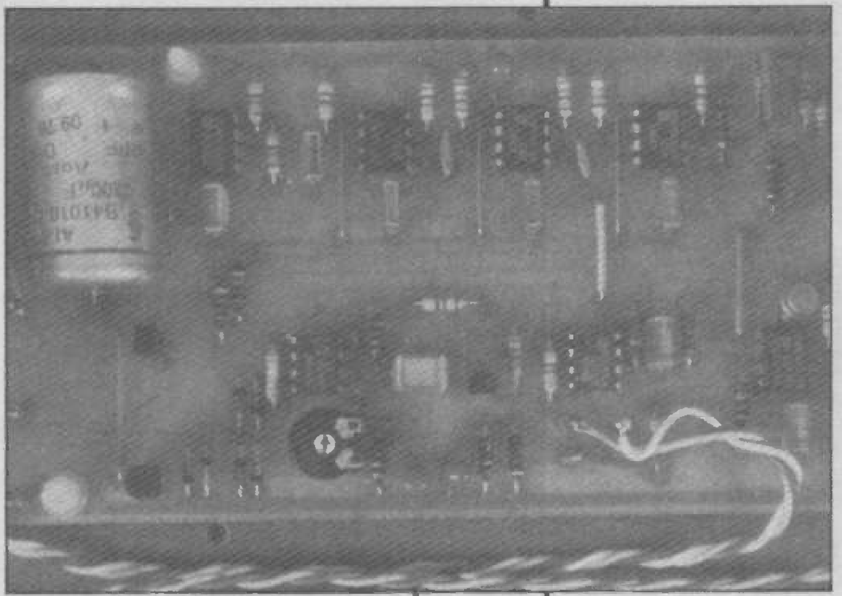
Batteries

Eight 1.2V AA size rechargeable cells provide the −10V supply. The machine consumes around 80mA of current so the batteries will give about five hours of continuous running. When the batteries are discharged, the click generator will go out of control. A 9V PP3 or MN1604 battery provides the positive supply for the op-amps. A voltage converter is not used to obtain this supply as these devices require an oscillator, the output of which might get into the receiver and cause interference. All the batteries are mounted inside the lid of the plastic control box and secured with strong rubber bands.

Then encapsulate the coils with Araldite and put the assembly into a warming compartment so that the Araldite melts and permeates into the windings before setting. Use plastic angle material to attach the assembly to a plastic or wooden stem. *No metal* should be used in the construction of the coil assembly. Any metal nuts, screws, washers or solder tags will upset the system.

An 80cm length of 20mm plastic tubing may be used to make the handle for the control box and can be bent into the traditional 'shepherd's crook' shape by means of a bending spring and hot water. A bicycle handlebar grip slipped on to the top end makes an ideal handle hold.

A 50cm straight length of 16mm plastic tubing can be used for the stem. One end was dipped in hot water and flattened with pliers and then attached to the coil assembly by means of a plastic nut and bolt. The stem is then slid up into the handle until the total length suits the operator and then bolted into position.



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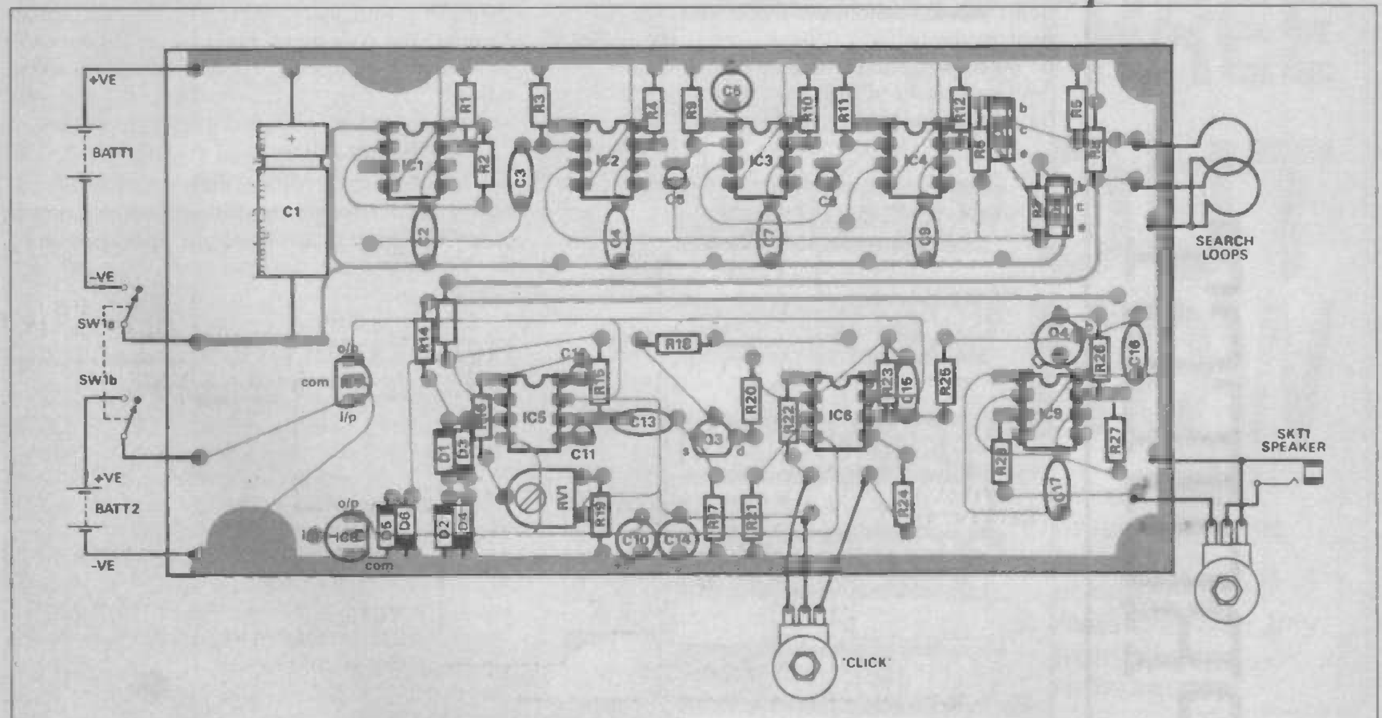
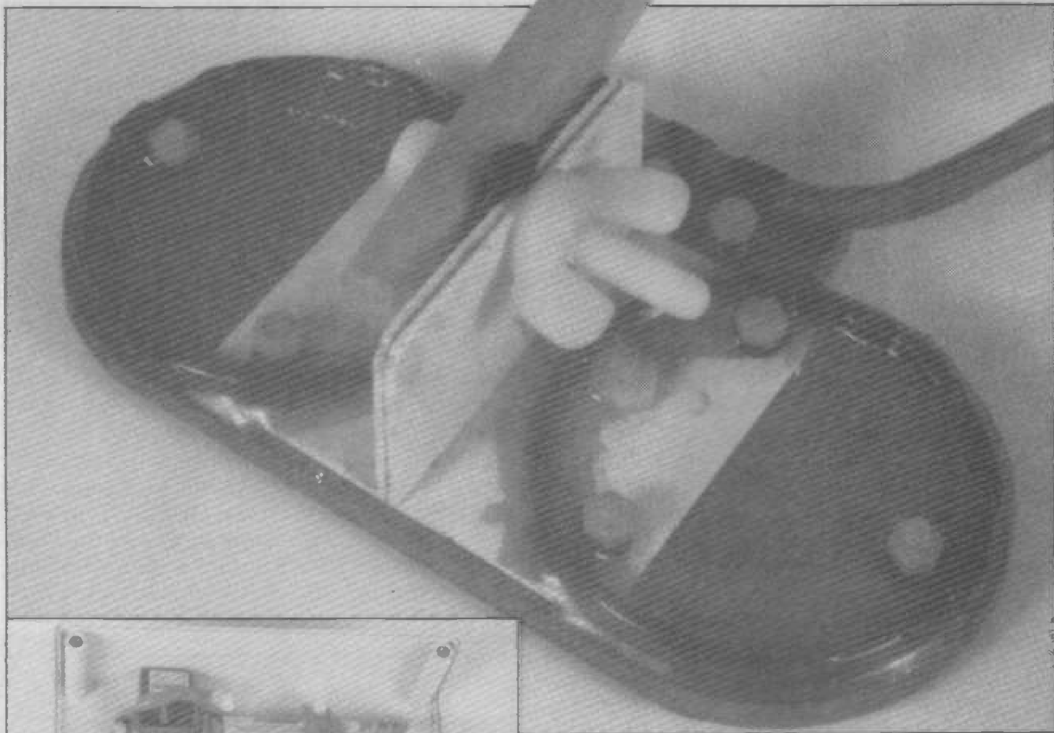
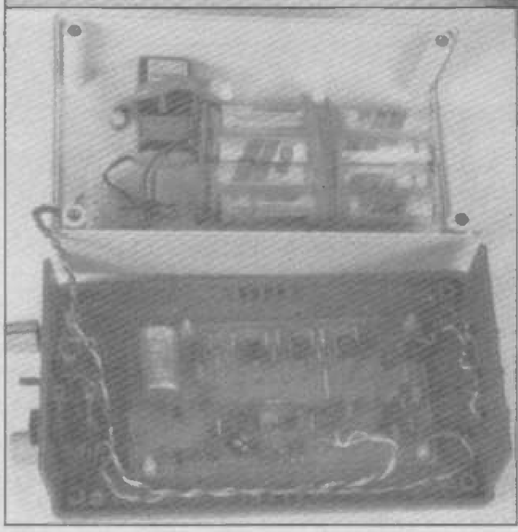


Fig. 6 Component overlay for the detector and off-board wiring





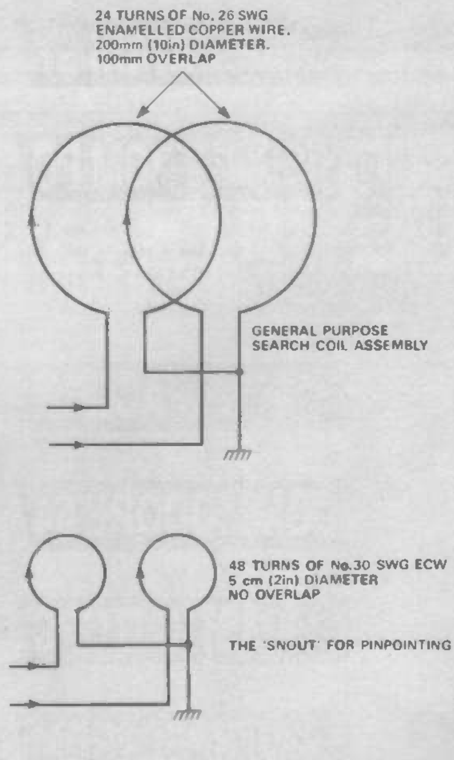


Fig. 7 (a) General purpose search coil assembly
(b) The snout for pinpointing

Alternatively one could use a wooden walking stick or adapt whatever non metallic material one has to hand. The only metal materials permitted are a few screws in the control box and the two screws securing the control box to the handle. Finally, insert a rubber washer between stem and coil assembly. This gives a non slip attachment to stop the search head angle being moved by rough grass.

Testing

The initial testing should be done in a metal free environment. Most work benches and tables contain large numbers of nails, screws and brackets so the reader is advised to suspend the coil assembly from the ceiling on a length of string to ensure that it is well clear of metal. With the click generator set to one click per second the operator will notice a significant increase in the click rate if a two pence coin is taken to a distance of 180mm from the search coil.

Once small pieces of metal have been located with the general purpose search coil, the final pinpointing can be carried out with a snout probe shown in Fig 7b and in the above photograph. This probe was constructed in a similar manner to the general purpose coil expect that the coils do not overlap. Each coil is made from 48 turns of 30swg enamelled copper wire making the loops 50mm in diameter and 70mm between centres.

HOW IT WORKS

The operation is as follows. The two switches in the transmitter close simultaneously for 165μs and allow a current of one amp to flow through each coil. This operation is repeated every 10ms (a frequency of 100Hz). The coin signals picked up by the coils along with the interference and ground effect are then routed to the op-amp A in the receiver (Fig. 1). Here the interference and ground effect cancel out and the amplified coin signals are passed on to the detector D. Detector D is switched on by the timing circuit 36μs after the end of the current pulse and for a duration of 50μs. The μs delay is to allow the coils to settle down because the sudden loss of the current causes a very large voltage spike to appear across each coil. The DC output of the detector now goes to the click generator which starts to click rapidly as the search coil approaches a coin.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,2,18,22,24	47k
R3,12	4k7
R4	15k
R5,8	680R
R6,7	150R
R9,11	68k
R10	3k3
R13,14	470R
R15	470k
R16	390k
R17	100k
R19	180k
R20	220R
R21	1k0
R23	1M5
R25	18k
R26,27	2k2
R28	180R
RV1	100k horiz preset
RV2	47k lin
RV3	4k7 lin
CAPACITORS	
C1	2200µ axial electrolytic
C2,15,17	100n polyester 7mm
C3	1n0 polyester 7mm
C4,7,9	10n polyester 7mm
C5,10,14	22µ 16V tant bead
C6,8	220p 63V ceramic
C11	3p3 63V ceramic
C12	10p 63V ceramic
C13	470n polyester 7mm
C16	220n polyester 7mm

SEMICONDUCTORS	
IC1,3,4,9	ICM7555IPA
IC2	NE555
IC5	µA709CP
IC6	TL081
IC7	78L05
IC8	79L05
Q1,2	TIP31A
Q3	2N3819
Q4	BC178
D1-5	IN4148
MISCELLANEOUS	
BATT1	8 x 1.2V AA rechargeable batteries
BATT2	1 x 9V PP3 battery
PL1-3	4mm plugs: 2 red, 1 black
PL4	2.5mm mono jack plug
Sk1-3	4mm sockets: 2 red, 1 black
SK4	mono 2.5mm chassis jack socket
SW1	double pole, double throw switch

Case. Enamelled copper wire, 28swg and 30swg. Plastic tubing, 16mm and 20mm. 6mm plywood. Plastic angle. Cable grips. Glue (Araldite)

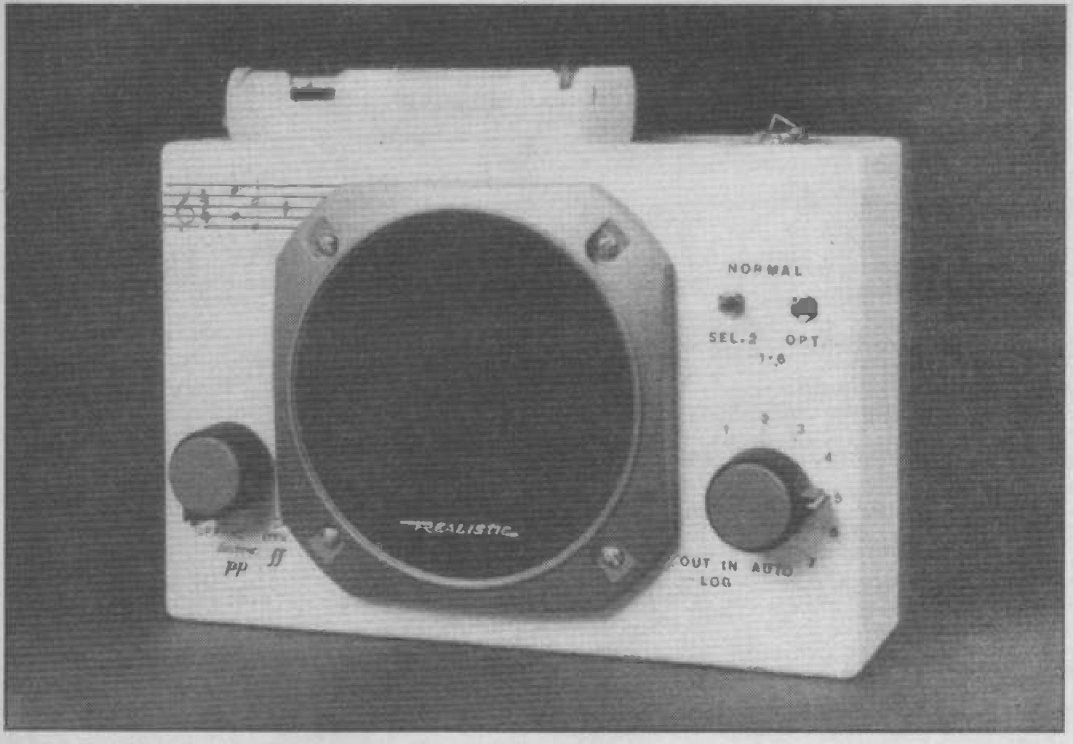
BUYLINES

You should have no problem in obtaining components as they are all readily available. The enamelled copper wire is available from Maplin who can also supply the 709 op-amp.

The plastic control box in the prototype was a Vero-box type 202-21031 but any box of equivalent size will do. A variety of plastic tubing is available in most DIY stores but must be rigid to make a good handle.

PROJECT

ETI



PROJECT

POLYBEL

Trevor Skeggs serenades his surroundings with this polyphonic programmable doorbell

Our many educated readers will instantly recognise the origins of this project's title with *poly* meaning *many* and *bel* meaning *beautiful* sounds. Indeed this project was benignly originated to bring direly-needed harmony into today's troubled world. However, amongst any readership there is always the world-wise minority who, with the baser instincts of experience, may ridicule this claiming cynically that *Polybel* is merely an abbreviation of *polyphonic doorbell*.

Ludicrous though such a claim may be, if it has to be called that in order to gain acceptance from, and thus enrich the lives of, such persons then so be it — but let's at least call it Britain's (if not the world's) first programmable polyphonic doorbell.

This music generator has been designed to be battery-operated and portable, to be constructed by the non-computer expert, to be flexible (no, not on plastic PCB, but adaptable), and to be efficient.

Adaptability must include the recognition that many humans quickly become bored with lack of change, and for this reason it is possible to build a version that you can re-program yourself by down-loading data from a home-computer equipped with a parallel port. A minimal knowledge of music is required for this and in a subsequent issue we'll look at how to transcribe sheet-music into hex code, and thence into the unit. The usefulness of anything is limited only by knowledge on how to use it, and to this end full information on the program and how to adapt it for your own ends will also be included then.

Regrettably, this is not a particularly low-cost project, primarily because of the box chosen, but with imagination and shopping-around it shouldn't bankrupt you. The fully-programmable version will however absorb your free-time in the way that computers first did!

Options

A number of options exist in the construction of this project that will need to be determined beforehand.

Is the unit to function in a pre-determined fixed manner, such as a rather novel music-box? In such a case a cheap EPROM will suffice, and you could make the box yourself, needing little in the way of switches and plugs; also a small cheap speaker will be adequate.

Do you just want to enjoy making electronic music? In this case, do you really need a box at all — why not eliminate the speaker and feed the output into the hi-fi? Perhaps even lash it up on an old piece of stripboard?

Do you really need to program it or just let it perform the "1812" and one or two other pieces?

Polybel has a maximum manual selection of 14 different tunes. This may be obtained by any number of switch permutations including DIL packs or headers, hex, rotary and/or toggle-switches. Because of the difficulty in obtaining hex rotary-switches, the program as supplied is arranged to look for a rotary 1-of-7 selection, plus a bank 1/bank 2 input. The program also caters for an 'option' on each of these 14 tunes, the meaning of which is up to you but typically is used for a short-version of the tune selected. It may also be used to select extra tunes. Thus we have (typically) a rotary-switch and two toggle switches, with perhaps a volume control and/or on-off switch.

If the EEPROM (Electronically Erasable PROM) version is built, the following extra facilities become available:

- down-loading from any home computer with an 8-bit parallel-port (from 7-bits by special arrangement)
- automatic selection of tune (from a maximum of 16) on a rotation basis (this may eliminate the requirement for some of the switches!)
- recording/informing of the number of times the bell-push is pressed during your absence (*monitor* and *tell-tale* modes).
- expansion of the operating system (Z80 programming knowledge required).

Construction — The Box

The PCB was designed to fit into the case, and if using this box two important features should be noted before

HOW IT WORKS

A block diagram for the Polybel is shown in Fig. 1 and is hopefully self-explanatory. The bistable regulator is a unique circuit that combines the roles of bistable (Power-On/Power-Off) with a +5V regulator. The bistable is triggered by an active-low input (a switch to 0V) and is reset by an active-low signal (HALT) from the CPU at the end of its melodic interlude.

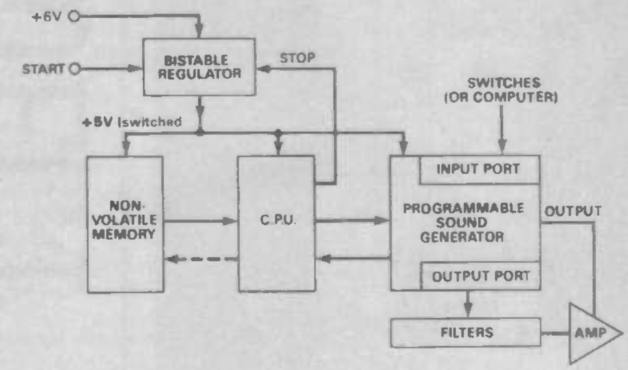


Fig. 1 Block diagram of the Polybel

The CPU then executes the program in its non-volatile memory, reading in the switches (via the input-port facility provided in the Sound Generator chip) to determine your selection. This selection determines one of 14 "buffer" areas in the PROM, which contains up to 128 bytes of special code. The CPU subsequently interprets those "buffer codes" via its "operating system" which resides in page zero (address-range Hex 000-0FF).

Most of these buffer codes cause the CPU to change the contents of one or more registers of the Programmable Sound Generator (PSG) which then outputs the required frequencies at the required volume or envelope to the output-stage. Crude filtering is also controlled by the data sent to the PSG's output-port, which allows for smooth bass. The CPU controls all of the timing functions and when the buffer code for "stop" is seen, it powers down the circuit by the use of HALT.

The analogue circuit is shown in Fig. 2. Assume Q2 is not conducting and therefore has its collector at 0V. Base-drive for Q3 is now available via R6, R3 and R4, causing a collector current of some 12µA through R8, R5 and R4. The voltage at the junction of R5 and R8 is thus comfortably greater than the 200mV internal reference of IC1a (which thus acts as a comparator forcing pin 1 low and cutting-off Q1 and Q2 — our initial assumption and therefore a stable state).

In this condition the only power-drain is through Q3 and IC1, which together consume about 300µA. A few micro-amps pass through R27 to ensure that IC1b is "cut-off"; this provides a valuable insurance against offset from the PSG which would otherwise cause a few milli-amps drain through Q4 and the speaker.

Action starts when the trigger input (from say a microswitch) sinks current from Q3 through D1 and C1. Being inherently lazy, not much current struggles through R8 resulting in a drastic electron depopulation at pin 8 to a few piffling millivolts.

This gets IC1a understanderbly miffed, as its positive input is getting an unfair 200mV and pin 1 therefore shoots up in protest. Transistor Q1, shocked at being kicked up its base-side by this revolt from the normally tranquil pin 1, sucks in sharply — drawing in current via the base of Q2. This opens up the flood-gates of Q2 and starts a 'hole' ugly stampede of restless energy, anxious to break-out of the confines of their tiny 1.5V cells and sing for joy.

It is the job of Q2 to regulate this rush and since the chips make an unholy noise if they don't get exactly 5V, Q2 has this voltage at its collector, wisely seeing that this will cause 200mV at the junction of R3 and R4 and bringing harmony to IC1a.

Q3 finds itself starved of base current with +5V on the other side of R6, and holds an embargo on the supply to pin 8: IC1a is, however, well-satisfied with the supply from R5 and all is well.

The 'holes', having had their emptiness filled by the PSG, re-appear harmoniously and concurrently on 'Channel' outputs to IC1b. Channel A develops a voltage across R20, where it waves at the input to IC1b through R21. Since Channel A usually carries the bass notes, C5 is used to shunt away the squeaky voices.

If PA0 (bit 0 of Port A) is set high under command of the CPU, D2 conducts and falls to a low impedance, shunting the alto voices away through C4, leaving only the real he-man bass voice. Thus, D2 is a poor-man's switch; D3 does a similar job for rounding-off the harshness of Channels B & C.

All three channels are combined at R24, then amplified and pushed through the speaker as a uni polar current. When the Z80 halts at the end of its duet with the PSG, Q3 is brought out of retirement by demand from R9, restoring the status quo and switching-off power to the digital circuit (and thus current through R9).

Moving to the digital parts of the circuit, the Programmable Sound Generator IC6 is an array of 16 read/write registers with frequency dividers, D to A convertors, two I/O ports and a noise-generator. Much information has already been published about this device (Electronics Digest Summer 1987) and from suppliers (Watford Electronics for one), and thus will not be explained here.

The method of controlling it is somewhat cryptic and will best be understood by reference to Table 1. This shows the eight permutations of the three control lines of the PSG and the corresponding result.

There are only four PSG modes (Read, Write, Select and do nothing); thus there are four redundant combinations. It is usual to select the last four as listed in Table 1, tying BC2 to +5V and encoding BC1 and BDIR from the CPU's IORQ, RD, WR and address lines using all manner of weird gate and diode arrays.

In this application, since the PSG is the only I/O device and there is no RAM to write to, the scheme of Fig. 3 has been adopted and the method of implementing this into hardware is shown in Fig. 4. This 'decoder' performs a decode/encode of the data type of instruction (that the CPU cannot do entirely internally) — read or write from or to the selected PSG register (IN/OUT to *any* Z80 I/O address), read from PROM, and select PSG register (write the required register number (0-15) to *any* memory address). This leads to very efficient programming and is part of the reason that a powerful 'interpreter' can be crammed into only 256 bytes. This method was used in the original prototype.

However, the introduction of the possibility of 'programming' the non-volatile memory in-situ has led to the amended circuit of Fig. 5. Here, we introduce address-line A15 as a PSG/MEMORY select line. A write of data 01 to address 0xxx results in selection of PSG register 1 for communication, whereas writing data 01 to address 8xxx results in 01 being written to memory address 0xxx (*if* you have an EEPROM or battery-backed RAM in that position!).

A difficulty arises in programming the EEPROM in-situ that may not be obvious at first consideration. The EEPROM is an ingenious device that latches the address and the data, then goes away and gets on with it. It informs the CPU that it is busy (for typically 10ms) by inverting bit 7 of the data just written (2816) or by use of a RDY/BUSY flag (2817). The CPU is thus free to go away and do other things and come back and 'poll' the EEPROM to see if it is ready.

When the EEPROM is the only source of telling the Z80 what to do, however, what we like to think of as the brains can go a bit gormless, and so here we use a 2817 with a BUSY output that can tell the Z80 to 'hang-on a moment' via its WAIT input. When the 2817 has written the data, the Z80 continues with the next instruction — a bit like coming out of a hypnotic trance, unaware that hours have gone by.

With the circuitry just described and the data bus being obvious, the only part left to describe is the circuitry around IC2. Inverting segment pins 13,12,11 forms the clock generator. This is necessarily CMOS to obtain the large voltage-swing demanded by the Z80, and takes the form of a relaxation oscillator at a frequency of 1MHz. Ceramic resonator X1 'locks on' when resonated near this frequency. Since there is only one supplier of this device, it is made an optional extra by replacement with a link. In this case, the pitch and tempo of the music is heavily dependent on choice and tolerance of R15 and C2. R17 provides a little bias to even-up the mark-space ratio.

The rest of IC2 forms a Schmitt trigger buffer for the power-up reset R14 & C3.

PROJECT

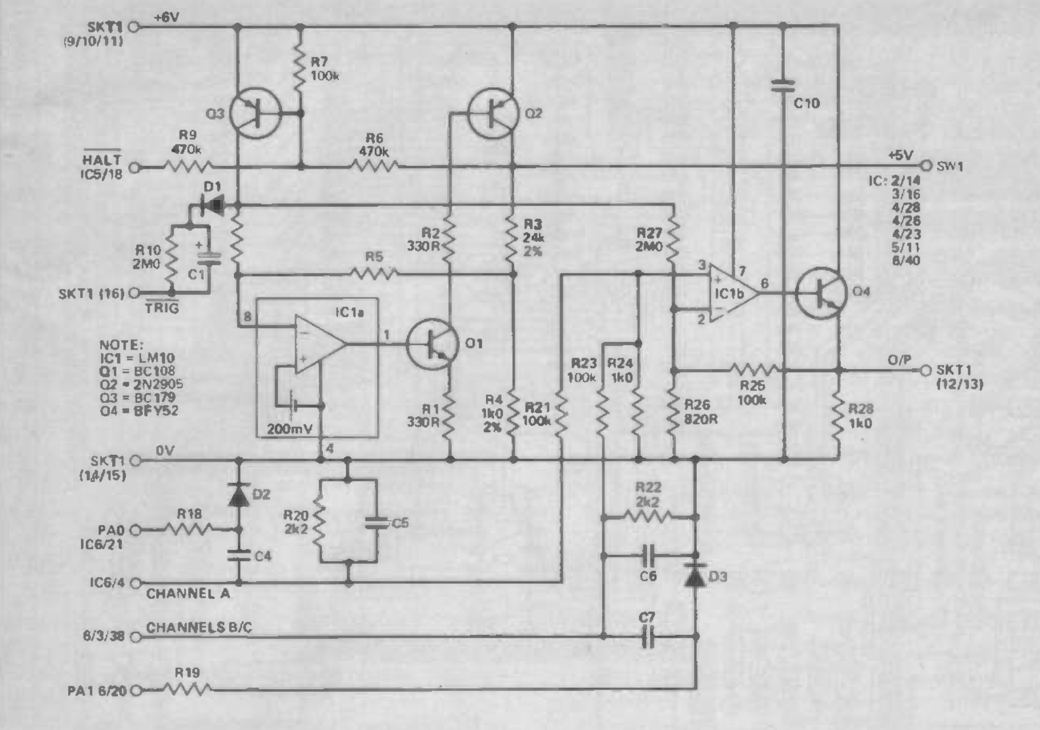


Fig. 2 The analogue circuit of the Polybel

	BC2 (IORQ + STORE)	BC1 (OUT)	BDIR (IN)	PSG ACTION
IN	(IORQ)	H	(RD)	011-110-011 (Nact-Read-Nact)
OUT	(IORQ)	(WR)	H	011-101-011 (Nact-Write-Nact)
STORE	(WR)	H	H	011-111-011 (Nact-Select-Nact)
FETCH	L	H	H	-011- (Remains Inactive)

Fig. 3 Encoding of the polyphonic sound generator bus control functions

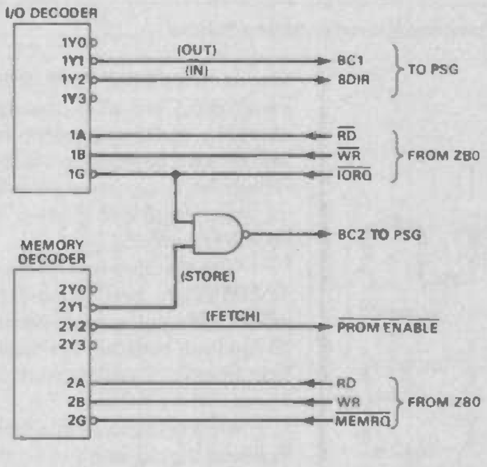
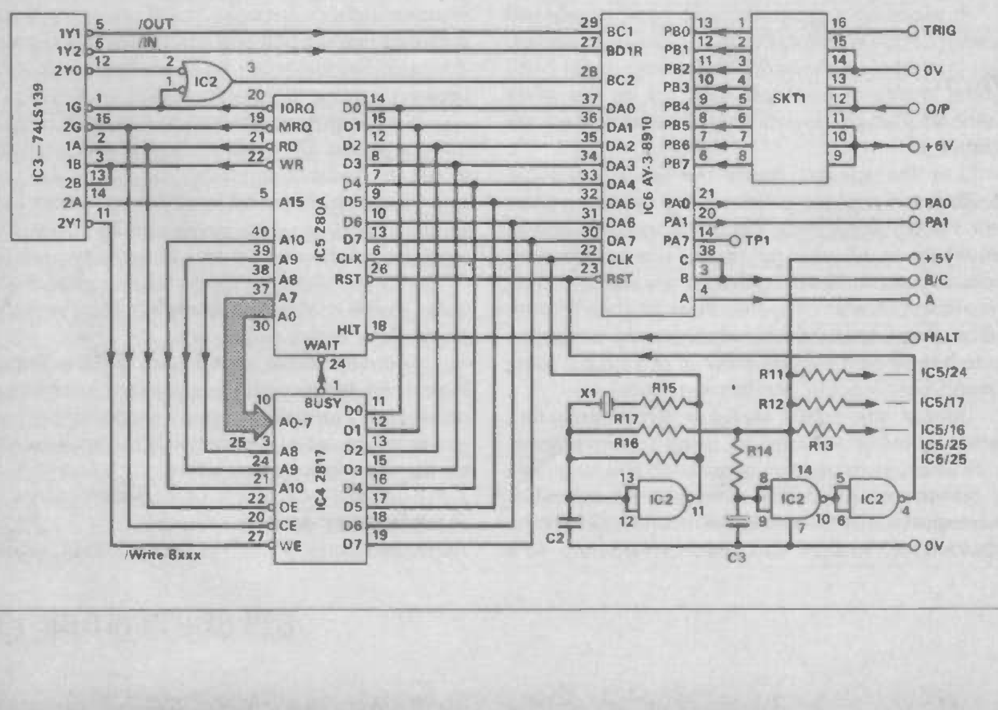


Fig. 4 Implementation of the PSG bus control

Fig. 5 The digital circuit of the Polybel



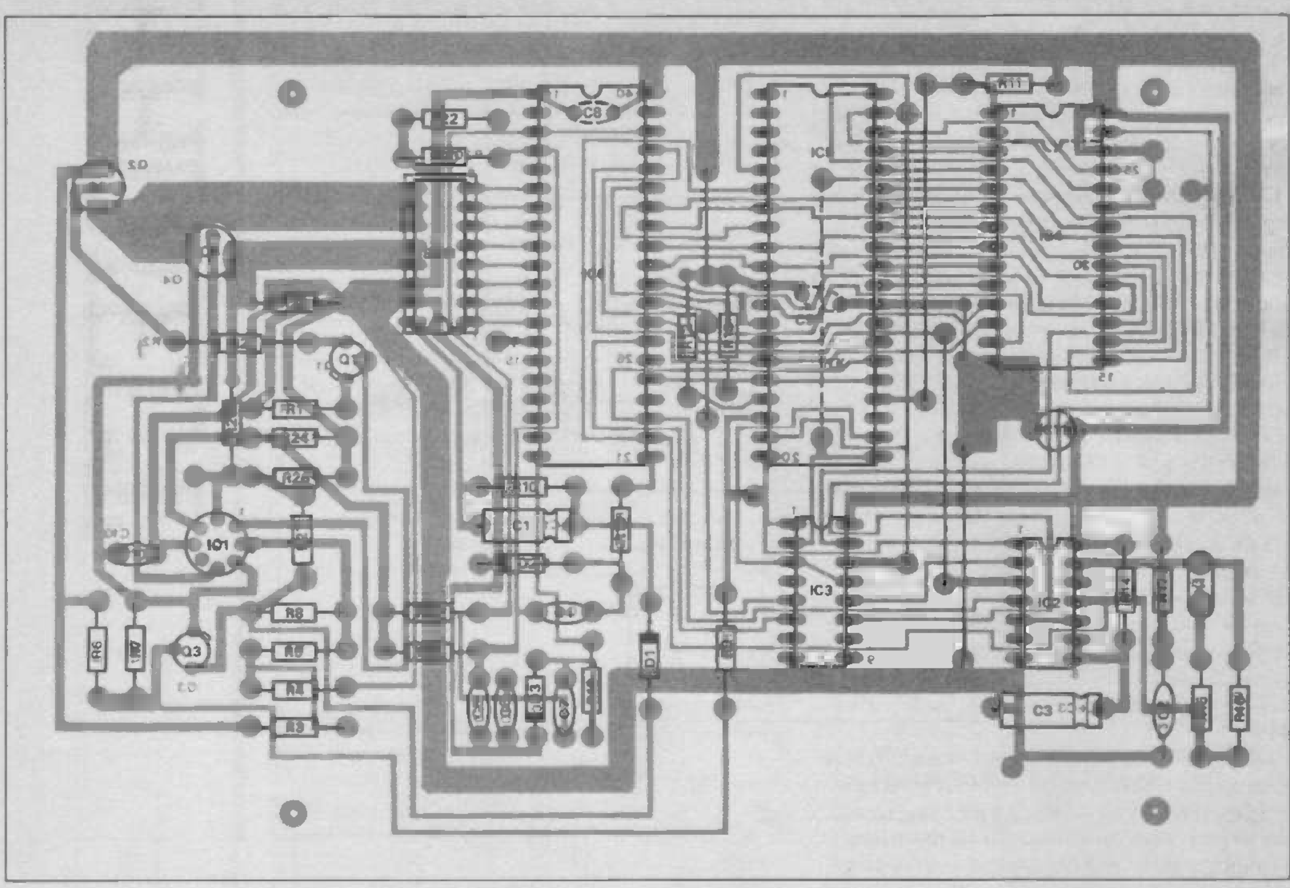


Fig. 6 Component overlay for the Polybel

PROJECT

any work is started. Firstly the slot knock-outs on the base (grey) are all in the same direction and will therefore determine the top (where battery-holder is mounted) if deciding to wall or door-mount the box. The lid will only fit onto the base one way, because of the tongue-and-groove, and therefore dictates layout of lettering.

The terminal-tags for the trigger and the battery-holder(s) are best situated on the top aluminium panel, although some types may have sufficient grip to hold the batteries in should you wish them to go underneath. There is insufficient room internally for them.

Most of the work involved will go into drilling the holes for the tag-strip if using the cheap one suggested but you could save effort by investing in a spring-terminal system as used for loudspeakers (from Tandy for example).

If requiring a programmable version, you will need to decide where to mount a Centronics socket. This could be on the same aluminium panel (with careful choice of battery-holder), or on the white plastic lid. This would definitely be easier and ensure a better fit!

Lay the speaker inside the lid between the standoffs and mark the position of the mounting holes with a sharp point. If the size of the speaker (and its grille!) permits, off-set slightly to one side to allow extra room for the switches. Remove the speaker and draw cross-lines between the points marked, then drill out the five points marked. Use whatever you can find to scribe a circle on the inside of the lid and cut-out using a wood-bore, coping saw or sharp knife!

Mount the rotary switches temporarily and decide on the arc-of-rotation, using a sharp point to mark where each position of the knob is to be. When all drilling and hacking is complete, dis-assemble, clean and dry. The plastic of the recommended case is too smooth to allow successful dry-lettering, so a coat or two of dry-lettering fixer is prudent here.

Construction — the PCB

Smooth off sharp edges and corners, degrease and clean the PCB. Start with the eight wire-links as shown on the layout in Fig. 6. The one under IC5 must be fitted before the socket.

Fit C8,C9 and then the IC sockets (now it will be seen how important the choice of 40-pin holders was!). If building a 2716-only version, then a 24-pin holder is inserted in the lower section of pad IC4 (towards IC2), not using pins 1,2,27 and 28. This is not recommended, however, as it limits future expansion.

The basic switch connections are shown in Fig. 7 and the differences in the programmable version are shown in Fig. 8.

At this stage it is very wise to do a pin-to-pin resistance check between the IC holders, using a coloured marker-pen and a photocopy of the circuit diagram. Finding open or short-circuited bus-lines later-on is going to get very tricky!

Now fit all the passive components, IC1, and all four transistors. Do *not* fit IC2 to IC6 — it is now time to test the 'bistable regulator'!

Tests of the board fall into three categories. Firstly, simple integrity checks, as mentioned above. Every minute spent here could save hours of anguish later. Check for such things as the track being cut by the drill-holes, cracks, solder leaking into adjoining tracks, mis-read colour codes and so on.

Secondly come digital tests. This will involve looking for signals with a scope (if available) or logic-probe and, if necessary, using a special test-program (more on this later). Lastly come the analogue tests on the regulator and amplifier.

Analogue Tests

As implied above, it is best to test the bistable regulator without the other ICs fitted — both protecting them and reducing confusion.

Temporarily connect the battery holder black wire to the 16-pin header pin 15 without the batteries. Connect the red to pin 9. Observe that the polarity of this connector runs *opposite* to the other sockets and insert.

Connect a dummy load across the 5V output by linking R12 (end nearest R9) to 0V. Connect a voltmeter across the +5V output at any convenient point, such as across R12. Double-check that IC1 pin 7 is about to receive +6V (it will fry-up if it doesn't like the flavour of the 6V!), breathe deep and insert the batteries!

Verify that you do *not* have 6V. Briefly touch pins 16 and 15 of the header together. Verify that the voltmeter reads between +4.8V and +5.2V.

Touch the end of R9 nearest to IC5/6 temporarily to 0V. Confirm that the voltmeter reads less than 0.2V. When triggered, the junction of R3/R4 should be at 0.2V and the base of Q1 at approximately 0.7V. In the event of difficulties here, refer to the *How It Works* section.

Re-trigger the circuit, then connect the voltmeter across R28 (+ve nearest Q4). Confirm that the meter reads zero: If a few hundred millivolts exists here, then the value of R27 will have to be decreased, perhaps to 1M5.

Temporarily connect R21 (end nearest IC6) to Q2 collector and check that the output goes to approximately 5V. If an oscilloscope is available, remove the meter and check for oscillations on the output at R28 when it is at 0V and 5V. Disconnect the supply and all leads.

Now you can continue construction, fitting IC3 first (to provide static protection) and then, carefully, IC2. Reconnect the supply for the first of the digital tests.

Connect a voltmeter to IC2 pin 4 and trigger the regulator. Check that the output rises shortly afterward.

Check pin 11 for some 2.4V (or use a scope to check for 1MHz at approx. 50% mark-space).

At this point, you could insert IC5 & IC6 and check the processor activity. However, you may as well go for broke now!

Faultfinding

If after powering-up for the first time you find the Philharmonic on strike, all is not lost! A small test program is given in Listing 1 with documentation which will check the basic CPU and PSG operation. However, let me emphasise that the primary cause during development of repeated playing of "The Sound of Silence" was found to be the selection of a blank buffer!

If no active-low inputs are found on pins 1-6 of SKT1, the default is to select buffer 7 at address &700 (Bank 1) or &780 (Bank 2). Make sure that you have something here or else link SKT1 pin 1 to ground and put in the demonstration tuneware.

The test program reads from Port B (the switches) and outputs to Port A. You can thus test the basic digital functioning with a voltmeter. First check that the +5V is up. If not, lift R9. Next check that the Z80 has not halted (pin 18 low). If it has, this means that an address line (or possibly a data line) is corrupted, or PROM is not accessed. Remove the chips and check for isolation between these lines.

Care has been taken in the test program to control address bus activity. Check that A0 to A3 are active (IC5 pins 30-33) and that A4 to A7 (pins 34-37) remain low. For each of the switch positions listed, check IC6 for a low (else high) and IC5 for a low (else active).

Check for activity on IC5 pins 19,20,21 and IC6 pins 27,28,29.

Position	IC6	IC5
1	21	38
2	20	39
3	19	40
4	18	1
5	17	2
6	16	3
Bank 2	15	4
Option	14	5

The second part of the test proves that IC1b and Q4 are able to drive the speaker. Briefly touch the lower-end of R12 to ground: The program located at &0066 now puts a single tone onto Channel A at volume and pitch determined by the switches — softest at position 4 and loudest at position 1.

Highest frequency is with position 6, Bank 2 and option. Lowest frequency is with position 1, Bank 1 and no option.

Tuneware

The details of programming 'tuneware' will follow in not a very long time.

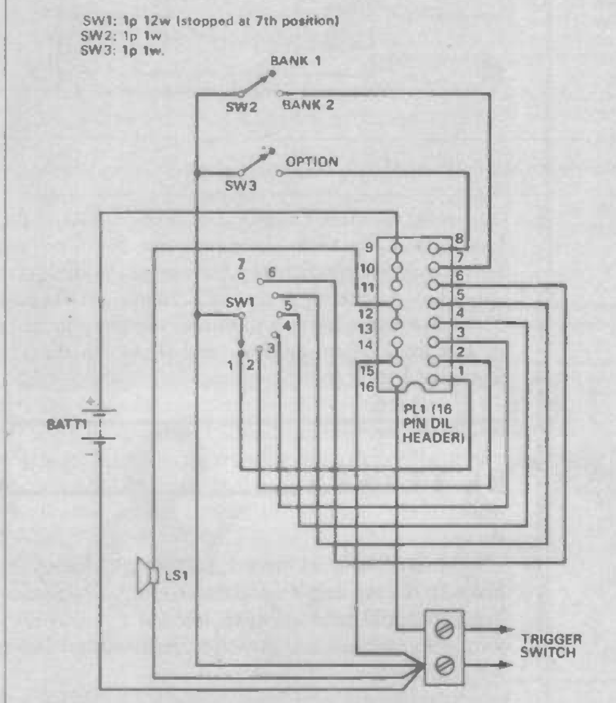


Fig. 7 The basic switching system and off-board connections

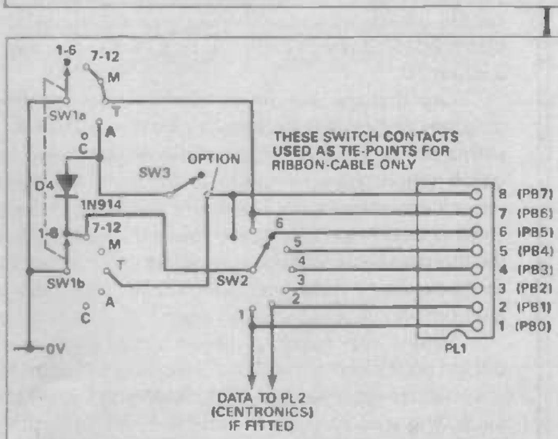


Fig. 8 The switching scheme for the programmable version

BC2	BC1	BDIR	PSG FUNCTION
0	0	0	INACTIVE (NACT)
0	0	1	SELECT REGISTER
0	1	0	SELECT REGISTER
0	1	1	INACTIVE (NACT)
1	0	0	INACTIVE (NACT)
1	0	1	WRITE TO PSG
1	1	0	READ FROM PSG
1	1	1	SELECT REGISTER

Table 1 Bus control codes

Posn.	Function	Bits (0-5)	Bit6	Bit7
1-6	Select Buffers 1a-6a	1 selected	O/C	Option
7-12	Select Buffers 1b-6b	1 selected	low	Option
M	Monitor	O/C	low	O/C
T	Tell-tale	O/C	low	low
A	Auto-select	O/C	O/C	Option
C	Computer	O/C	O/C	O/C

BATTERY LIFE AND COMPONENT CHOICE

The drive capability of Q1 and Q2 was designed to support the common (or garden) Z80 and 2716. However, these are power-hungry beasts. The first prototype built in 1985 brought forth complaints from the original recipients that they were buying batteries every two weeks! Thus the vital R27 was discovered; this should be checked by lifting R9 and connecting a current-meter in series with the supply. With the speaker disconnected, the running current may be observed as well as standby current when the Z80 powers down; this should be no more than 300µA.

Even so, the running-current of a Z80 and 2716 was found to be some 210mA, rising to 230mA if a higher-speed Z80C was used, or 240mA if a 2816 EEPROM was used. Substituting a CMOS processor saved 120mA, and a CMOS EEPROM some 36mA. (The CMOS Z80 can drive a non-CMOS prom but the latter may require extra decoupling with a small electrolytic.)

The conclusion is that there is no justification for not buying a CMOS Z80, especially as the prices are falling now, and the same will soon be true for CMOS EEPROMS although these can be extra-ordinarily hard to find.

With both CMOS devices, battery life should extend over two months.

Acknowledgement is made to John and Judy who graciously surrendered the world's only Polybel for dissection!

BUYLINES

MAPLIN: (Tel: 0702 554161) Resistors — 'M' series metal-film 0.6W 1%. C2,C4,C7,C8-C10 (BX47B,WW49D,WW37S,WW33L,YR75S) Screw-terminal (FK16S), Speaker, box, transistors
CIRKIT: (Tel: 0992 444111) X1 (resonator 16-10003) 40-pin DIL skt (28-00040) Battery-holder (01-04104)
WATFORD: (Tel: 0923 37774) LM10, AY-3-8910 & booklet.

Be careful not to choose a single-beam socket for IC5 (that is one that has a central cross-bar) as you will be unable to fit C9 underneath. There may also be difficulty in obtaining miniature tantalum capacitors (STC type TA/2.2/K20), in which case you will need to up-end them.

There is a great deal of variation in the prices of IC1, IC5 and IC6 and it is well worth shopping around: do not go after the high-specification, high-price LM10B or C, or the high-speed Z80B or C. Many readers will have access to PROM-blowing equipment but to assist those without, a programming service is offered by the author at the following all-inclusive prices:—

27C16	£ 7.50
28C17	£15.00
PCB	£13.00

Contact: T. Skeggs, 36 Wealdstone Place, Milton Keynes, Bucks MK6 3JG.

PARTS LIST

RESISTORS (all ¼W 5% unless specified)

R1,2	330R
R3	24k 1%
R4	1k0 1%
R5	24k
R6,8,9,17	470k
R7,14,16,21,23,25	100k
R10,27	2M2
R11,20,22	2k2
R12,13,24,28	1k0
R15,18,19	3k9
R26	820R

CAPACITORS

C1,3,11	2µ2 tantulum
C2	150p polystyrene
C4	470n polyester
C5	47n polyester
C6	--
C7	22n polyester
C8,9,10	100n ceramic

SEMICONDUCTORS

IC1	LM10CL or LM10BL
IC2	CD4093BE or MC14093BCP
IC3	74LS139
IC4	2716 or 27C16 or 28C17
IC5	Z80A or Z84C0004 or D70008C
IC6	AY-3-8910
D1-4	1N914
Q1	BC108
Q2	2N2905A
Q3	BC179A
Q4	BFY52

MISCELLANEOUS

BATT1	4×C-size batteries
LS1	Loudspeaker 8R 2W
SW1,2	2-pole 6-way
SW3	1-pole 1-way toggle

PCB. IC sockets. Verobox 202. Battery holder. Ribbon cable.

OPTIONAL

Ceramic Resonator, 1MHz	CSA1.0MK
On-off soft-loud switch	3-pole 4-way
Volume Control	20-ohm (Maplin)
SKT2 Centronics socket	36-way

PCB pins or test-points
Speaker grille
Tie-wraps, bases.

PROJECT

```
                 TEST-PROGRAM

 \ x0 x1 x2 x3 x4 x5 x6 x7 x8 x9 xA xB xC xD xE xF
00 18 0B 73 DB 00 72 D3 00 AF ED 4F 18 F5 01 7E 00
01 11 0F 0E 21 07 00 F9 75 ED 49 C3 02 00 FF FF FF
02 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
03 FF FF FF FF FF FF FF FF 76 FF FF FF FF FF FF FF
04 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
05 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
06 FF FF FF FF FF FF 73 DB 00 70 D3 00 36 08 E6 0F
07 D3 00 18 F2 FF FF FF FF FF FF FF FF FF FF FF FF
08 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
09 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0A FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0B FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0C FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0D FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0E FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
0F FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF

000   18 0B       JR 00DH       Jump to initialisation
002   73          LD (HL),E     Select register 15
003   DB 00       IN A,(00)     Get PORT B switch data
005   72          LD (HL),D     Select register 14
006   D3 00       OUT (00),A    Send data to PORT A
008   AF          XOR A
009   ED 4F       LD R,A        Clear refresh register
00B   18 F5       JR 002H       Loop back
00D               ;
00D   01 7E 00    LD BC,007E    Clear B
010   11 0F 0E    LD DE,0E0F    Data = 14 & 15
013   21 07 00    LD HL,0007    Protect EEPROM from ..
016   F9          LD SP,HL      ..address bit A15
017   75          LD (HL),L     Select register 7
018   ED 49       OUT (C),C     Configure PORT A = O/P
01A   C3 02 00    JP 002H       Start the loop
01C               ;
01C         ORG 38H
038   76          HALT          FF byte was executed!
039               ;
039         ORG 66H
066               ;
066   73          LD (HL),E     Select PORT B
067   DB 00       IN A,(00)     Get switch data
069   70          LD (HL),B     Select register 0
06A   D3 00       OUT (00),A    Set the frequency
06C   36 08       LD (HL),08    Select register 8
06E   E6 0F       AND 0FH
070   D3 00       OUT (00),A    Set the volume
072   18 F2       JR 066H
```

Listing 1 Test program

```
 \ x0 x1 x2 x3 x4 x5 x6 x7 x8 x9 xA xB xC xD xE xF
00 97 57 0E BC 59 D9 ED 62 36 0F ED 78 CB 77 CB B7
01 20 02 CB FD 0F 24 38 FC 18 1E D9 DD 62 DD 6B D9
02 DD E9 D9 D1 D9 10 0E 2B 71 ED A3 FF D9 C1 D9 10
03 06 D9 7D D9 6F 05 23 23 ED 57 28 06 80 3D ED 47
04 28 EF 97 47 57 B6 28 EF E6 0F 4F ED 6F FE 0F 20
05 01 81 5F 23 F9 DD 21 E0 00 DD 19 DD 5E 00 DD 6B
06 DD E9 02 ED 49 FF C3 00 00 FD E1 FD 60 10 C8 E9
07 4B 2B 04 CB D9 7E 23 05 CB 67 CB E7 28 04 CB 6F
08 20 04 36 0D ED 51 FD F9 DD 21 00 04 DD 39 00 D2
09 8C 00 08 37 71 ED 78 28 03 3D ED 79 D9 3F 30 F4
0A 08 3D CB 67 20 D8 FF 36 0F ED 78 F2 B9 00 10 87
0B F1 96 3C ED 47 7D D9 6F D9 6E 18 86 EB 2E D0 09
0C 6E 1F 30 02 29 29 87 02 ED 69 3C 02 ED 61 EB FF
0D F0 D8 C0 B4 AB A0 90 80 78 6C 60 5A 55 50 48 40
0E BC BC BC 1A BC 70 70 70 62 62 62 28 62 62 62 73
0F 73 73 22 75 2C 75 B9 27 27 27 6F A7 B0 69 38 01
```

Listing 2 The Polybel operating system

```
 \ x0 x1 x2 x3 x4 x5 x6 x7 x8 x9 xA xB xC xD xE xF
10 B7 78 FE 30 F8 F9 CC E1 10 45 25 AE 63 63 63 48
11 22 18 8F F0 73 63 63 25 17 8F F0 73 63 63 4D AF
12 28 16 8F F0 73 63 63 15 8F 2A F0 63 63 63 13 8F
13 26 4B AD F0 63 4A 63 49 63 B4 3C AF 25 12 8F B7
14 58 B6 0F F5 06 F0 6B B6 17 11 8F F0 6B 10 8F 4D
15 22 F0 7B FC 7A B7 78 A0 FD 2E 57 4B AE 21 B1 02
16 B0 15 8F F0 63 4A 63 4B 63 49 27 15 8F F5 0A F0
17 6B 90 F8 63 63 63 6F 7F FB 76 F5 0A F0 7F FB 76
18 B7 78 FE 1A F9 FA CF E3 F5 08 45 63 48 B2 28 63
19 47 B2 2D 63 48 B2 30 63 49 B2 36 63 4A B2 3C 63
1A 4B 2E FF 63 19 2F 4D 8F C5 57 CF 63 4B 2E 63 17
1B FD A5 AE 15 FD A5 AB FC EF 4B 26 63 4D 27 13 8F
1C 9F F1 23 4E 15 8F 63 4B 29 9F 16 8F F1 23 4D 17
1D 63 C5 4A 25 9F 18 8F F1 07 B2 3C 9E 57 2F 15 8F
1E 53 B2 3C 53 2E 53 2F 8F 53 2D 10 8F 57 CF F1 7F
1F FF FF FF FF FF FF FF FF FF FF FF FF FF FF FB 76
```

Listing 3 Demonstration tuneware

THE *ORIGINAL* SURPLUS WONDERLAND!

SPECIAL PURCHASE V22 1200 baud modems

We got a tremendous buy on further stocks of this popular **Master Systems 2/12** microprocessor controlled V22 full duplex 1200 baud modem - we can now bring them to you at ***half last advertised price!*** Fully BT **approved** unit, provides standard V22 high speed data comm, which at 120 cps, can save your phone bill and connect time by a staggering 75%! Ultra slim 45 mm high. Full featured with LED status indicators and remote error diagnostics. Sync or Async use; speech or data switching; built in 240v mains supply and 2 wire connection to BT. Units are in used but good condition. Fully tested prior despatch, with data and a full 90 day guarantee. What more can you ask for - and at this price!! **ONLY £69 (D)**

MONITORS

COLOUR MONITORS

Decca 16" 80 series budget range colour monitors. Features include PIL tube, an attractive teak style case and guaranteed 80 column resolution, features which are only normally seen on colour monitors costing 3 times our price! It is absolutely ready to connect to a host of computer or video outputs. Manufacturers fully tested surplus, sold in little or hardly used condition with 90 day full RTB guarantee.

Decca 80 RGB TTL and sync input for BBC and similar type interface etc.

Decca 80 COMPO 75 ohm composite video input with integral audio amp & speaker. Ideal for use with video recorder or our Telebox ST, or any other audio visual use.

Any type only £99.00 (E)

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Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubushi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case. Full 90 day guarantee. **Only £149 (E)**

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Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

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Motorola M1000-100 5" black & white compact chassis measuring only 11.6H x 12W x 22D. Ideal for CCTV or computer applications. Accepts standard composite or individual H & V syncs. Needs 12vdc at only 0.8a. Some units may have minor screen blemishes. Fully tested with 30 day guarantee and full data. £29.00(C)

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JVC 751 ultra compact chassis monitor for 12vdc 0.7a. Dim 11 x 14 x 18cm. Simple DIY data included to convert to composite video input. Full data. BRAND NEW £65.00(B)

20" Black & white monitors by Aztek, Cotron & National. All solid state, fully cased monitors ideal for all types of AV or CCTV applications. Standard composite video inputs with integral audio amp and speaker. Sold in good used condition - fully tested with 90 day guarantee. £85.00(F)

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TATUNG PC2000. Big brother of the famous Einstein. The TPC2000 Professional 3 piece system comprises: Quality high resolution Green 12" monitor. Sculptured 92 key keyboard and plinth unit containing Z80A CPU and all control circuits. PLUS 2 integral TEAC 5.25 80 track double sided disk drives. Generous other features include dual 8" IBM format disk drive support, Serial and parallel outputs, full expansion port, 64K ram and ready to run software. Supplied complete with CP/M, Wordstar and Basic. Brand new and covered by our famous 90 day guarantee and backup. Normal price of this unit is over £1400!

Our Price ...only........£299 (E)

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NEW 5¼ inch from £29.95!

Massive purchases of standard 5¼" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from +5 & +12vdc, are of standard size and accept the standard 34 way connector.

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4 inch	AC 1½" thick	£ 9.95(B)
10 inch	Round.3½ thick. Rotron 110v	£10.95(B)
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4 inch	DC 12v. 12w 1½" thick	£12.50(B)
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VG Electronics 1033 Teletext Bridge	£3750
Tektronics R140 NTSC TV test signal standard.	£ 875
Versatek V80 Printer plotter	£1500
DEC LS11/02 CPU board	£ 150

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Conver AC130. 130 watt hi-grade VDE spec. Switch mode.+5v @ 15a.-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms £49.95(C)

Boshert 13090. Switch mode. Ideal for drives & system. +5v @ 6a. +12v @ 2.5a. -12v @ 0.5a. -5v @ 0.5a. £29.95(B)

Farnell G6/40A. Switch mode. 5v @ 40a. Encased £95.00(C)

Farnell G24/5S. As above but 24v @ 5a. £65.00(C)

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Built to BT's rigorous standards. We have no data so units are supplied for experimentation. EPSU1:+5v 2a.-12v 1a,+24v 1a,+5v fully floating 50ma. EPSU2:+5v 6a,+12v 1a.-12v 0.5a & 5 others.30-70vdc input. Parts alone value!

EPSU1..............£16.95(C) EPSU2............£9.95(C)

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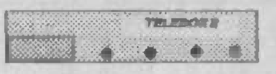

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Brand new high quality, fully cased, 7 channel UHF PAL TV tuner system. Unit simply connects to your TV aerial socket and colour video monitor turning same into a fabulous colour TV. Dont worry if your monitor does'nt have sound, the TELEBOX even has an integral audio amp for driving a speaker plus an auxiliary output for Headphones or Hi Fi system etc. Many other features: LED Status indicator, Smart moulded case, Mains powered, Built to BS safety specs. Many other uses for TV sound or video etc. Supplied BRAND NEW with full 1 year guarantee.

Telebox ST for composite video input monitors..........	£29.95(B)
Telebox STL as ST but with integral speaker............	£34.95(B)
Telebox RGB for analogue RGB monitors..................	£59.95(B)

NOT suitable for IBM clone type colour monitors.

BRAND NEW PRINTERS

Epson MX-80 F/T One of the most popular printers around! Bi-directional printing with full logic seeking. 9 x 9 dot matrix for enlarged, bold, condensed etc. Standard parallel interface. Brand label removed from front. Handles tractor, fanfold and individual paper. OK with IBM PC and most others. A tremendous buy! £129.00 (E)

Hazeltine Esprint small desktop.100 cps with RS232 and standard parallel. Full pin addressable and 6 user selectable fonts. Up to 9.5" paper. Sheet & tractor feed. £149.00(E)

Centronics 150 series. Always known for their reliabilty in continuous use - real workhorses in any environment. Fast 150 cps with 4 fonts and choice of interfaces.

150-SN up to 9.5" paper..	£155.00(E)
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Specify whether serial or parallel required.

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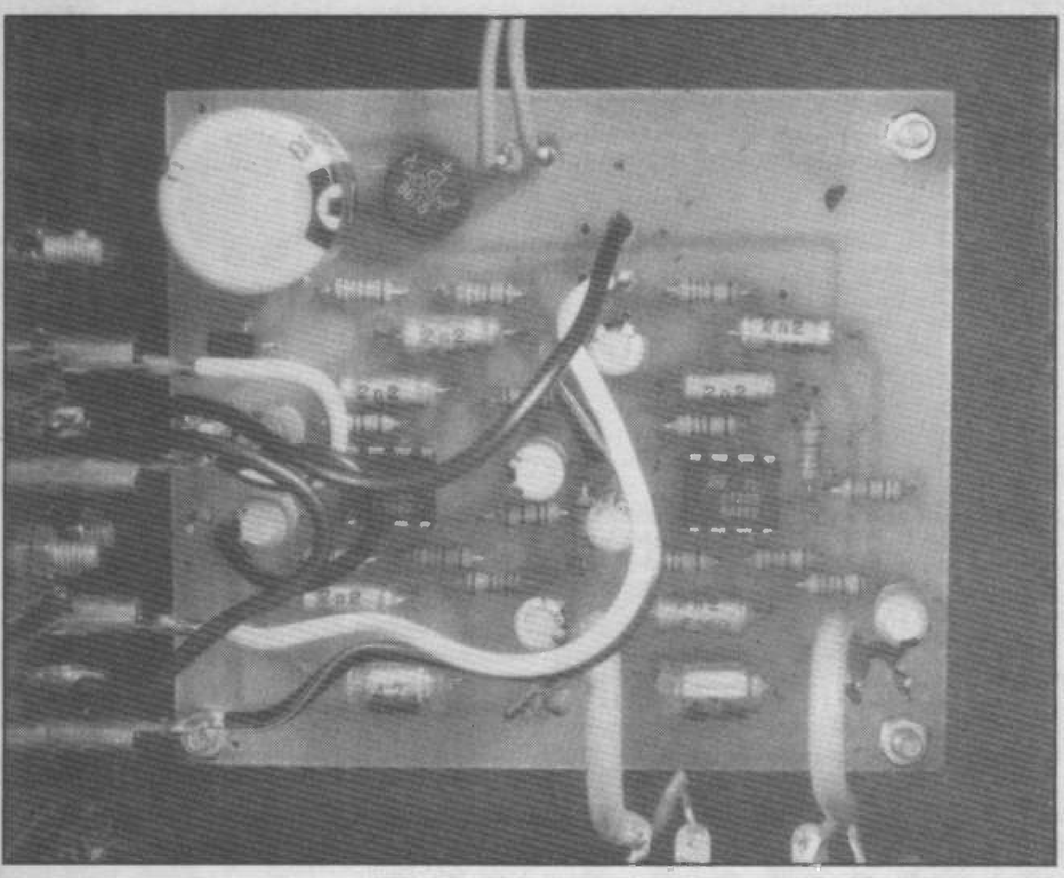
BI-AMPING THE MICRO MONITORS

PROJECT



Jeff Macauley activates last month's bass reflex speaker design

To get the full benefit from the Micro Monitor bass reflex design described last month it is preferable to biamp the speaker. This isn't as difficult as it sounds. If you have a spare stereo ampifier it's quite easy. What is required is an active filter circuit which will match the characteristics of the drivers.

To understand why an active filter should be preferable to a passive network some of the difficulties with the latter should be examined. A passive crossover is generally required to divide the incoming full range signal from the power amp and split it into signals of the required frequency bands. In principle it's quite easy to design such a filter knowing the crossover frequency required and the load impedance of the speaker. In practice the load impedance is just that, an impedance, and a complex one at that. A simple filter, even if very carefully designed, will not operate exactly as required.

The basic problem is that a speaker consists of both a DC resistance and a complex (mainly inductive) reactance. In more complex crossovers, attempts are made to compensate for this inductive reactance with a parallel capacitor resistor network. In theory such a network will compensate for the speaker impedance completely, producing the required resistive loading for the crossover. In practice this solution is at best partial and the results are very driver dependent.

Other problems include a deterioration of the power amp's damping factor as seen by the driver's speech coil. Although speakers are essentially current driven devices they operate best when driven from a pure voltage source (zero impedance). The damping factor of a power amp is defined as the impedance of the speaker divided by the output impedance of the amplifer driving it. As mentioned in the July issue, all speakers exhibit an electro-mechanical resonance which limits performance. A high damping factor effectively lowers the electrical 'Q' of this resonance improving performance. Indeed it can be shown that a high output impedance will lead to a hump in a speaker's bass response. Valve amplifiers exhibit this behaviour leading many listeners to comment on the valve's 'woolly' bass.

Having described some of the shortcomings of passive crossovers we can turn to the advantage of active type. In fact there is very little comparison. An active filter is placed before the amplifier and is load independent. This means that the speaker impedance can do what it likes, with no effect on the filter's response. The full damping factor of the amplifier is applied to the speaker's voice coil leading to a much better transient response. Providing the speaker's response is fairly flat at the crossover frequency, the acoustic response will follow the electrical response of the filter.

It's easy to adjust the relative levels of the drive signals to the woofer and tweeter, allowing fine tuning of the system in situ. This is important because the ultimate sound of a speaker system depends on the listening room.

A system with a flat response in an anechoic chamber will often sound far from flat in the lounge, because of the influence of furnishings on the sound. A room with sparse furnishings will tend to sound harsh whilst one full of soft furnishings will sound bassy. This is why the speakers that sound so good

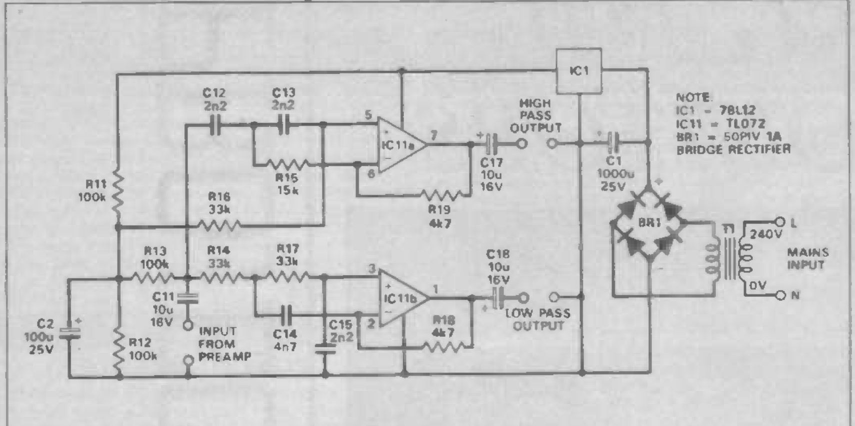


Fig. 1 The circuit for a single channel of the active crossover

at the showroom rarely sound the same when you get them home! Another complication is that of personal preference. With an active system you can cater for all tastes with one system.

As with passive filters, active crossovers are characterised by their slope. First order filters are rarely encountered because the slope is too slow. Both speakers would operate over too great a range. Second, third and fourth order filters are more normally found. As well as the slope the 'Q' is also important. For audio work the ideal 'Q' for a simple filter is 0.7, the so-called Butterworth response.

For this design I have chosen a second order network, for the following reasons. Firstly a second order filter uses only one op-amp so that each channel can be built with a TL072. Secondly although a fourth order filter is theoretically phase linear this advantage cannot be exploited without extra changes to compensate for speaker placement. Lastly the phase shift of a second order filter is less destructive to transient response than higher orders.

Examination of the response curves of the drivers allows a fair amount of latitude in the placement of the crossover frequency and I have decided to place it at 3kHz. Second order filters exhibit phase quadrature at the crossover frequency so that, for a flat response, the tweeter is phase inverted with respect to the woofer. Also note that, at the crossover frequency, both filters are −3db down. Fourth order types are −6db down at crossover.

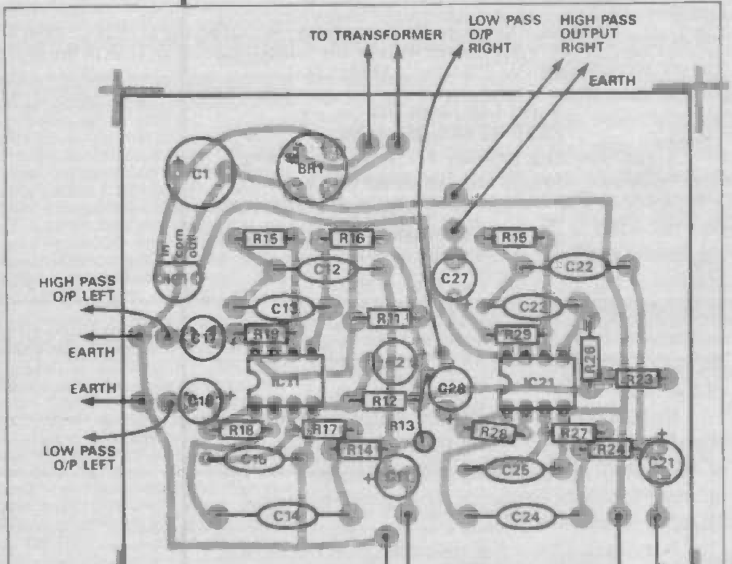


Fig. 2 Component overlay for the crossover

The Circuit

Figure 1 shows the circuit of one channel of the active crossover. The other channel is identical. The circuit chosen is a variation of the 'Sallen and Key' filter which has a 'Q' of 0.7. The circuit is based around a TL072 dual biFET op-amp, one in each channel. For simplicity a single regulated supply rail is used, this being supplied by a standard 12V regulator IC1. Bias for both channels is supplied by the resistive divider consisting of R11 and R12 in series. Since these are of equal value, a 6V biasing point is provided at their junction. C2 decouples this point to ground at audio frequencies.

Input signals from your preamp are coupled into the circuit by C11 which blocks any DC present whilst looking like a short circuit at AF. R13 ties the non-inverting input to the bias network via R14 and R17. The low pass section to drive the woofer is built around IC11b. The actual network consists of R14,R17,C14 and C15. The op-amp's gain is set to unity by the 100% negative feedback supplied by R18. The filtered output signal is fed from the circuit to your power amp's input via C18. This component has the same function as C11 in passing, the audio but blocking unwanted DC levels.

The hi-pass section, built about IC11a, is very similar. C12,C13,R15 and R16 form the filter whilst R19 and C17 perform the same functions as R18 and C18 respectively.

At a pinch you can discard the regulator and operate the circuit from a PP3. But it's likely to be expensive, considering the cost of batteries. A better solution is to use the power supply circuit shown. T1 is any transformer with a secondary rated between 12 and 24V and a current capacity of 100mA or so. You're likely to have something suitable in your junk box! The secondary is full wave rectified and smoothed by C1 before being applied to the regulator.

Since the ripple rejection of the regulator is 60dB and the op amp's is the same a hypothetical ripple voltage across C1 of 1V would produce 1µV of ripple at the output terminals of the IC. I mention this to show that the components used in the power supply are quite uncritical and almost any bridge rectifier and capacitor can be put into service for BR1 and C1. The minimum requirements are 50piv, 1A for the bridge and 1000µF for C1. When choosing C1, be sure that the working voltage is adequate for the DC input you're using.

Construction And Use

The whole circuit, with the exception of the power supply, can be accommodated on the PCB as shown in Fig. 2. Ensure that the polarised components are correctly orientated. When you have finished soldering, turn the unit over and check that there are no unwanted dry joints or solder blobs. The whole unit can then be built into a small case. There is no setting up procedure to follow — if you've constructed it as shown it should work first time.

In use the crossover connects between the pre-amplifier and power amp. Some amplifiers will already have facilities to disconnect the pre and lower stages. If not you will have to connect the crossover in the tape loop so that the circuit is fed from the tape output of the preamp and into the tape or auxillary input socket. If in doubt consult your dealer.

For stereo use you will need two stereo amplifiers. These need not be identical. A minimum power output of 15W will be sufficient for the woofer channel. The tweeter will require somewhat less. However this doesn't mean that you cannot use 50W amplifiers.

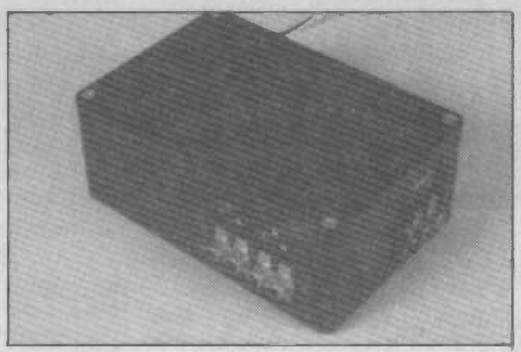
The first job is to unscrew the recess dish on the back of the speakers and disconnect the passive

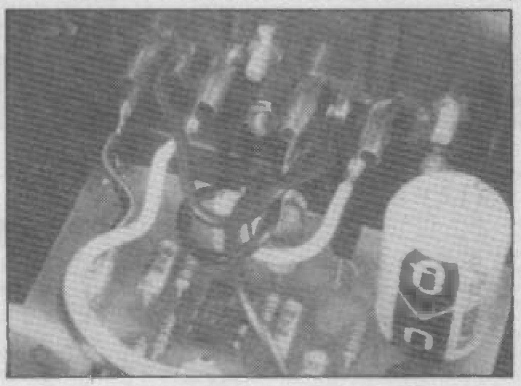
PARTS LIST

RESISTORS (all 1% metal film ¼W)	
R11-13,23	100k
R14,16,17,24,26,27	33k
R15,25	15k
R18,19,28,29	4k7
CAPACITORS	
C1	1000µ 25V
C2	100µ 25V
C11,17,18,21,27,28	10µ 16V
C12,13,15,22,23,25	2n2 polystyrene
C14,24	4n7 polystryrene
SEMICONDUCTORS	
IC1	78L12
IC11,21	TL072
BR1	50piv 1A
MISCELLANEOUS	
T1	12-24V sec, 240V prim mains transformer
PCB. PCB pins, Case. 3 dual phono sockets. Wire. Solder	

crossover from the socket. The woofers connect to the appropriate stereo amp and the tweeters to the other. Note the common earth connection.

Turn the volume controls down to a minimum when you first switch on. Adjust the woofer chanel for a comfortable level. Now adjust the tweeter level. To obtain the best response a source of speech is ideal. I would suggest Radio 4 (on FM of course!). Once you have adjusted the controls or the best sound here you can go on to music. Happy listening!





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Peak Programme Meter (October 1988)
In Fig. 4 D21 and D22 should be swapped, C13 should be 100u and have no connection to IC12. The anodes of D15 and D17 should be connected to the input of IC12 (negative of C11).

On Fig. 7 the capacitors from top to bottom should be labelled C10,13,9,11,12.

On the Parts List R15,36 = 51k. R44,45,46, 49,50,51 = 2k7.

Chronoscope (November 1988)
In the overlay diagram for the counter PCB (Fig. 3) the polarity of C12 is shown the wrong way around. SW1a-d is shown as SW1-4. In Fig. 4 the cathodes of LED 8 and 9 are the righthand and lefthand pads respectively. The cathodes for LED 6,7 are marked as the wrong pin. In the text section on Battery Operation, Q1 should read T1. In Fig. 5 SW2 is incorrectly labelled SW5.

Doppler Speed Gun (December 1988)
In Fig. 2 the labelling of pins 7 and 4 of IC2 are transposed. IC10a Pin 1 and IC9c Pin 10 should connect together and not to the 5V rail. The positive terminal of C3 should connect to the junction of R2/R3. Pin 7 of IC2 should connect to the 12V rail and not to Pin 6/R1. So the pin labelling of CONN1 runs left-right on the overlay diagram, the corresponding labelling in Fig. 2 should be 3-1-2, reading downwards. Fig. 4 is correct in all respects except for the orientation of Q2 for which the c and e labels should be transposed. In addition the extra switch to be seen in the photograph of the prototype is a hangover from a previous incarnation. Just ignore it!

Burglar Buster (December 1988)
The foil part of the component overlay for the basic alarm (Fig. 1) was printed the wrong way around. It should be rotated through 180° as in Fig. 5.

Rev-Rider (January 1989)
In the Parts List RV2 is incorrectly given at 33k. It should be 22k as in the circuit diagram. A 'blob' went missing from the circuit diagram. RV2, R7, R4, C1 and D3 should all be connected.

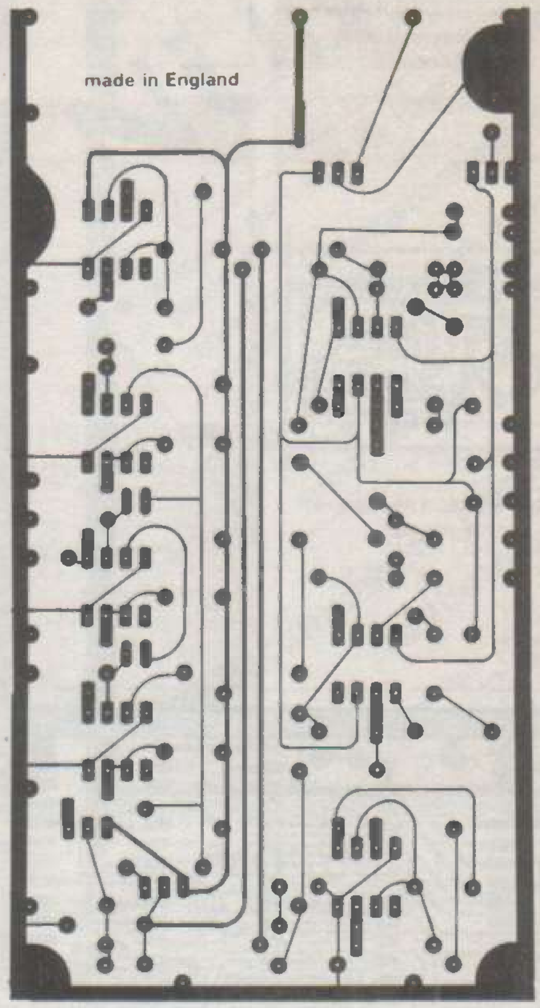
In-car Power Supply (January 1989)
Fig. 3 shows the front view of the 317 regulator with the pin-outs reversed. The photograph, circuit and overlays are all correct showing the ledge at the front of the device.

Audio Design MOSFET Amp (May 1989)
For home constructors of the power amp PCB (Fig. 8), the copper area connecting the negative of C7, C14 and R20 is a 0V #2 connection and should be linked to the 0V #2 copper area at the junction of C16 and C18+. Hart's kit PCB has a ground plane and no mod is necessary. Note that the preset at the bottom right of Fig. 8 takes the place of an external RV3 rheostat when bench testing and is not normally required.

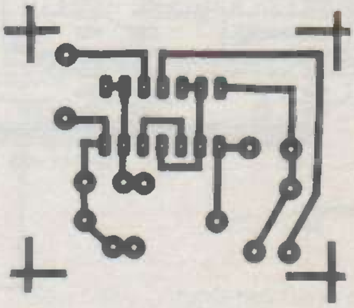
Bench Power Supply (May 1989)
In the Parts List, Q3,4 should be BC237 not BC307. The value in the circuit diagram is correct.

How To MIDI A Piano (June 1989)
In Fig. 5 the connection from pin 19 of IC8 (MREQ) should go to pin 12 of IC7a, not pin 13 as shown. The component overlay is correct.

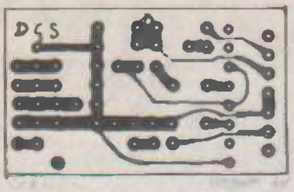
PCB FOIL PATTERNS



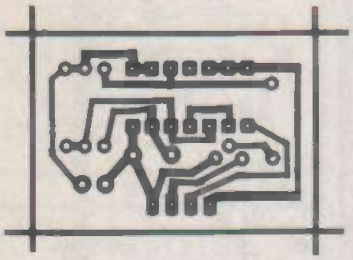
Metal locator foil pattern



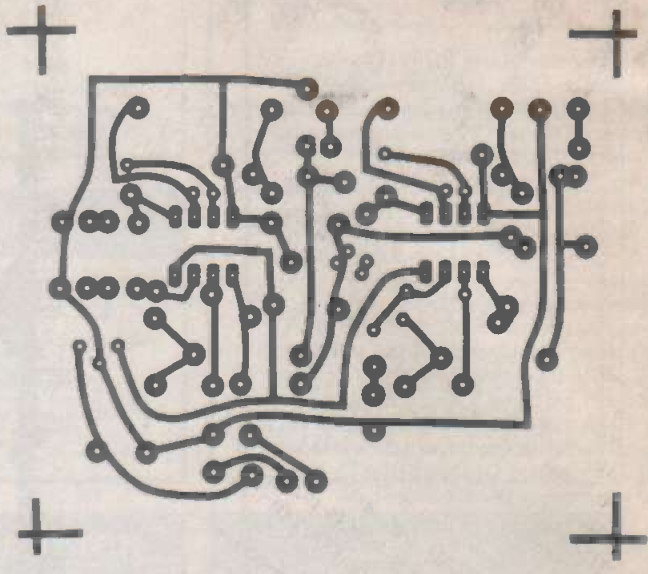
Trembler foil pattern



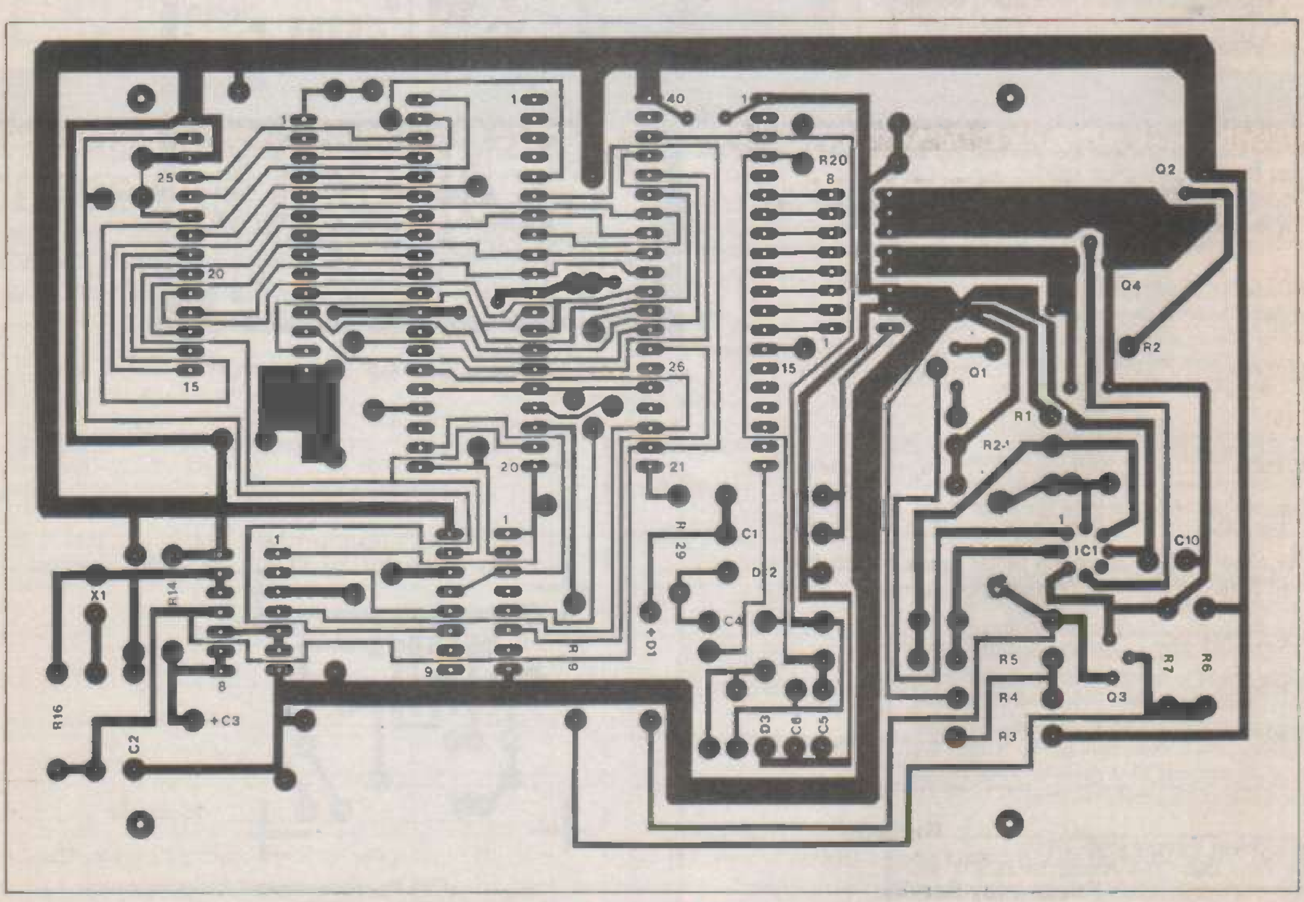
Field power supply foil pattern



Chronoscope auto-reset foil pattern



Active speaker foil pattern



The Polybel foil pattern

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In the next issue of the finest electronics magazine you can buy (this means us!) we'll be turning up the collars of our ETI trenchcoats and heading out of the back door into the world of surveillance. We'll be showing you what you can do legally (not much) and what can be achieved with a certain amount of stealth. We'll be asking the experts how it's done and finding out how often it happens — and if it could be happening to you . . .

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There will also be the second part of John Linsley Hood's voyage through the depletion zone, looking at the evolution of the transistor.

• • •

Plus we will be starting a major new series on test gear which marks the welcome return of Mike Barwise, Mr Chip In himself.

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Crammed among these fascinating features will be a package of prestige projects including an intruder-beam infra-red alarm and a multimeter design for beginners to whet their irons on.

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Besides all these, we'll try to find room for all the news, regular columns, reviews and comment that makes ETI the indespensible collection of pages that it is.

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The above articles are in preparation but circumstances may prevent publication

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