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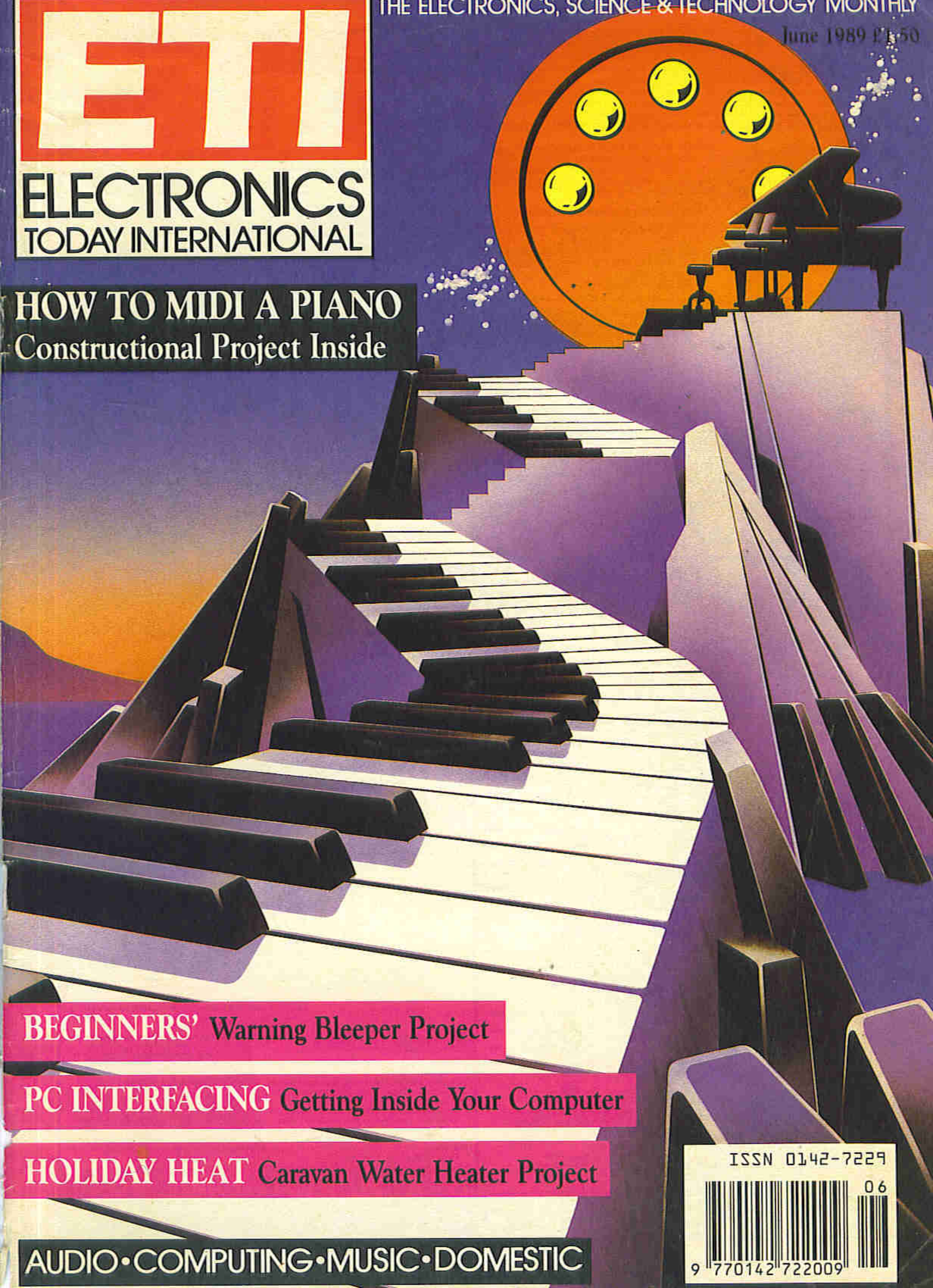
ETI
ELECTRONICS TODAY INTERNATIONAL



HOW TO MIDI A PIANO
Constructional Project Inside

BEGINNERS' Warning Bleeper Project

PC INTERFACING Getting Inside Your Computer

HOLIDAY HEAT Caravan Water Heater Project

AUDIO • COMPUTING • MUSIC • DOMESTIC

ISSN 0142-7229

06

June 1989

VOLUME 18 No 6

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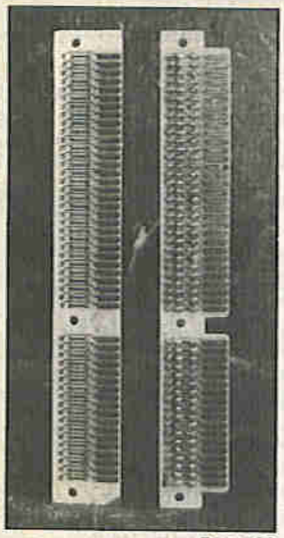

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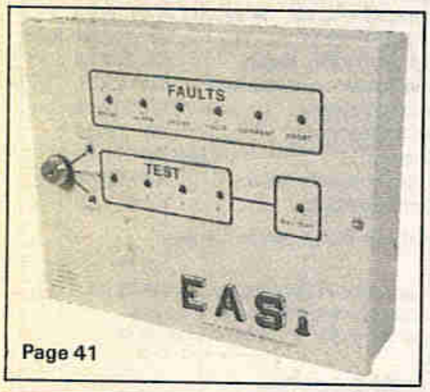

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REGULARS

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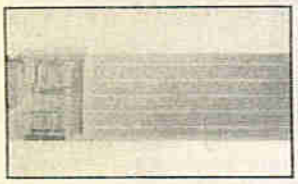
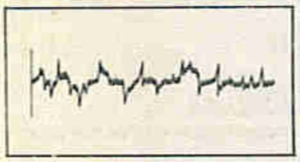
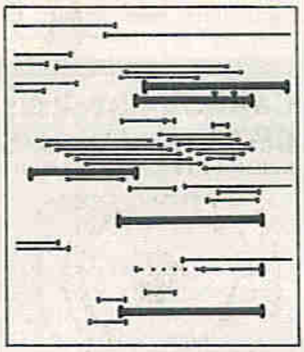
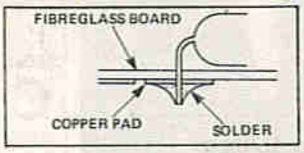
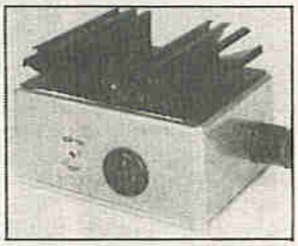
FEATURES/PROJECTS

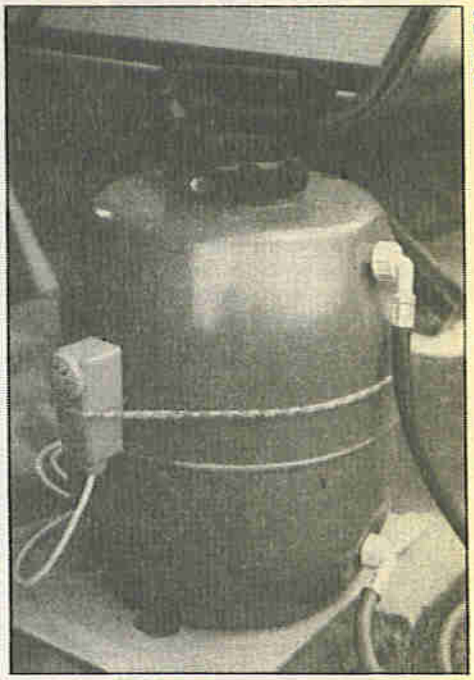












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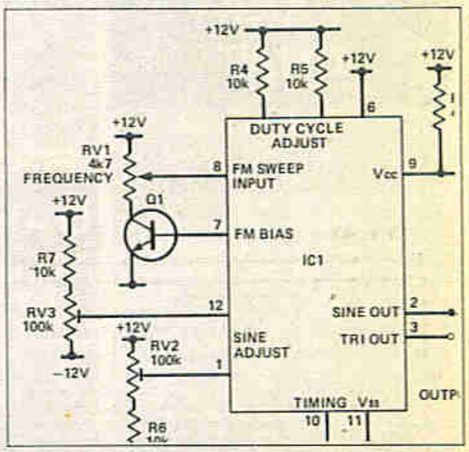

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NEWS

FIBRE OPTICS ON THE ROAD

The Ford Motor Company is conducting research into the possibilities of fibre-optics in the design of headlamps and instrumentation.

Fibre optics would enable a light source to be contained inside the vehicle with relatively small apertures at the front — perhaps only one centimetre in height. The same light source could be used for both front lamps and reverse lighting — although the safety aspects of source failure would require careful consideration.

It is hoped that by the middle of the next decade a system should be viable for use in Ford sports models, where the design and aerodynamic advantages can be maximised and where existing lamp systems are expensive enough to justify the substitution.

BACK CHAT

In a conciliatory turnaround, British Telecom has agreed to reintroduce the chatline gossip services that were only recently removed from its lines. This announcement comes just days after winning High Court actions brought against it by chatline operators trying to force reinstatement.

The apparent contradiction is explained by the fact that the lines now being offered by BT are not profit-yielding premium rate lines but are charged at the standard rates. This cuts costs to callers but gives no share of the charges to chatline operators so that alternative methods of charging will have to be introduced. Some form of subscription seems the most likely option.

The closure of the original chatlines came after widespread campaigning against such services, citing cases of inadequate monitoring of conversations and huge bills amassed by teenage users.

Meanwhile the Independent Committee for the Supervision of Standards and Telephone Information Services has tightened its rules governing premium rate services run by private operators. Medical services will now be more strictly controlled and hardcore pornography banned. Any service operator that ignores the new regulations will lose its lines.

INK LINKS

A versatile 'conductive pen' for drawing links and jumps onto circuit boards (or elsewhere) is available mail order from the US.

The Circuit Works Conductive Pen uses a highly conductive silver bearing thermoplastic acrylic polymer ink which dries in minutes and is far more conductive than solder — about .04ohms/mm². Traces down to about 1/16 in can be drawn and an average of about 150ft of lines can be drawn with each pen. The ink is solderable although this is not the easiest task in the world with a hand soldering iron.

The pens are available for \$9.95+\$2p+p. Cheques or money orders should be in US\$.

Contact Planned Products, 21105 Santa Cruz Highway, Brush Road, Los Gatos, California 95030, USA. Tel: 010-1-408 353-4251.

DARK SECRET

Boulby in North Yorkshire has been chosen as the proposed site for a subterranean detector of dark matter particles — material that is believed to constitute nine tenths of the universe's mass.

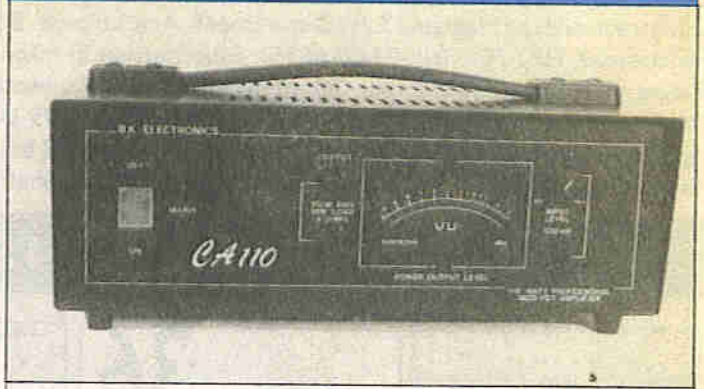
There are several contenders for the specific particles that make up this mass. Photinos, heavy neutrinos and gravitinos are among the possible causes for the missing mass that must exist if the present assumptions of gravitational interaction are to be maintained.

Six UK colleges and the Rutherford Appleton College are involved with the proposed scheme to site an underground detector in a disused potash mine in Boulby.

The equipment to supercool the detector to $^1/_{10}$K dwarfs the table-sized detector and shielding will be required to prevent the detection of particles from the surrounding rocks, which in turn shield the unit from cosmic rays and particles.

The cost is estimated at £¾million over four years. Funds are being sought.

BK TAKES THE CASE



Cased versions of BK Electronics' OMP MOSFET Power Amplifiers are now available from BK's base in Southend.

The CA110, the cased version of the MF100, gives 115W into 4R or 105W into 8R. The CA210 is the cased MF200 and gives 215W into 4R or 150W into 8R. All power figures RMS, power bandwidth (−3dB) of 1Hz-50kHz.

Both amplifiers have input sensitivity of 500mV for full power output and retain all features of the orignal modules including the toroidal transformer power supply. The cased versions (see picture) include LED VU meter and input level control.

Prices are £79+£4 postage for the CA110 and £99+£5 postage for the CA210.

Contact BK Electronics, Unit 5, Comet Way, Southend-on-Sea, Essex SS2 6TR. Tel: (0702) 527572.

SMART PARTS

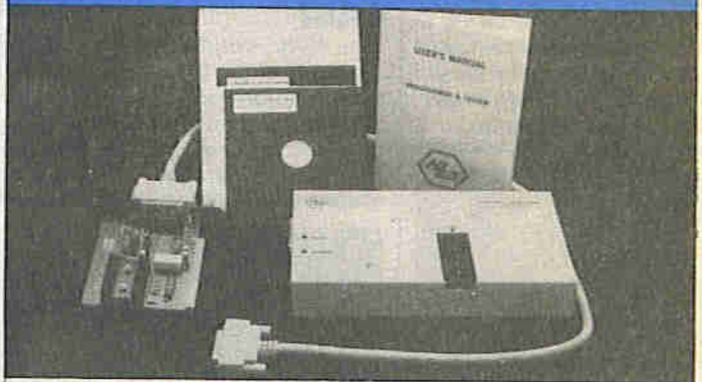
A new range of educational and recreational electronic projects kits is being distributed in the UK by Hobbykits.

The Smart Kit project kits cover alarms, amps, instruments, light, music, telephone, video/TV not to mention power supplies, transmitters and receivers.

Kits come with instructions and circuit diagrams, together with a silk-screened PCB.

Hobbykits has produced a free catalogue. Send an SAE (28p stamps) to Hobbykit Ltd, Unit 19, Capitol Industrial Park, Capitol Way, London NW9 0QQ. Fax: 01-205 0603.

TEST CARDS



A new PC-interfacing programmer and tester is available from Temple.

The TMP ALL-01 interfaces to any PC or clone via a half-width expansion card, taking its power from the computer. It accepts ICs from 8 to 40 pins in size and can provide programming voltages up to 25.6V to programme E(E)PROMs, PALs, FPLs, EPLDs, EPROMs and 8748/51 series microcontrollers. ICs from AMD, MMI, NS, Signetics, and Texas are all supported, including 27C512s and 87C51s.

As a tester the TMP ALL-01 can check 74 series TTL, 40/45 series CMOS and dynamic and static RAMs.

The unit is menu-driven from the PC and can be upgraded by later software updates.

The TMP ALL-01 retails at £499+VAT.

Contact Temple Ltd., Rivington Business Centre, Rivington House, 82 Great Eastern Street, London EC2A 3JL. Tel: 01-739 8410.

TUBEGATE

Delays, bottlenecks and chaos have accompanied the introduction of London Underground's automated ticketing procedures. The scenes at Kings Cross on the first day of automation operation were worrying enough to elicit calls for a safety enquiry.

The automated system (examined in detail in ETI August 1988) consists of two operations — automatic ticket issuing from wall-mounted dispensers and automatic ticket barriers to read coded information in magnetic ticket stripes, returning partly used tickets (travelcards, returns and so forth) and retaining exhausted ones.

The dispensers have proved a great success, cutting queues and quickly gaining public acceptance.

The automatic barriers however are proving to require a huge public relations exercise to coerce acceptance by the punters. When they came into operation at major stations such as Oxford Circus and Kings Cross, commuters tended to head straight for the remaining manned gate despite a heavy staff presence to assist with the new technology.

Why should this be? There seem to be three explanations. Firstly there is the inertia of any system to change — commuters are reluctant to trust a weekly or monthly travelcard to the ticket readers, the cost of a mistake is at best great inconvenience as the machine is dismantled to retrieve the ticket. LRT is reluctant to discuss the present failure rates of barriers but the constant presence of staff with screwdrivers would seem to indicate less than total confidence.

The second delay explanation is the time taken to remove travelcards from the plastic wallets. Although seemingly trivial, many passengers prefer to head for the manned gate. LRT is concerned enough to have designed new wallets with cutaway plastic facings.

The last reason for delays is the most trivial of all — the basic sheeplike propensity of commuters. Since most people are heading for the manned gate or gates, an obvious traffic stream is created and people seem reluctant to break away from it. The easiest solution to this problem would be for LRT to position manned gates in the most inconvenient places with relation to rising escalators, making the natural flow towards the automatic gates. This is not however the case in most stations.

LRT is certainly aware of the problems and is confident that the gates will be accepted in time. An attempt to speed commuter awareness was made at Green Park where staff started refusing exit from the station unless commuters used the new gates.

The gates were supposed to reduce fraud (despite the fact that anyone can now buy and use a child ticket) and to reduce manning levels in stations. So far the results have been less than the smooth-running success story for which the planners had hoped.

TV AUCTION ACTION

The Government seems likely to accept in full the proposal from the IBA's reply to white paper plans to auction TV franchises.

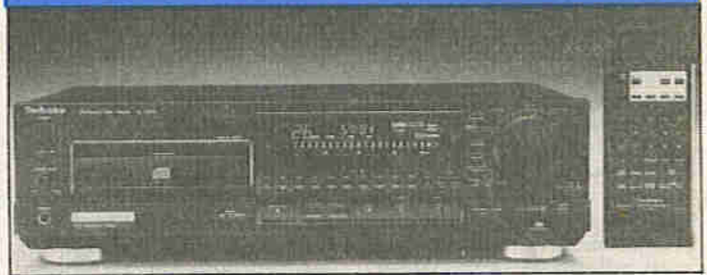
The Independent Broadcasting Authority has announced its reply to the Government white paper plans to auction TV franchises for the 1990s.

The IBA's reply put it in conflict with the existing 16 ITV companies which are claiming that a highest bidder sale would produce unacceptable continuity problems and would have a devastating effect on quality.

The IBA proposals make only a passing nod to such concern by suggesting removing implausibly high bidders from the auction.

It also advocates that each bidder should submit a detailed 10-year plan to be assessed for programme quality as well as cost. These plans would be examined by the Independent Television Committee (the IBA's successor) together with Treasury and financial representatives.

TECHNICS HIGH-SPEC CD



The new Technics compact disc player SL-P999 claims high specification and audiophile performance.

The unit features eight times oversampling and 20-bit decoding.

Four DACs are used, two on each channel, in a configuration that eliminates digital zero cross distortion. A system of eight sample linear interpolation claims to conceal errors from scratches or gunge on the disc.

The SL-P999 retails at £449.95.

BUDGET KITS

TK Electronics has introduced a trio of beginners' projects at budget prices.

The whistle switch kit can be used to trigger just about anything by whistling in its frequency identification range. A second whistle will reset the switch.

The door chime is a straightforward button-triggered melody playback unit.

The sound genertor produces four sound effects: police siren, fire engine siren, ambulance siren and machine gun (the last presumably to bring to justice anyone who ignores the first three).

Each kits includes PCB and all components except the battery — a PP3 in each case. Instructions are also supplied.

The price of each kit is £3.90 + VAT and £1 p + p to the total order.

Contact TK Electronics, 13 Boston Road, London W7 3SJ. Tel: 01-579 9794.

FREE BOARD

Motorola and Axiom Electronics are offering a free car alarm PCB which uses their new improved MC68HC04 microcontroller.

The PCB comes with a free design pack — datasheets, applications notes and so on). There is also a questionnaire with the pack which may be completed and returned. If Axiom decides you qualify as a possible account holder it will also supply a free MC68HC04 device programmed with the car alarm software.

Contact Axiom Electronics, Turnpike Road, Cressex Estate, High Wycombe, Bucks HP12 3NR. Tel: (0494) 465465.

FIBRE TELEVISION

Approval from the DTI has been granted for a BT trial service supplying television, radio and video services over optical fibre systems.

The Government's policy until now of blanket banning has been intended to prevent telecommunications companies extending their effective monopolies into the television arena.

The approval has come as a relief to many in the industry who have worried that the UK's established position in fibre-optics might be threatened.

The trials will take place in Bishops Stortford in Hertfordshire and will test two systems: broadband integrated distributed systems (BIDS) and telephony over passive networks (TPON).

The BIDS system will be set up first, using switching to route services in a similar way to the networks used by Westminster Cable TV. This should be operating by next March.

TPON will take a further six months to initiate and will carry only speech and low rate data at first. It will be upgraded to a broadband passive optical network (BPON) in 1991 and will then carry stereo television, radio and video services.

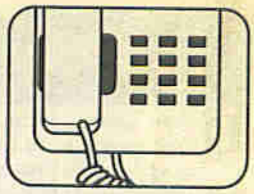
GREEN POWER

The ecological awareness that is gradually increasing its grip on the planet has reached the doors of Panasonic.

The new range of Panasonic Green batteries are 'environmentally friendly batteries' with no mercury content, thus freeing the planet-concious battery user from worry. The range has already found success in Germany and Scandinavia and is now available in the UK.

The batteries are for heavy duty use and are easily recognised by their flamboyant green packaging.

OPEN CHANNEL



A predicted 2.5 million UK people or businesses will have a second generation cordless telephone (cryptically known as CT2, more graphically as *telepoint*) by 1995. What's more, some 150 million European users are predicted by the end of the century. Equipment should be in the shops already as you read this, and the UK system looks set to become a first standard in the pan-European market.

For those not yet conversant, telepoint is a nationwide cordless telephone service which allows a user to make telephone calls when within a 200 metre distance, and in line of sight, of a base point. A multitude of base points is envisaged, although how quickly these are set up will define how quickly the service is adopted by users, I'm sure.

Initially, base points will be located at main centres of public convenience (not including loos, however), such as train and bus stations, airports, market places, high streets and so on. Eventually, if the system is a success, base points will presumably be situated such that most high-population areas could be covered. The system has been compared to cashpoint cards — great if you're close to a hole-in-the-wall machine but not much cop if you're not!

For business users (and rich individuals I suppose), a private base point can be purchased which allows coverage of localised premises, much as current cordless telephones do.

Telepoint was initialised early this year, when the Department of Trade and Industry (DTI) licensed four network operators for the service. These are:

- a consortium comprising British Telecom, Telecom France, STC and Nynex. BT has a large share (50%) in the consortium and will call its system (just to confuse the issue) *Phonepoint*.
- a consortium comprising Mercury, Shaye Comms and Motorola. Mercury has a 50% holding of this consortium.
- a consortium comprising Philips, Barclays Bank and Shell.
- Ferranti Creditphone, a subsidiary of the large Ferranti electronics group.

Although the licensing of four competitive operators may cause fears of incompatibility, all have agreed in the long term to the Common Air Interface (CAI) specification which means that handsets from any operator will work on all four networks. This will be a major factor in telepoint's acceptance by potential users, both here *and* across Europe.

Equipment prices should be much lower than cellular telephone equipment, around £150 for a telephone, maybe £200 for a private base point. In common with all electronic equipment, prices should rapidly fall and telephone prices of £50 or so have been quoted for the middle of next decade.

Low prices where in comparison with *cellular* systems shouldn't be taken too seriously, as telepoint is only a one-way communications system — calls can be made but not received. Also, the restrictions on base point availability must be taken into consideration. So, before you all rush out and buy a CT2 telephone, stop and work out the pros and cons.

Telepoint's main disadvantage of being a make-only means of communication may be partly eschewed if plans to incorporate alphanumeric radio-pagers into some telephones prove fruitful. Users could then be made aware that someone is trying to contact them while, say, the number to call back is displayed on the radio-paging part of the telephone.

European Standards

For once, Britain is ahead of the rest of the world in communications. The CT2 system is estimated as being around two to three years ahead of any other similar technology and this is why the DTI and the British operators are hoping that the CAI specification will become a de facto European standard.

Against this, however, the European Telecommunications Standards Institute (ETSI) is working on a *Digital European Cordless Telecommunications* (DECT) standard, based on time division multiple access (telepoint as it stands is on a more conventional frequency division multiplexing). The two to three year lead on DECT, however, gives us a head-start which we should not waste. The DTI's licensing arrangement, which incorporates Shaye Communications and Ferranti in the list of operators, is designed specifically to help keep this head-start — both Shaye and Ferranti have pioneered CT2 technology (as readers of this column over the past couple of years will already know) and will be selling their equipment to the other operators as a result. If the four UK operators and the DTI get their act together quickly, Britain could clean-up the European market quite nicely, thank you.

USA Follows Suit

Talking about cellular telephones (which we weren't), it's interesting to note that the next generation of USA cellular equipment is likely to follow a similar standard to the pan-European next generation. A digital time division multiple access format, very much like that proposed for Europe, is to be used as a basis for the USA system too. Equipment will not however function on both sides of the Atlantic, so if you're thinking of doing some transatlantic roaming, forget it!

Emergency Emergency

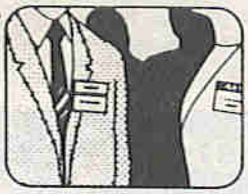
We shall all be highly pleased to note that the Conference of European Postal and Telecommunications organizations (CEPT) has agreed to adopt the code *112* as a pan-European emergency telephone number.

Old Enemies Shake Hands

British Satellite Broadcasting (BSB), providers of the British direct broadcast by satellite (DBS) television system to start-up later this year, has contracted Philips to manufacture receivers. Philips leads the European drive to use the D2-MAC format, while BSB has always specified and will use the better D-MAC format. In the past, many a cross word has been said regarding their differences. Money talks I guess — it's a funny old world, innit?

Keith Brindley

DIARY



OS/2 — May 3-4th
Churchill Hotel, London. Seminar on IBM's latest PC operating system. Contact Blenheim Online on 01-868 4466

Graphic Display Devices — May 8th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Advanced ADC And DAC Techniques — May 8th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Automan — May 9-12th
NEC, Birmingham. Automated manufacturing show. Contact Cahners Exhibitions on 01-891 5051

Inspex 89 — May 9-12th
NEC, Birmingham. Quality control exhibition. Contact (0234) 4003.

Packet Video — May 16th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Biotech 89 — May 16-18th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466

Energy 89 — May 16-18
NEC, Birmingham. Contact Emap Maclaren on 01-660 8008

Scitech 89 — May 17-21st
Alexandra Palace, London. Exhibition of all the best British science and technology. Contact British Science And Technology Trust on 01-992 0684

Networks 89 — June 6-8th
NEC, Birmingham. Contact Blenheim Online on 01-868 4466

Electronic Filters — June 9th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Software Tools 89 — June 13-15th
Wembley Conference and Exhibition Centre, London. Contact Blenheim Online on 01-868 4466

Image Processing And Its Applications — July 18-20th
University of Warwick. Third International Conference. Contact IEE on 01-240 1871

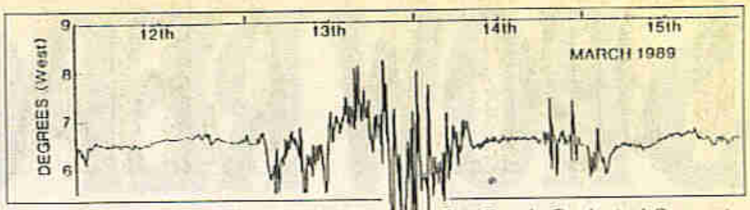
Holographic Systems, Components And Applications — July 11-13th September
University of Bath. Second International Conference. Contact IEE on 01-240 1871

Vacuum Microelectronics — July 24-26th
University of Bath. Conference sponsored by The Institute of Physics, IEE and IEEE. Contact The Institute of Physics on 01-235 6111

Circuit Theory And Design — September 5-8th
University of Sussex. Ninth International conference. Contact IEE on 01-240 1871

Holographic Systems, Components And Applications — September 11-13th
University of Bath. Second international conference. Contact IEE on 01-240 1871

INSIGHT



At present we are approaching a peak in the cycle of solar activity that produces geomagnetic storms in the Earth's atmosphere. The major storm of the 13th and 14th of March brought home to many companies the consequences and costs that can result from serious errors of magnetic reference and electrical disturbances that complement them.

There is more to come. Although major storms are a rarity (generally once every two or three years) the Geomagnetic Research Group at the British Geological Survey in Edinburgh predicts that the approaching peak will produce a relatively high number of storms.

During the March storm, compass headings in the North Sea deviated by up to eight degrees from normal (see diagram) with rapid change rates of up to a degree a minute.

Apart from the obvious dangers of using a magnetic compass in such circumstances, the many navigational aids that use radio transmission were blacked out or phase shifted by the extreme ionospheric disturbance so that equipment showed false positions.

However navigational problems were only part of the story. The storm produced large induced voltages in power lines, transoceanic cables and in networks for telephones and cable TV. Transformers were burnt out by the overloads.

There were communication problems with ground-to-ground radio connections being blacked out by interference and disruptions in ground-satellite-ground communication and radar systems. Some satellites were shifted in their orbits by the increased ionospheric density.

The radiation levels may have caused the malfunction in the computer systems of the Discovery Space Shuttle launched on 13th March and recalled a day early as a result of the problems. False triggering was also reported from microelectronics in other high-flying aircraft.

The British Geological Survey is eager that people should be aware where enquiries for advice should be directed. Following the March storm companies apparently attempted to elicit assistance from the Met. Office, The Royal Observatory and even the British Astronomical Association of amateur astronomers.

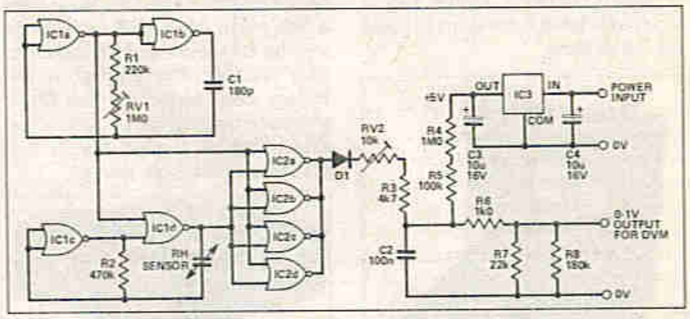
The Geomagnetic Research Group supplies oil companies with a 24-hour data service relating to present conditions and possible disturbances, and may be contracted at the British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA. Tel: 031-667 1000. Fax: 031-668 2683.

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.

This month Mr A Ridley from Shropshire would like to know how to measure relative humidity (rh) electronically. He says *"I know of two methods to measure humidity, one is to use a piece of hair which changes its length in reponse to changes in rh, the other is to compare the temperature of wet and dry bulb thermometers and look up the rh on a psychrometric chart. Neither of these methods will fill my need, which is to drive a meter readout of rh and to provide a signal for a data logger."*

This is a very good question. The measurement of relative humidity is fundamentally a difficult process. For a long time, the standard method was to use a sling psychrometer, a sort of frame containing two thermometers. One of the thermometers has its bulb surrounded by a wick, kept wet with distilled water. To use the instrument you wave it round your head for a while. The airflow over the wick evaporates water and cools the bulb of one thermometer. The less water vapour in the air, the faster the water evaporates from the wick and the lower the temperature falls. Once the readings have stabilised, you look up the rh on a psychrometric chart.



This method can be used electronically with wet and dry thermistors and a fan to aspirate them but it is not very practical and few commercial instruments use this means.

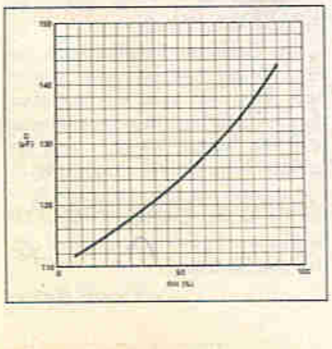
Another way is to measure the dew point. In this type of instrument a laser is beam is reflected from a face silvered mirror, which is cooled by a peltier effect device. When traces of condensation form, the beam is dispersed and this effect is detected. The microprocessor in the instrument now knows the absolute humidity, which is directly related to the dew point. The relative humidity is a function of how much warmer the air is than the dew point, since warm air can absorb more water. Once the processor has carried out these two measurements it can calculate relative humidity.

Capacitance

Cheap and down to earth instruments normally use a sensing element whose capacitance is affected by relative humidity. This element is in effect a capacitor with a polymer dielectric and very thinly deposited electrodes. Water vapour is absorbed (absorption just in a surface layer) so it can be taken up and released relatively rapidly, over a period of a minute or so. All that is required to measure rh is an accurate capacitance meter, which may incorporate linearisation if the change of capacitance with rh is not linear.

Philips make a reasonably priced sensing element, as these things go, and it is available from Farnell Electronics (part no 2322-691-9001) for around a tenner. Tel: (0532) 636311 or from Trilogic (0274) 684289. In my experience this works well for its price (you can pay many tenners for a really accurate sensor).

Figure 1 shows a suggested application circuit for the sensor. This circuit gates one oscillator, whose period is dependent on the capacitance of the rh sensor, from a fixed frequency oscillator. The net output is zero if the period of the monostable is the same as one half cycle of the oscillator and increases as the capacitance increases past that point.



Linearity

Figure 2 shows a typical response curve for the sensor, which is not completely linear. The circuit from D1 onwards is a reasonable attempt at linearising the response so that a 0-1V DVM scaled 0-100% can be used for the readout. Calibration really requires the use of an accurate capacitance bridge. Connect a capacitance of 118pF in place of the sensor and adjust RV1 for minimum meter reading. Then replace this with a capacitance of 159pF and adjust RV2 for a reading of 100%. The unit is now calibrated for a nominal sensor.

To make it more accurate a source of known humidity is required. A sealed jar containing potassium carbonate will give an rh of 44% at 20°C. If the sensor is acclimatised in such a jar for at least 30 minutes, it will have settled and RV1 may be adjusted to produce a meter reading of 44%.

Don't forget that the capacitance of the sensor leads could be significant. If the leads are in a different position when the instrument is in use from when it is calibrated, the calibration may have shifted. The shorter the connections the better.

The instrument must be run from a regulated power supply. The largest current drain in the instrument will probably be the ground current of the 78L05 and if it is to be run from a battery then a LM2930 CZ 5.0 could be used instead to cut power consumpton.

Andrew Armstrong

SHOW REPORT

The Cable and Satellite 89 show was this year an altogether different event to its previous incarnations.

The most obvious difference was sheer size. With the newfound importance afforded by Astra, Sky and national newspaper promotion, the show has moved from the quaintly overcrowded Wembley Conference Centre setting of the past two years to the wide open spaces of Olympia.

The new commercialism was obvious in the number and type of exhibitors too. In past years the biggest stands have been those of Intelsat, Eutelsat and Astra — the satellite owners (or would-be owners) and the largest companies concerned. This year the biggest stands were from Amstrad, Sky and BSB — closer to the consumers' end of things.

Gone is the 'club-like' atmosphere, now it's down to hard sell.

Of course there was a profusion of new Astra receiving systems. Everyone who is anyone (and many who are not) had a system to sell. The famous names were all there — Amstrad, Connexions, Ferguson, Grundig, Micro-X, NEC, Pace, Salora and Tatung, plus a hundred and one others, all competing to attract attention with the cheapest or best or most versatile.

In truth, there appears to be little difference between models. The more you pay, the more you get in the way of remote control, dish positioning, number of channel memories, fancy styling or whatever. The basic quality remains pretty constant for all the hype.

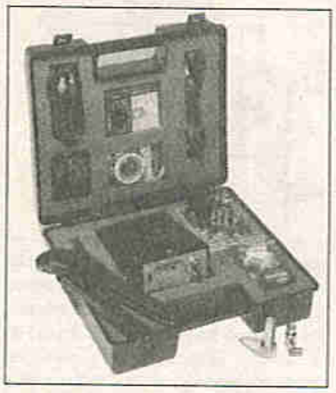
Of course, prominent amongst the melee was Cambridge Satellite Receiver Systems, otherwise known as Clive Sinclair's Cambridge Computer bunch. Here was the much vaunted square antenna which Sir Clive was shouting about so loudly a few months ago.

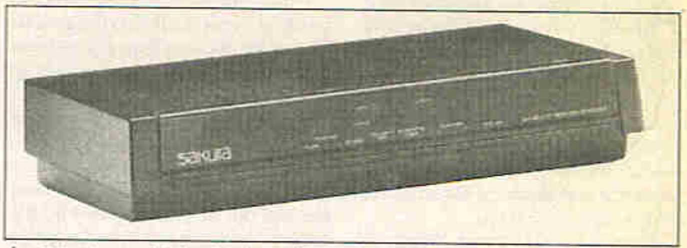
The aerial is indeed square, but in cross section only. It is not a 'squarial' in the vein of BSB's future offerings. This somewhat absurd piece of engineering in plastic is in effect an enclosed dish. Over the front of a steeply curved (oh yes, and square) black plastic dish sits a clip-on white cover to keep the rain and snow off the reflective surface, feedhorn and LNB inside.

It seems more a development of the sandwich box than the satellite antenna. Nevertheless, it must be said that covering the dish to keep out the elements is a good idea and system prices (with remote control) starting at £199 are certainly attractive.

Incidentally, the shallow circular dent in the front of the cover is only there to give rigidity to the thin plastic cover. It serves no wave-guiding purpose and it only barely makes the cover rigid enough. The whole thing wobbles and ripples precariously when prodded and conjures nostalgic memories of the ZX80 flexible computer days.

Among the more traditional system designs, cheapness is the bottom line for many manufacturers. However, the essential item missing from so many packages is any material help in setting the thing up. To spend only £200-300 on a complete system is admirable, unless a further £70 is required to bring in someone to install the damn thing.





The Sakura SR800ER system (£299) includes the simple but clever idea of an audio signal strength meter sounded through the TV. With the TV volume turned right up, you should be able, even from the roof-top, to hear the rising tone whistle which signifies accurate alignment of the dish with Astra.

If installation is still a befuddling problem then two How-to-DIY videos were doing a roaring trade for their producers. Eastman Educational and Brightstar at £9.99 and £11.50 respectively.

For anyone thinking of making a living out of this game, Connexions had a complete installation kit of signal meter, multimeter, compass, leads, splitters and crimping tool, all in a dinky attache case for under £150 — trade only, though.

The growth in STV with Astra has prompted a few companies to jump on the lucrative accessories band-wagon. First in with what must be the tip of a profitable iceberg is Waso with a dish alarm. Your LNB cable plugs into this £80 device and it connects to your receiver. Any change in the voltage drop across the line (from someone unplugging or cutting the cable) triggers a siren. Simple but probably increasingly useful.

A couple of manufacturers had stands to sell decoders under various guises. The Fallen 'Automatic signal stabliser' would 'stablise' Filmnet, Premier and BBC Europe transmissions for £100. Rather rashly, the company spent much of the show time assuring the public that encryption methods on these channels were sure to remain the same indefinitely. Fallan also wins *Hypocrisy Of The Year* award for including a Premier subscription application form with every decoder!

A clever idea from Consolidated Cable International was flat multicore cable. With positionable dish systems using anything up to ten core cable plus a co-ax signal lead, having the whole lot in one and flat so it can snake under carpets and other such out of the way places seems an excellent idea.

There was even (apparently) call for Celtel to (almost exclusively) stock a stand with universal remote controls for use with the punters' rapidly increasing stock of remote controlled consumer valuables. Unlike so-called 'programmable' units, the Celtel handset has no learn facility. Instead, Celtel claims that all known control codes from all manufacturers have been reserched and built-in so all you need to do is point and press. Must try that out on the ETI infra-red control system and seen what happens . . .

Of course, the majority of the show was devoted to Astra. Some cable-only stands were in existence (the forthcoming 'Discovery Channel' for example) and some professional SMATV equipment was there too but the major opposition was from BSB-related suppliers.

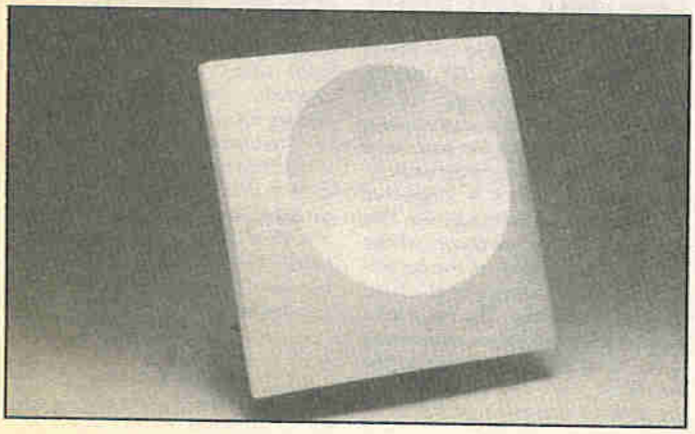
The stand from BSB itself was impressive enough with continuous, convincing and a little misleading demonstrations of the advantages of MAC. Sample videos of the five BSB channels-to-be were also pulling in a good audience. Only dummy squarials were on show, though.

Ferguson hedged its corporate bets with two separate systems for Astra and BSB. Of course, the Ferguson squarial was not yet ready for demonstration but then nor was the £80 smartcard pay-TV decoder for receiving Sky Movies and Disney Channel after October!

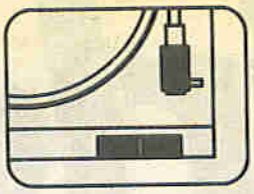
The only company with a square antenna (no Sir Clive, a flat one) was Sony. Tucked away in a corner was the Sony stand with cut-away model of 50×45cm flat antenna and a TV connected to a working one on the roof showing excellent reception from a 63.8dBW source (BSB will be 62dBW). At least I think that was it. Nobody on the stand spoke a word of English so it may actually have been connected to a VCR under the counter. Who knows?

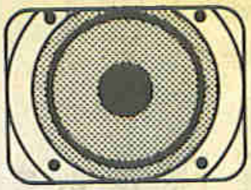
The Cable and Satellite Show, like the industry itself, has now come of age. The next year will see even greater public and commercial interest with the launch of BSB and the second Astra satellite coming closer. For anyone with any interest in STV the Cable and Satellite '90 show will be a case of be there or be square (no, not you Sir Clive).

Geoff Bains



PLAYBACK





In the not too distant future the discrete hi-fi system of today is likely to be integrated into some sort of universal home entertainment centre. Hi-Fi VCRs are commonplace now while true A/V amplifiers, with or without surround sound decoders, are beginning to make their presence felt. The introduction of CDV also represents a milestone in the marriage between sound and vision. Now it seems that even home games machines are getting in on the act.

Let me explain. About a year ago a games console called the PC Engine from NEC found its way onto the UK market. This is an 8-bit system operating at a very fast 18MHz and designed to accept games software in the form of 2Meg 'credit cards'. A library of 30 or 40 games are available at present though these constitute a mix of Japanese as well as English coin-op conversions.

The machine uses a six channel, eight-octave sound chip but its sound quality is still pretty basic and — well — synthesised. Using the SCART Euro-connector the visual quality is very good indeed even if the sound effects are less impressive.

With the introduction of Sega's 16-bit games console the 8-bit PC Engine might have withered into obsolescence if NEC had not pulled a rather interesting rabbit out of its corporate hat. This rabbit comes in the form of a dedicated CD-ROM player, the CDR-30, which can be controlled by the PC Engine via a proprietary interface unit. A CD-ROM disc can be used to store up to 600Mb of data so their potential in the adventure and arcades gaming arena seems very wide ranging indeed.

At present there are no computer games that utilise full-motion video animation (CDV style) but at least the use of sound-synthesiser chips can be done away with. CD-ROM opens up the way for 16-bit sound quality both in effects and accompanying music that should approach the quality offered by conventional domestic CD players.

NEC's CD-ROM player takes the form of a very ordinary-looking portable unit and has outputs that cater for both headphones and line-level components (amps or cassette decks). Away from the PC Engine, the CDR-30 looks and functions just like any other portable CD player. However, like most portables it features a very basic array of facilities like track skip and all-repeat for instance.

Now here's the interesting bit. Once the CDR-30 is connected to the PC Engine and the CD-ROM system card is loaded, a whole host of features and facilities are suddenly at your disposal. The system card generates a colourful icon-driven TV display that allows you to operate the CDR-30 as a CD player but using the screen menu and accompanying joystick as a kind of wired remote control! All you have to do is link the PC Engine to the line inputs of your hi-fi amplifier and experience stunning sound effects with the games or music with ordinary CDs.

The CDR-30 will cost around £280 which is fairly typical for a portable. However what is far from typical are the software-derived facilities that include fast music search, direct track access, a 99-track random access memory, L/R level indicators, full track and time notation, A-B repeat, random play and intro-search. These are the sort of features that grace full-sized players costing upwards of £250 but then the Philips' and Marantz's of this world cannot play computer games . . .

Viewed as a conventional portable the CDR-30 performs fairly well. Distortion hovers around 0.1% at the peak level of 1.3V but inevitably increases to around 5 or 6% at −60dB. The line output is reasonably flat but experiences a +0.5dB list at 15kHz while the headphone output demonstrates a rather droopy HD response. I detected the presence of high-order IM sampling artifacts within the audio band but the overall linearity of the player was remarkably good, just 3.3dB out at −90dB.

It was no match for players like the Marantz CD6511 or the Technics SLP-200 when it came to the listening tests but neither did it disgrace itself. NEC are offering a fairly inoffensive, moderately detailed and slightly 2-dimensional sound with the CDR-30, but it does escape the trap of sounding harsh or bright. As a result you could listen to this player for long periods without wanting to give your ears a rest. When you do, just switch off the sound and exercise your trigger finger!

Paul Miller

Cirkit NEWS

MAY 1989

YOUR CHANCE TO WIN...

Once again, you'll need all your wits about you to identify the six items we've picked from the catalogue, and a Lodestar audio signal generator worth more than £180.00 is waiting for the sender of the first all-correct entry drawn in this season's competition.

Second and third prizes are top-of-the range multimeters from Cirkit's outstanding new range, offering frequency and capacitance measurement and transistor test, and valued at £55.00 each.

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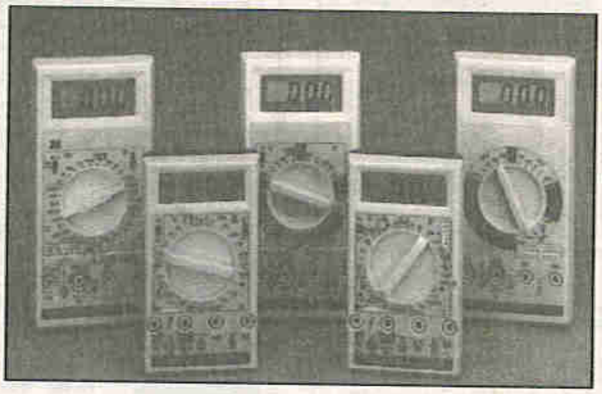
NEW CATALOGUE OUT 25th MAY

Over 3,000 product lines feature in the Summer 1989 edition of the Cirkit Constructors' Catalogue, available from most larger newsagents or direct from the company priced at £1.50. The latest books, an RF frequency meter, two new PSU designs and a 3.5MHz converter are among the innovative new kits this issue, while our construction project - a 2 Watt stereo amplifier - is bound to prove an absorbing activity for dedicated constructors. In the test equipment section there's a whole new range of multimeters, a bench DVM and a triple output PSU.

For eagle-eyed readers who enjoy a challenge of a different sort, there is the opportunity of winning an audio signal generator worth more than £180.00 In the latest fiendish competition. All prices now include VAT for quicker, easier ordering; and Cirkit's same-day despatch of all orders, combined with value-for-money discount vouchers, makes the line-up even more attractive.

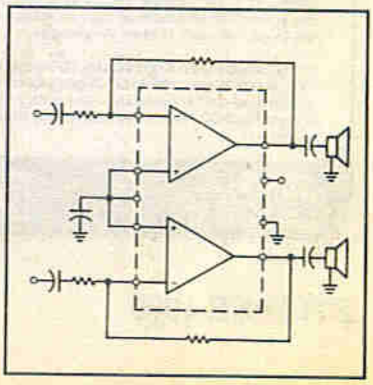
D-MM GOOD VALUE!



Cirkit's six new digital multimeters are packed with sophisticated extra facilities: capacitance measurement, frequency measurement up to 20MHz, temperature reading, transistor test and logic test in addition to the usual volts, current (DC and AC) and resistance measurement - and all unbeatable value with prices ranging from **£20.00** to **£55.00!**

FEATURE PROJECT: 2W STEREO AMP

Our construction project this issue is for a straightforward but very effective 2 Watt stereo amplifier. Based on the LM1877, it is the perfect amplifier for a 'Walkman' cassette deck and equally suitable for AM/FM radios or mixer desks. Featuring 2W per channel and 75dB channel separation, it operates from a 10-26 volt supply, making it ideal for in-car applications. The catalogue includes full details of this economical kit.



PC INTERFACING

Mike Bedford catches the PC bus and examines the possibilities of peripheral prototyping

In the March ETI we looked at the IBM PC and compatibles in a new light. As a potential enthusiasts' computer built up from board level at a price to beat the offerings of Alan Sugar, the PC can be used not only for the ordinary uses of a home computer but also for hardware development and experimentation.

In this article we consider interfacing to a PC — not through its RS232-C and Centronics ports (see ETI March 1987) but with peripherals which need to connect directly to the system bus of the PC. It should be pointed out that this isn't intended as a beginner's article. Generalised microprocessor interfacing is not covered here, only that which is specific to the PC or PC/AT. For those hoping to make a start on microprocessor interfacing for the first time and who intend to use a PC, it is suggested that this article is read in conjunction with introductory books or magazine articles on such interfacing (see *Books* section). It will certainly be necessary to know something of how DOS and BIOS work. Also IBM's Technical Reference Manuals (which are by no means inexpensive) are some of the few places where true hardware information may be encountered.

PC vs PC/AT

The bus of the PC is a subset of the AT bus. Since the AT uses the 16-bit 80286 processor compared to the 8-bit 8088 in the PC (actually 16 bits internally but only 8 data bits being brought to the outside world), the AT bus has a number of extra signals, most notably an extra 8 data bits and 4 extra address lines. The physical design of add-on cards is such that PC-compatible boards may be used in an AT — although they don't give the same rate of data transfer as that of true AT cards, this isn't usually too important (except for applications such as memory expansion or disk controllers).

Expansion Cards

Figure 1 shows a full size PC expansion card and Fig. 2 shows the equivalent for an AT. It will be noticed that there is an optional area shown hatched on the PC version. The PC card can be expanded into the shaded area (as on some commercial boards) but will not then fit the AT slot. Half size expansion cards may be used if less circuitry is required, the usual limit for such a format being indicated by dotted lines on the diagrams of the full size cards.

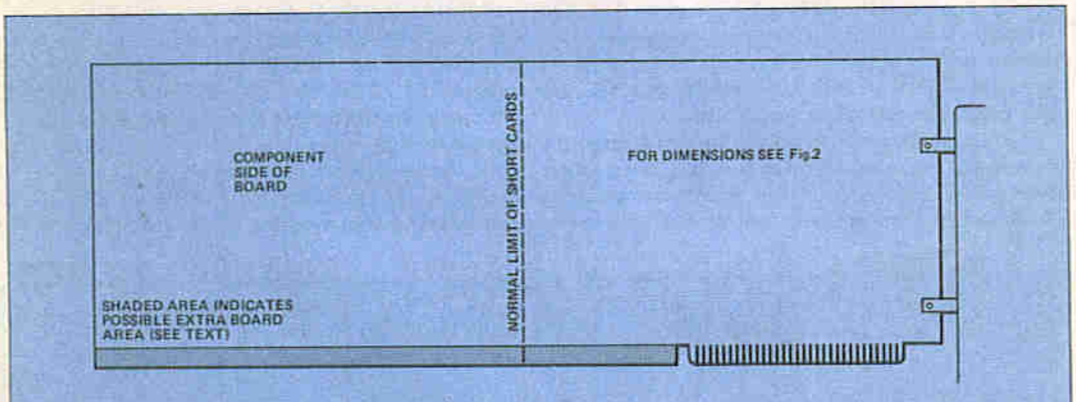


Fig. 1 Physical details of PC expansion cards

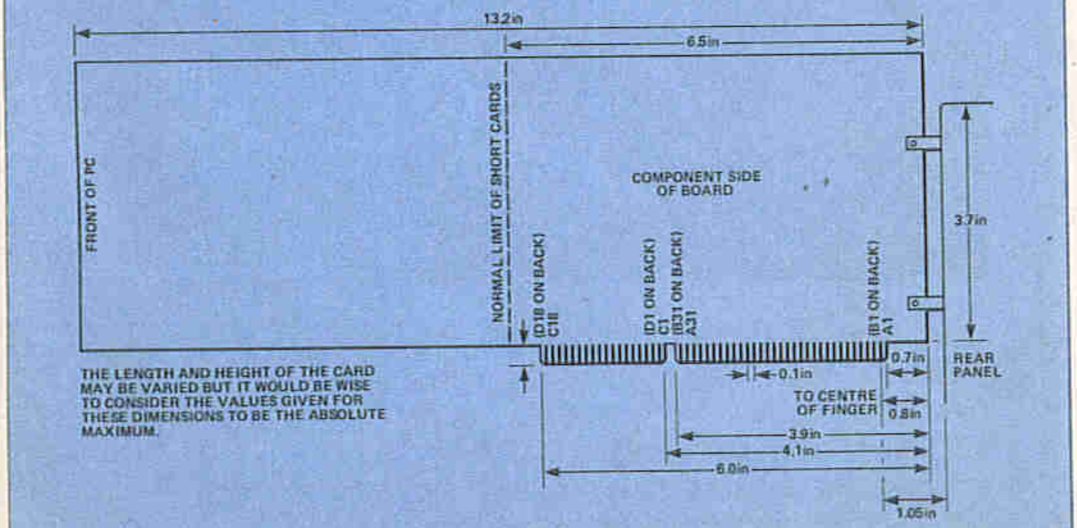
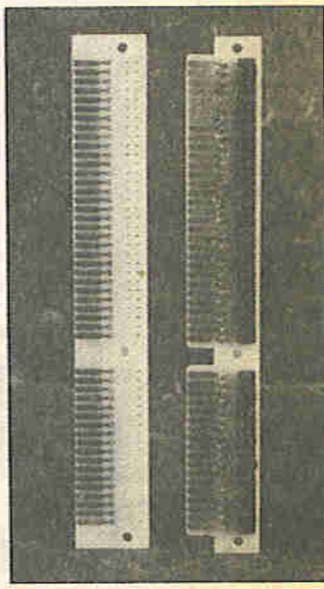


Fig. 2 Physical details of AT expansion cards



The normal separation between expansion slots on a mother board is 0.8in which obviously limits the thickness of the cards. The IBM technical reference manual recommends that the maximum thickness of a card including both the circuit board and the components is 12.7mm (0.5in).

To fit an expansion card, the blanking plate is removed next to the intended slot on the rear panel of the PC. The rear panel of the expansion card fills the gap created by removing the blanking plate and whereas in applications such as memory expansion it serves no purpose other than making up the gap, the plate is generally available for accommodating sockets which will then be available to the outside world on the rear of the computer. Fig. 3 is a mechanical drawing of an expansion card rear panel. Such a plate could be constructed fairly easily at home or alternatively sneak into the newsagents and read advertisements for PC hardware in the blossoming area of PC magazines.

PC cards have a direct edge connector. The PCB itself plugs into the socket, tracks at the edge, both sides of the board making the contact. Normal practice is for the edge connector to be gold plated but tin plating the contacts is adequate so long as the board isn't repeatedly inserted and removed. However, there is still a problem with making up a prototype on stripboard (although the prototype adapter discussed later solves this problem in many instances). Also the edge connector requirement means that all PCBs have to be double sided, however simple the circuit. ETI has solved this problem using a PC edge connector which is available through our PCB service. This is a small double-sided PCB containing tin-plated edge connectors which connects to a board devoid of such a connector via 0.1in pitch pin strips. The card is designed for an AT compatible card but the extra portion may be cut off for PC use. The card is shown as Fig. 4 — PCB artwork is in the foil pages. See also the 'Edge Connector' section of text.

It should be noted that since the edge connector attaches to the component side of the board rather than being integral to it, the maximum available thickness of the card adjacent to it on the non-component side is slightly reduced. This should not be a problem since most cards are only about 0.4in thick at the most and use of the 'indirect direct edge connector' does not affect things more than 0.1in.

Address Maps

Address maps in the plural? Those of us brought up on 6502 or 6809 based machines had I/O devices (VIAs, UARTs etc) attached to the processor in the same way as memory and therefore accessed by use of the standard load and store instructions.

All the I/O devices would normally be grouped together in a block of adjacent addresses — a small hole in the memory map. On Intel processors (the 8088 and 80286 coming into this category) memory and I/O are dealt with totally independently. Different sets of processor instructions are used to access memory and I/O devices; different write enable and read enable signals are available for each. Accordingly we have two separate address maps. These are shown as Table 1 (memory) and Table 2 (I/O).

We won't say a lot about the memory map since most machines already have 512K or 640K. Memory expansion cards are readily available and inexpensive. It will be noticed that the limit of the memory map is 1MByte, the maximum addressing range of the 8088. The 80286 can address up to 16MByte but since MS-DOS only expects 1M, to all intents and purposes we can forget about this. There are exceptions to this rule as mentioned in March.

In the I/O map, there is a maximum of 64K available on the 8088/80286. The design of the PC reserves I/O addresses up to &0FF for use on the main boards and places a &100-&3FF limit on I/O addresses available for use on expansion cards. Because of this limit only the bottom 10 address bits need decoding for I/O cards. Conversely, cards should not use memory above &3FF since other cards in the system will only be decoding A0-A9 and a clash could thereby occur.

Addresses are assigned to a whole realm of options. An expansion card could be designed to address the area assigned to say the SDLC1 card if

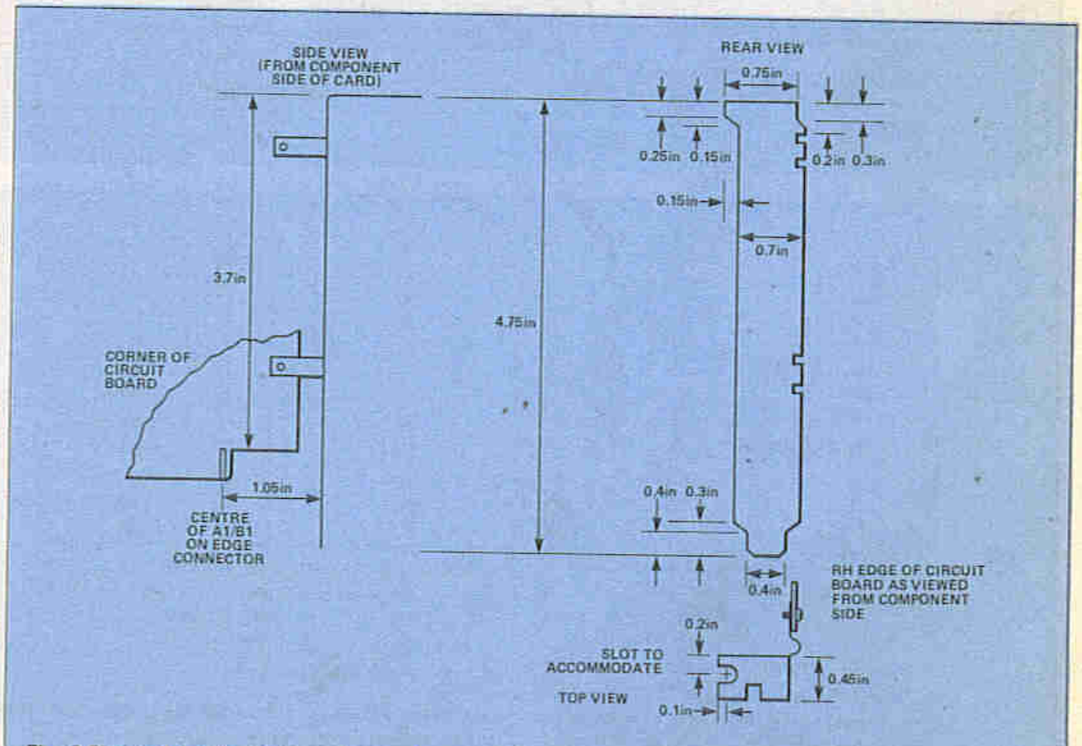


Fig. 3 Physical details of expansion card rear panel

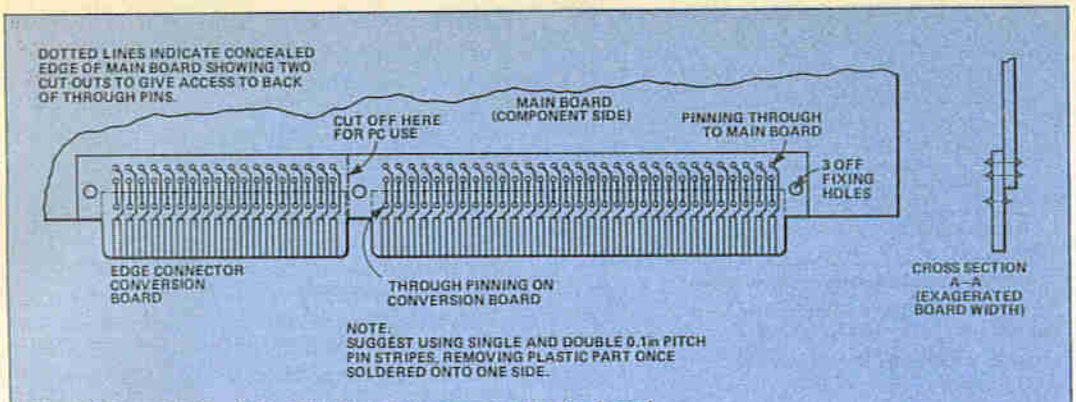


Fig. 4 Fixing details of the ETI edge connector conversion board

it wasn't present in a particular machine, but staying away from all assigned addresses makes the card of more universal appeal. In fact it would be well worthwhile designing in some link or DIL switch options in terms of addresses occupied.

Block 0	00000-0FFFF	RAM to 64K
Block 1	10000-1FFFF	RAM to 128K
Block 2	20000-2FFFF	RAM to 192K
Block 3	30000-3FFFF	RAM to 256K
Block 4	40000-4FFFF	RAM to 320K
Block 5	50000-5FFFF	RAM to 384K
Block 6	60000-6FFFF	RAM to 448K
Block 7	70000-7FFFF	RAM to 512K
Block 8	80000-8FFFF	RAM to 576K
Block 9	90000-9FFFF	RAM to 640K
Block A	A0000-AFFFF	Extended video memory
Block B	B0000-BFFFF	Standard video memory
Block C	C0000-CFFFF	BIOS extension (eg EGA)
Block D	D0000-DFFFF	Other use
Block E	E0000-EFFFF	Other use
Block F	F0000-FFFFF	BIOS EPROM

Table 1 Memory map

Interrupts

There are two interrupt request pins on the processor, one maskable and one non-maskable. Since the NMI is intended only to signal catastrophic failures to the processor and should not be used for any other purpose, nothing more will be said about it.

The non-maskable interrupt allows one of 256 interrupt vectors to be accessed, the number of the required interrupt being set up on the lowest order eight address pins by the interrupting device when the interrupt request signal is asserted. In actual fact these 256 interrupts are also used as processor generated interrupts (such as divide by zero exception) and software interrupts (such as BIOS calls) so the number available as hardware interrupts is much less. Table 3 shows the 8 (15 on the AT) true hardware interrupts on a PC, some of which are used on the main board and others for expansion cards.

However, designers of expansion cards do not have to build in circuitry to put a number from 0 to 15 onto the address bus when generating an interrupt. The 8259A Interrupt Controller chips do all the work (most modern designs won't have any discrete 8259As but the job is done by one of the VLSI

Address	Description	Note
1F0-1F8	Fixed disk	1
200-20F	Games adapter	
210-217	Expansion unit	2
278-27F	2nd parallel printer port	1
2B0-2DF	Alternate EGA	
2F8-2FF	2nd serial port	
2E1	GPIB (0)	4
2E2-2E3	Data Acquisition (0)	4
300-31F	Prototype card	
320-32F	Fixed disk	2
360-36F	PC Network	
378-37F	1st parallel printer port	
380-38F	SDLC/2nd Bisynchronous	3
390-393	Cluster (0)	4
3A0-3AF	1st Bisynchronous	1
3B0-3BF	Monochrome display/printer	
3C0-3CF	EGA	
3D0-3DF	CGA	
3F0-3F7	Floppy disk	
3F8-3FF	1st serial port	

Notes		
	-	Devices on main board not included
	1	AT only
	2	PC only
	3	2nd Bisynchronous on AT only
	4	These devices decode the full 16 address bits thereby allowing further devices in the same category above 3FF (eg GPIB (1) = 22E1 etc)

Table 2 I/O map

Bussed Signal PC	Bussed Signal AT	Hardware Interrupt Level: Int Ctrl 1	Hardware Interrupt Level: Int Ctrl 2 (AT only)	Processor interrupt number (Hex)	Function
		IRQ0		08	Timer output 0
		IRQ1		09	Keyboard
* ✓		IRQ2 ←		0A	Reserved (Int Ctrl 2 on AT)
			IRQ8	70	Realtime clock
*	✓		IRQ9	71	S/W Redirected to IRQ2
	✓		IRQ10	72	Reserved
	✓		IRQ11	73	Reserved
	✓		IRQ12	74	Reserved
			IRQ13	75	Co-processor
	✓		IRQ14	76	Hard disk controller
	✓		IRQ15	77	Reserved
✓	✓	IRQ3		0B	Serial port 2
✓	✓	IRQ4		0C	Serial port 1
✓	✓	IRQ5		0D	Hard disk (Printer 2 on AT)
✓	✓	IRQ6		0E	Floppy disk controller
✓	✓	IRQ7		0F	Printer port 1

* The PC has IRQ2 as a bussed signal. On the AT IRQ2 connects to the second interrupt controller to fan this one interrupt out into another 8. In order to provide compatibility within the PC, the software on the AT redirects IRQ9 to the IRQ2 handler. Accordingly, the same pin on the expansion slot which is IRQ2 on the PC is IRQ9 on the AT.

The function of IRQ2 (or IRQ9) is officially reserved and would not be a good one to consider using as it is used by EGA cards.

Table 3 Hardware interrupts

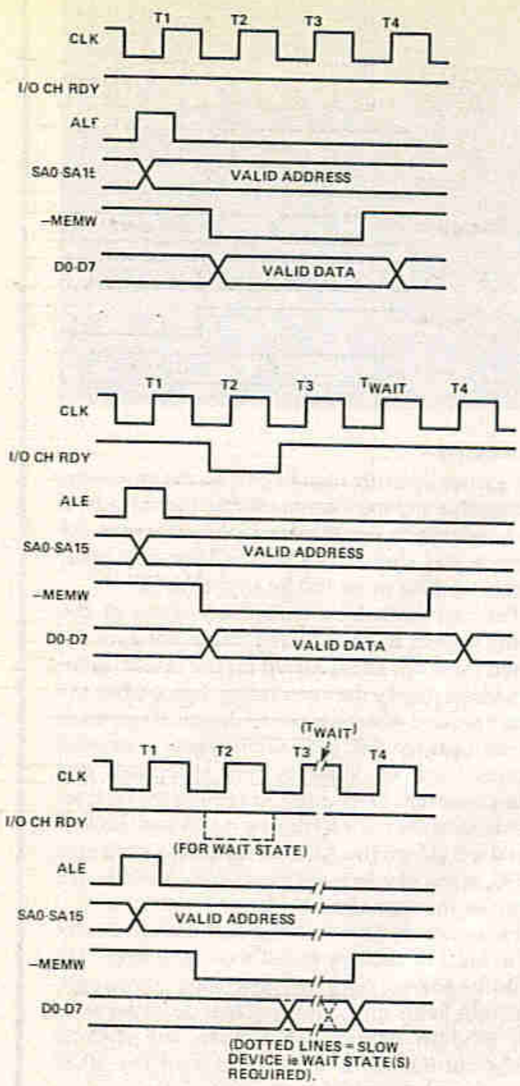


Fig. 5 PC timing diagrams with (a) write no wait state (b) one wait state (c) read with no wait and one wait states combined

devices). To generate an interrupt it is only necessary to assert a high level on one of the bussed interrupt request signals.

Which interrupt to use for a given design? Clearly all are already assigned and use of such an interrupt will cause things to go drastically wrong unless the proper precautions are taken. A particular system may not use all the interrupts so, for example, if a second parallel port is not present on an AT (as will often be the case) then interrupt five could be used.

With a bit of care an interrupt level already in use could even be used. This is done by overwriting the system vector for the interrupt in question to point to a new service routine. This routine checks the new hardware to see if it is responsible for generating the interrupt. If so it does whatever is necessary, otherwise it jumps to the original interrupt handler. There could obviously be timing implications here so you need to be careful!

I've noticed also interrupt levels for COM1: and COM2: (the serial ports) are supposed to be different, on my system the interrupt vectors for IRQ3 and 4 are the same, suggesting the system would work with the same levels for both ports, thus freeing up the other. Note that this is not a proven technique. It is good practice to build in flexibility and make the interrupt number link selectable in some way, perhaps between 3,4,5 and 7.

DMA

It isn't intended to say much about DMA since it will probably only be used on the minority of adapters to be designed for the PC. All that is presented here is information on the designations of the DMA channels in order to ensure that any hardware designed does not clash with other peripherals. Once again we would suggest building in linkable (or DIL switchable) options although it will be noticed that there is far more scope here as one of the channels (five on the AT) is designated as spare and one assigned to the SDLC card which is an unlikely add-on for the home user.

The PC has four DMA channels provided by an 8237A DMA controller whereas the AT has seven provided by a pair of these chips. On the AT the channels provided by the second controller (five, six and seven) have a 16-bit capacity. As with the interrupts, using two controllers doesn't quite give twice as many channels since one channel on the second controller is used as a cascade to the first.

Timing Diagrams

In order to make the following discussion of wait states and the I/O channel signal descriptions more easily understood, we have produced a selection of timing diagrams in Fig. 5 (for the PC) and Fig. 6 (for the AT). It should be stressed that these diagrams are only approximate and full timing information should be sought (if required) from the appropriate Intel data book. There will be slight differences between what is shown in the Intel book (which refers to just the processor) and what is produced here (the complete system). Most of the signals will be buffered by the PC circuitry hence adding a few ns extra propagation delay but the main difference will lie in the address bus since the system has to demultiplex the address from the data and latch the address on the PC or latch the address (or at least the first 20 of them) on the AT.

Wait States

Most processors provide some means of slowing things down to allow for slow memory or I/O devices. In the world of Intel microprocessors, this slowing down is carried out by adding extra processor cycles after the address (and data for a write) is present on the bus. Such cycles are referred to as wait states and clearly must last for an integral number of processor cycle times.

The need for wait states obviously depends on the timing specification of the device to be interfaced and (with a family of computers with different processor speeds) also on the computer specification. This is confirmed by looking at the original PC (4.77MHz) and the original AT (6MHz). In order to cope with readily available memory of the time, the AT automatically inserts one wait state into all memory cycles compared to zero wait states on the PC. Similarly, since I/O devices are often slower than

DMA Channel: DMA Ctrl 1	DMA Channel: DMA Ctrl 2 (AT only)	Function
	4	Cascade for Ctrl 1
0		Memory refresh (AT-spare)
1		SDLC
2		Floppy disk
3		Spare
	5	Spare
	6	Spare
	7	Spare

Table 4 DMA channels

memory, the PC had one wait state I/O cycles. (This explains why some adapters which did include fast I/O devices and which were speed critical were memory mapped rather than interfaced in the normal way to the I/O map.) Due to availability of higher speed memories, today's AT clones (even the 12MHz variants) have a link selectable automatic wait state generator which can be set to zero if fast memory is used.

Since there are so many variables in terms of processor clock speed, wait states is another area where the designer may consider building in some flexibility. If the adapter is intended to be of universal appeal it would be wise to build in a link selectable wait state generator. The exception to this rule, of course is for applications where speed isn't important and therefore a couple of wait states (or whatever) could always be inserted.

The IBM Technical Reference Manual for the prototype adapter suggests a wait state circuit which uses a delay module. Since this gives a delay of a fixed time interval it is not suitable for use in cards which could be used in machines with a variety of clock speeds. Instead it is suggested that a circuit which counts clock cycles is used. Such a circuit is shown as Figure 7. Of course, if it is only required to give options of zero or the wait states then the 74LS164 can be omitted and the D-type flip flop in the unused half of the 74LS74 package used instead.

Prototype Adapter Cards

The most obvious method of building an I/O adapter is by use of a printed circuit board, the problems for the home constructor associated with the direct edge connector being overcome as described earlier. Whereas those designing an adapter which will be reproduced by others (for a magazine article for instance) will need to design a PCB, those building a one-off or experimenting with the initial prototype have other options available.

IBM publishes details of a so-called prototype adapter. In the UK similar cards are produced by Vero Electronics and distributed through the normal channels but, it has to be admitted, not at an insignificant price. Prototype adapters are the size of full sized adapter cards (half size also available) and are complete with the appropriate 31+31 way edge connector (and also the extra 18+18 way on the AT variant). Component positions and associated tracking dedicated to signal buffering and decoding is present at the rear of the cards, the remainder having a grid matrix and ground/power distribution busses for 'breadboarding' the remainder of the circuitry.

Holes to accommodate a D-type connector up to 37-way which may be fitted on the rear panel are also provided. It should be noted that according to the system I/O map there is a reserved address area for the prototype adapter. Accordingly these cards don't provide generalised address decoding but instead generate the enable signal for the I/O address range &300-&31F.

Whereas it isn't intended to give a full description of the operation of the prototype adapters it is felt beneficial to present their circuit diagrams here. Even for those readers who don't intend to do any experimentation on such cards it would provide a good exercise to consolidate the information contained in the previous section by working through the circuits. The PC prototype card is shown as Fig. 9 and the AT variant as Fig. 10.

Prototype adapter cards have the following Verospeed part numbers and may be ordered on (0703) 644555:

PC compatible: 222-42697G
AT compatible: 222-53100K

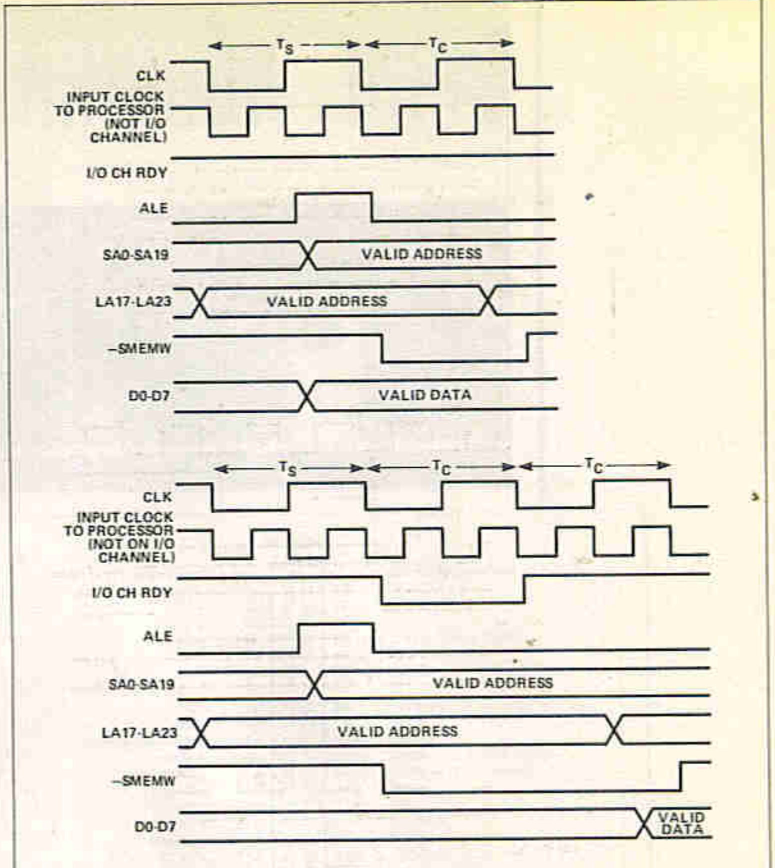


Fig. 6 AT timing diagram with (a) write no wait state (b) read with one wait state

BOOKS

- An Introduction to Microprocessors. Adam Osborne. McGraw-Hill.
- Programmer's Guide to the IBM PC. Peter Norton. Microsoft Press. (This is particularly recommended and contains both PC and AT information).
- Inside the IBM PC. Peter Norton. (Also contains information on the full PC family.)
- Handbook of Software and Hardware Interfacing for IBM PCs. Jeffrey P. Royer. Prentice-Hall. (Although this book doesn't contain any AT specific information, it is unusual in containing a mixture of hardware and software information.)
- Personal Computer Technical Reference Manual.
- Personal Computer/AT Technical Reference Manual. Ref. No. 1502243. IBM.
- Microprocessor and Peripheral Handbook. Volume 1 – Microprocessors. Intel Corporation.

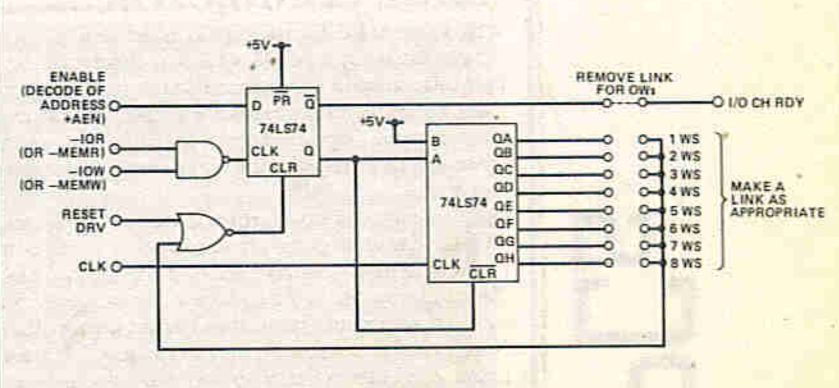
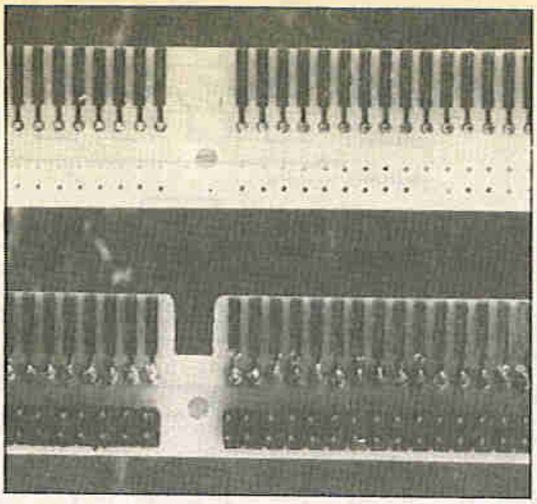


Fig. 7 General purpose wait state circuitry



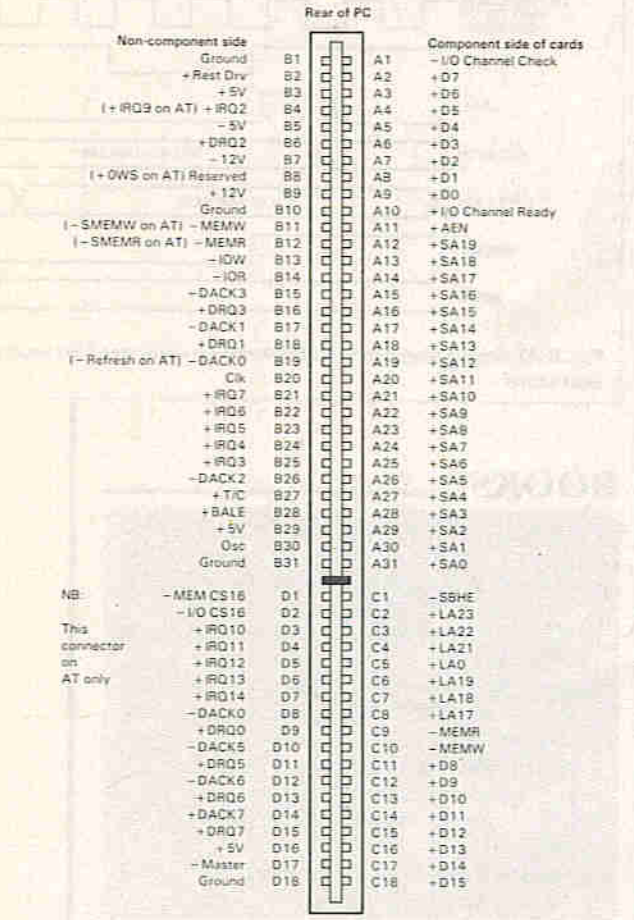


Fig. 8 I/O channel designations

EDGE CONNECTOR

As supplied, the card will be completely rectangular and hence will require the two corners and the centre notch sawing or filing out.

One point on the construction: 0.1in pitch single and double pin strips will prove much quicker to fit than dozens of vero pins but once soldered in place, the plastic portions could prove difficult to remove. For the single strip it will, nevertheless, be possible by levering it off with a screwdriver blade (being careful not to damage the tracks) which is just as well since these pins need soldering onto both sides of the board.

On the other hand, removing the plastic portion from the double pin strips which make the contact with the main board will prove virtually impossible. This being the case, if such pin strips are used, the edge connector board will be spaced that extra 0.1in or so from the main board.

I/O CHANNEL SIGNAL DESIGNATIONS

Figure 8 shows the designation of each conductor on the 62-way (and also the 36-way on the AT) edge connector sockets which make up the I/O channel (the system bus in non-IBM language). In the following description the function of each signal is followed by (I), (O) or (I/O) to indicate inputs, outputs or input/outputs relative to the motherboard ((I) indicates an input *to* the motherboard and so on).

Those marked (*I/O) indicate signals which during normal processor operation are outputs but may become an input during DMA cycles. In common with normal Intel practice, signals which are active low are preceded by a minus sign whereas those without a preceding sign or with a plus sign are active high. So, for example −IOR could be represented as IOR.

One final point before the complete round-up — the outputs on the I/O channel are designed such that the equivalent of two LS TTL loads per expansion slot may be placed on them.

POWER SUPPLIES

Ground	Common return for power supplies.
+5V	Regulated +5V supply.
−5V	Regulated −5V supply.
+12V	Regulated +12V supply.
−12V	Regulated −12V supply.

ADDRESS BUS AND ASSOCIATED SIGNALS

SA0-SA19 (*I/O)	Address bits 0 to 19. SA0 is the least significant. These signals are gated when BALE is high and latched on the falling edge of BALE. These bits allow addressing up to the 1MByte limit but to fully decode within 16MByte (AT only), LA17-LA23 are required.
LA17-LA23 (*I/O)	AT only. Address bits 17 to 23, only valid during BALE high as they are not latched on the falling edge. Designs requiring these signals will need to latch them on board. Boards not requiring addressibility beyond 1MByte can be designed to obviate the need to decode these signals (see −MEMW and −MEMR).
AEN (O)	Address enable. Differentiates between SA0-SA19 and LA17-LA23 being driven by the processor and being driven by a DMA device. Only when a DMA controller has control of the address bus will this signal be asserted. AEN should therefore be included in all decodes of the address bus.
BALE (O)	Address latch enable. Used on the system board to latch address bits SA0-SA19. To a device on the I/O channel this signal may be used to detect the start of a processor or DMA cycle.
SBHE (*I/O)	AT only. Bus high enable. Used to indicate that the data transfer is to take place on bits SD8-SD15 in addition to the transfer on bits SD0-SD7 which is common to all cycles.

DATA BUS

SD0-SD7 (SD0-SD15 on AT) (I/O)	Data bits 0 to 7 (0 to 15 on AT). SD0 is the least significant. All devices use SD0-SD7. SBHE is used to indicate that the top half of the data bus is in use on the AT.

INTERRUPTS

IRQ2-IRQ7 (IRQ3-7, 9-12, 14, 15 on AT) (I)	Interrupt requests. Order of decreasing priority is 9, 10, 11, 12, 14, 15 (AT only), 2 (PC only), 3, 4, 5, 6, 7. For situation regarding IRQ2 and IRQ9 see Table 3. There is no hardware interrupt acknowledge signal but since the 8259A interrupt controllers are used in edge triggered

mode there are no critical timing limitations. It is normal practice to keep the signal high and pulse low to generate an interrupt.

-I/O CH CK (I) — I/O channel check. This signal indicates a memory parity error to the system board. NMI is asserted as a result of this signal being active.

DIRECT MEMORY ACCESS

DRQ1-DRQ3 (DRQ0-3, 5-7 on AT) (I) — DMA requests. DRQ0 has the highest priority and 3 (7 on the AT) the lowest. Although DMA channel 0 exists on the PC it is used exclusively for memory refresh and is therefore generated on the mother board.

On the AT, dedicated circuitry independent from the DMA controllers is used for memory refresh and accordingly DMA channel 0 is made available to I/O devices. DRQ0 is sometimes labelled DRQ4 on ATs (and -DACK0 as -DACK4) to avoid confusion with memory refresh.

An active level on a DRQ signal must be maintained until the corresponding -DACK signal is asserted.

-DACK0-3 (-DACK0-3, 5-7 on AT) (O) — DMA acknowledge. Although DRQ0 is not a bussed signal on the PC (being dedicated to memory refresh and the request being generated on the mother board), the acknowledge signal is present on the I/O channel to indicate a refresh cycle. (Note above comment about DRQ0 and DRQ4 on the AT.)

-Refresh (O) — AT only. Memory refresh. Occupies the same I/O channel pin as is used by -DACK0 on the PC.

T/C (O) — Terminal count. Indicates that a DMA channel has reached terminal count. It is a pulsed signal.

-Master (I) — AT only. Master. Used in conjunction with a DMA request line to take control of the bus. A processor of DMA controller on the I/O channel asserts a DMA request in cascade mode and receives a DMA acknowledge. -Master may then be asserted causing the address, data and control lines to go tri-state. The device must then wait one clock period before driving the address and data bus and two cycles before doing a read or write. This signal must not remain asserted for more than 15μs or else system memory could be lost due to lack of refresh.

CONTROL SIGNALS

-MEMR (-SMEMR on AT) (*I/O) — Memory read. Note the different name on the AT: System memory read. -MEMR also exists on the AT (see below). This signal instructs the memory device to put data onto the data bus. On the AT this signal is only active if the read is from memory within the first 1MByte (which is really the same as on the PC where this is the limit of the PC's memory). Use of this signal on an AT obviates the need to decode address bits LA17-LA23 when working within the first MByte.

-MEMR (O) — AT only. Memory read. Note this is not the same as -MEMR on the PC. Similar to -SMEMR but is active for all read operations. This signal will only be used for accesses to memory outside the first MByte.

-MEMW (-SMEMW on AT) (*I/O) — Memory write. Again a different name on the AT: System memory write. -MEMW also exists on the AT (see below). This signal instructs the memory device to store data from the data bus. Only active on ATs if the write is to memory within the first 1MByte. Use of this signal on an AT obviates the need to decode address bits LA17-LA23 when working within the first MByte.

-MEMW (O) — AT only. Memory write. Not the same as -MEMW on the PC. Similar to -SMEMW but is active for all write operations and is only used for accesses to memory outside the first MByte.

-IOR (*I/O) — I/O Read. Instructs the I/O device to put data onto the data bus.

-IOW (*I/O) — I/O Write. Instructs the I/O device to read data from the data bus.

Reset Drv (O) — Reset Drive. Generated during power up. Used to initialise devices on the I/O channel.

-MEM CS16 (I) — AT only. Memory 16 chip select. Informs the motherboard that the memory transfer is 16 bits wide. Failure to assert this signal (as will be the case with PC boards) will result in the 16 bits being transferred as two 8-bit operations.

-I/O CS16 (I) — AT only. I/O 16 chip select. Informs the mother board that the I/O transfer is 16 bits wide. Failure to assert this signal (as will be the case with PC boards) will result in the 16 bits being transferred as two 8-bit operations.

WAIT STATES

I/O CH RDY (I) — I/O channel ready. Should be pulled low to indicate 'not ready' by slow devices requiring additional wait states to be inserted. It should be driven on detecting a valid address and a read or write signal and should be held for an integral number of clock cycles. There is no harm in using this signal to insert wait states already generated by the mother board (or more usefully to increase the number of wait states).

0WS (I) — AT only. Zero wait state. Causes the automatic wait state generation of the motherboard (if present — see main text) to be overridden. To complete a 16-bit memory cycle without wait states this signal is derived from an address decode and either the read or write signal. To reduce the wait states on an 8-bit memory cycle to 2, this signal should be made active one system clock after the read or write command. 0WS should be driven with an open collector capable of sinking 20mA.

OSCILLATORS

CLK (O) — The system clock. The frequency depends on the system. True PC clones have a frequency of 4.77MHz whereas newer clones often offer higher clock speeds. Original ATs were 6MHz, current one may offer up to 15MHz.

This signal has a 50% duty cycle. On the 80286 processor (used in the AT) although the input frequency is double the actual processor internal working frequency, the CLK signal is still the processor frequency (although actually in antiphase for reasons of compatibility with the PC).

OSC (O) — Oscillator. A high speed clock with a frequency of 14.31818 MHz. The frequency of this signal does not depend on the processor clock speed and the signal is not synchronous with it.

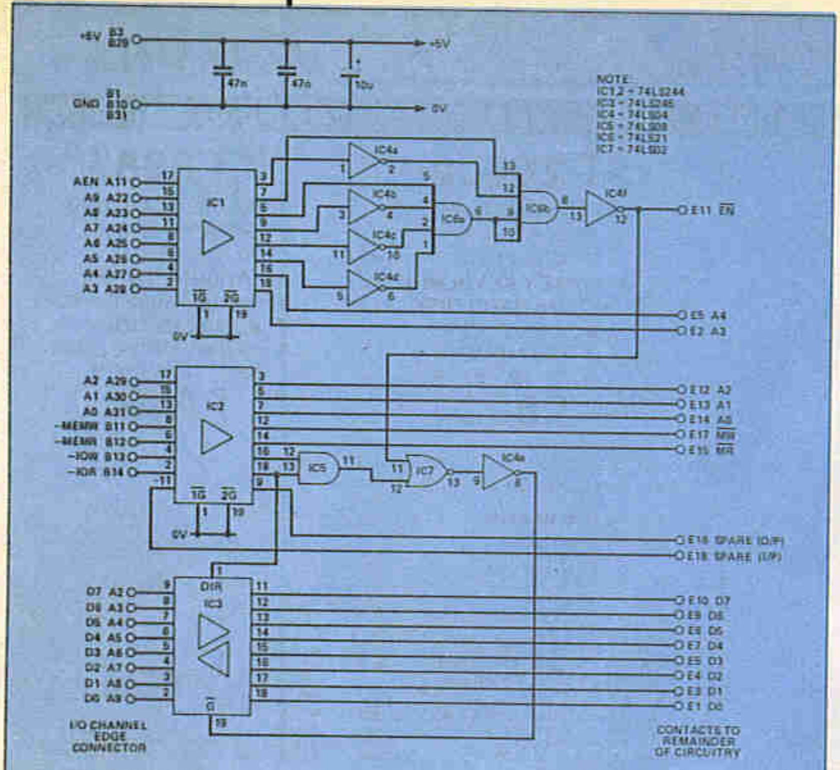


Fig. 9 PC prototyping card

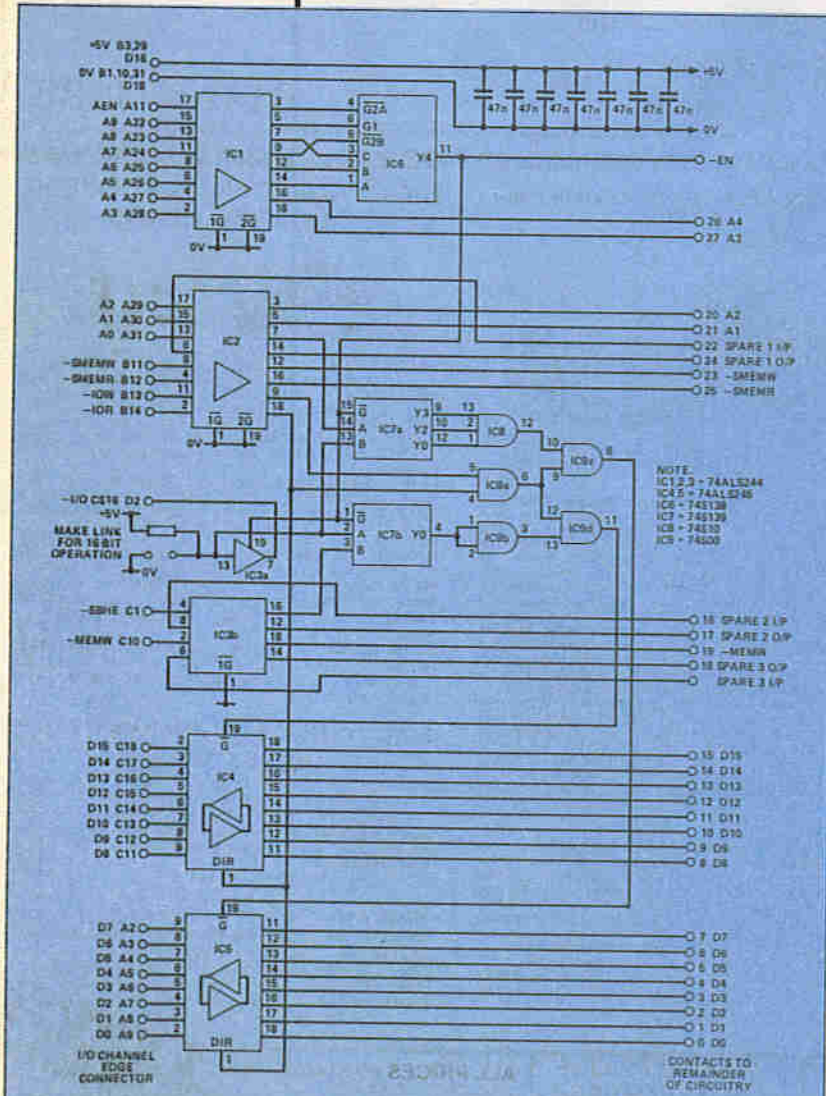


Fig. 10 AT prototyping card

In Conclusion

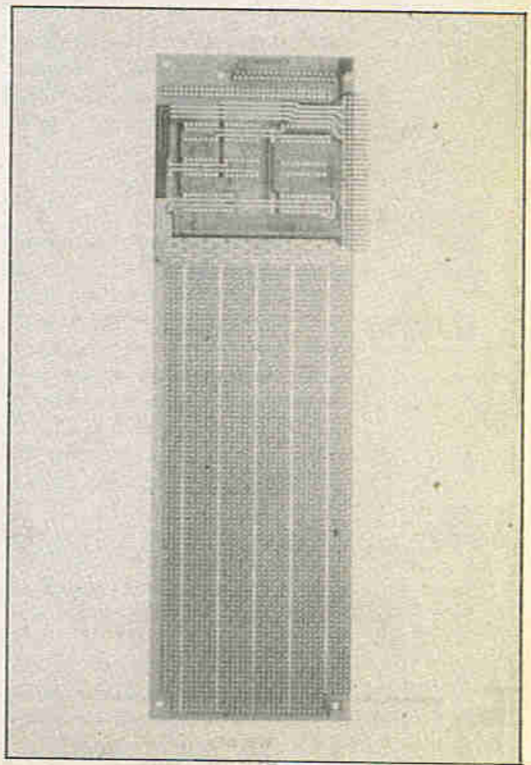
We've covered a lot of facts in the past few pages and to those new to microprocessor interfacing this may look a bit daunting. Whereas we still maintain that the beginner should read this article in conjunction with some basic material on the topic we certainly hope we haven't put the inexperienced off. Remember that a large proportion of all this won't be relevant to any one project — for example although we have described the functions of 58 (93 on the AT) signals on the I/O channel, IBM's official asynchronous communications adapter card uses only 29.

Nevertheless, we do advocate some caution. Whereas home computers in the past have represented quite a modest capital outlay with a correspondingly modest degree of risk in plugging one of your own constructions into it, the cost of putting right any damage we do to say an AT could be quite considerable. This is aggravated by the fact that circuit diagrams were often available for the Tangerines and Nascoms of this world but may not be easily obtained with a PC clone. We don't say this to frighten people off but just to ensure that the basic precautions are taken. As an absolute minimum we would recommend the following checks prior to plugging a home constructed card into a PC.

- Carry out a close visual inspection for shorts, solder blobs and so on.
- Use a multimeter to check that there isn't a dead short between any of the power rails and ground.
- If the board uses power rails other than +5V, apply power to the board (but not by plugging it into the PC) and check with a meter that ±12V or −5V hasn't found itself onto any of the other edge connector contacts.
- Don't plug the board into the PC power applied.

So, that's about all there is to be said. Happy interfacing and if you prototype a classic design, let the Project Editor here at ETI in on your secrets!

ETI



Vero's PC prototype adapter card

NOISE ANNOYS

Paul Chappell enters the world of allegory to check out the random racket from the real world

For some bizarre and totally implausible reason, you are standing in the street outside a cinema recording the flow of people from the exit door after a film. Counting the number of people spilling into the street every fifteen seconds, you discover that the flow of persons per unit time, or *People Current* as the Implausible Surveys Office calls it, is pretty even. Since you are also a Martian and know nothing of the behaviour of people in cinemas, you might reasonably conclude that the pressure driving the patrons from the auditorium acts on each in exactly the same way, causing an orderly flow from seat to street.

Meanwhile, back on Mars, your colleague is conducting an equally vital experiment. He is measuring the flow of electrons at the exit lead of a resistor. His meter shows a steady flow of electrons per unit time, or *current* as he prefers to call it, and he too concludes that the behaviour of the particles in his resistor must be very regular. They all, he thinks, drift in an even and orderly fashion towards the exit lead.

Returning from your cinema survey, you are able to check out your colleague's prediction about the electrons. On your travels around the Galaxy, you have obtained a pair of the coveted Quantum Specs which allow you to *see* individual subatomic particles. Looking at the resistor you find that even before any voltage is applied the electrons are already fidgeting about in their seats. When the voltage is applied, far from moving in an even fashion there's a lot of jostling about with some electrons making more progress than others, and some even moving in the wrong direction entirely.

is the result of electrons fidgeting about in the sensitive input stages of the pre-amp.

Noise, the general term for unwanted voltages and currents caused by unpredictable movements of the charge carriers, can arise in a number of ways. One is by thermal agitation: the electrons in a conductor will be in constant movement whether or not an external voltage is applied. This is called, reasonably enough, *thermal noise*, or *Johnson noise* after J. B. Johnson who published his experimental findings on the subject way back in 1928. The subject was also investigated theoretically by Nyquist, who derived a formula for the amount of noise generated by any conductor. This was also in 1928.

Other sources of noise occur whenever you ask electrons to do anything more than move along through a bulk metal. Suggest that they cross a junction, step from grain to grain in a carbon resistor, combine with a 'hole', or do anything else that they consider to be outside the terms of their contract of employment and they'll make a lot of noise about it. Essentially, the noise occurs because the processes don't happen evenly and regularly. If more electrons arrive in one picosecond than in the picosecond before, there is a current variation. Noise.

Apart from odd occasions, like ETI's Dream Machine, where producing noise is the aim of the circuit, it is almost always a nuisance. Hi-fi designers don't want their amplifiers to hiss, instrumentation designers don't want random variations of the readings, communications engineers would like the equipment at the other end of the channel to receive the information reliably. Knowing how to keep the noise down is an essential for any designer.

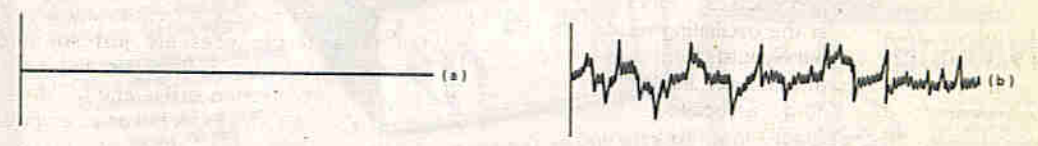


Fig. 1 (a) Desired and (b) accurate oscilloscope traces of current through a resistor

So what inferences can we draw about the behaviour of people in cinemas? My own theory, which has not yet gained wide acceptance, is that their motion is not at all regular. Some will be sprinting for the exit before the credits have begun, while others will remain gravitationally bonded to their seats to see who did the soundtrack. Some may move forward quickly, then slow down as they reach a crowded area. Others may stop altogether. Some will be jostled sideways, and others might even oppose the general flow by returning to their seats to collect something they've left behind.

My claim is that the apparent regular outflow is really the sum of a lot of pretty chaotic individual movements. I admit that I have no direct proof of this as yet but would like to propose it as a subject needing further study.

Noise

Although the chaotic movement of individual electrons won't show up on your multi-meter, the results are easy enough to see on a scope. Figure 1a shows the trace you'd hope to see in displaying the current through a resistor; on a sensitive enough setting, with the DC component cancelled out by the Y-shift control, the display might look more like Fig. 1b. If you don't have a scope, you can still experience the results of electrons doing their own thing. Turn up the volume control on your hi-fi amp when all the signal sources are off. The hiss you hear

Thermal Noise

The formula that Nyquist came up with for the thermal noise produced by a conductor was $N = kTB$ watts. The formula gives N (the average noise power from the conductor) in terms of k (Boltzmann's constant), T (the absolute temperature) and B (the bandwidth). It assumes that the conductor is matched into a lossless transmission line, which is not the usual situation!

For practical purposes, the related formula $v = \sqrt{4kTBR}$ is more useful. This gives the RMS noise voltage present in a resistance R which is open circuit. The value of k can be taken as 1.38×10^{-23} J/°K for most purposes, although your scientific calculator will probably give the value to a dozen figures! Remember that T is the *absolute* temperature — for practical calculations you can take room temperature to be about 290°K. If the resistor is not at room temperature, add 273° to the Celsius temperature.

The bandwidth is an interesting one. Notionally, a resistor on your bench is generating noise voltages from DC to as high as you like. So is everything else for that matter — thermodynamics makes no distinction between our packaged and striped resistors and everything else in the world with the property of resistance. As I type, there are random noise voltages between the various keys, across my coffee cup, between the toe of my left shoe and the back of my seat — the whole world is a huge noisy resistor!

CIRCUIT THEORY

Looking at Nyquist's formula for the available noise power, there seems no reason to suppose that the bandwidth is limited in any way and if it can be arbitrarily large then so can the available noise power from any conductor! There are echoes here of the 'ultraviolet catastrophe' — the prediction of classical physics that a black body at room temperature should be radiating lethal amounts of high frequency radiation. The similarity is not surprising, since both results are derived from very similar reasoning. Quantum mechanics put paid to the black body question and also settles the infinitely noisy resistor paradox.

The details of Nyquist's reasoning are not essential for dealing with real life circuits — the more practically inclined can skip on a bit here. For those left, here's how Nyquist came to his conclusions. He started off by imagining two resistors matched into a lossless transmission line (Fig. 2a). In this condition, the noise power from either resistor will travel along the line and be completely absorbed at the other end.

If the line is suddenly short circuited at both ends, instead of being completely absorbed, the energy is totally reflected from either end of the line, becoming trapped as standing waves. The line becomes an oscillator (Fig. 2b). (You might have the idea in the back of your mind that an oscillator is a bit like a sine wave factory — it needs a transistor or an IC to 'make' the oscillations. All the active device is doing in any sine oscillator circuit you might build is replacing the energy lost in the frequency selection network and supplying any extra oomph to drive the following circuitry. In this case there are no losses, no following circuitry, so no need for any active components!)

This type of oscillator, where all the vibrations occur in one dimension (along the length of the line) is quite easy to deal with mathematically. Classical physics gives the energy of each oscillating mode as kT and integration over the oscillating modes in a given bandwidth turns out Nyquist's formula as stated earlier. Where quantum theory differs is in the expression for the energy associated with each oscillating mode. By Planck's law, this becomes

$$\delta W = \frac{hf}{e^{hf/kt} - 1}$$

At first sight this formula is so unlike the simple $\delta W = kT$ that you'd think there could be no possible confusing of the 'right' answer with the 'wrong' one, but not so.

Try something on your calculator. Enter a number much less than one, then press the 'e^x' key. Try it with several numbers, and see if you can spot a pattern. If you entered 0.02, the result of pressing e^x will give (with an error of 0.02%), the result 1.02. Try it with any other small number and you'll see that pressing 'e^x' is almost the same as adding one to the number you first thought of. The smaller the number you enter, the more accurately this will work (try it with 0.00002, for instance). Another way of saying this is that for any x much less than one, $e^x - 1$ is almost exactly x.

Apply this to the Planck formula, and you'll see that as long as hf is much less than kT, the formula gives almost exactly the same result as $\delta W = kT$. If you don't follow the reasoning and want to try it out with the whole formula, the value of h (Planck's constant) is about 6.6×10^{-34}. Choose various values for f, the frequency, and see if you can find one that gives a significant difference between the two formulae.

As it turns out, the two formulae are in pretty good agreement (good enough for outdoor work, as they say in the music biz) up to about 10,000GHz.

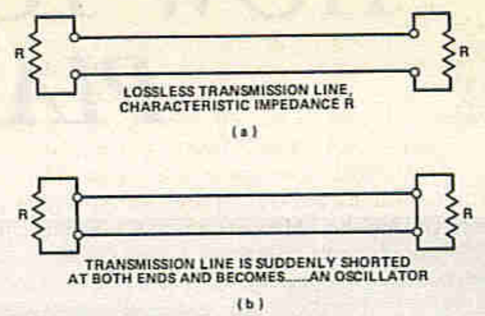


Fig. 2 (a) Resistors in transmission line (b) Line becomes an oscillator

After that they go their own separate ways, with the classical formula predicting an equal energy per unit bandwidth from here to infinity and the quantum formula predicting a tail off in noise power at higher frequencies. So we can't use noisy resistors as an alternative to nuclear power after all.

Practical Matters

So what of the resistor on your bench? It is really producing noise voltages of 10 terahertz and beyond? Here's an experiment you can try. Poke it with a pencil. What inference can you draw about its output at 4GHz? Or try this: dip it in your coffee, then flick it six inches across the bench. Exactly six inches, mind. Now what do you say about the power density between 250kHz and 10MHz?

What I'm saying, in my elliptical way, is that until the resistor becomes part of a circuit, any notions about the noise it produces are just so much theoretical fantasy. Is the resistor on the bench generating frequencies around 10 terahertz? Maybe, maybe not. The physicists say so, but as an engineer I'm not going to commit myself either way until I see what practical consequence it has.

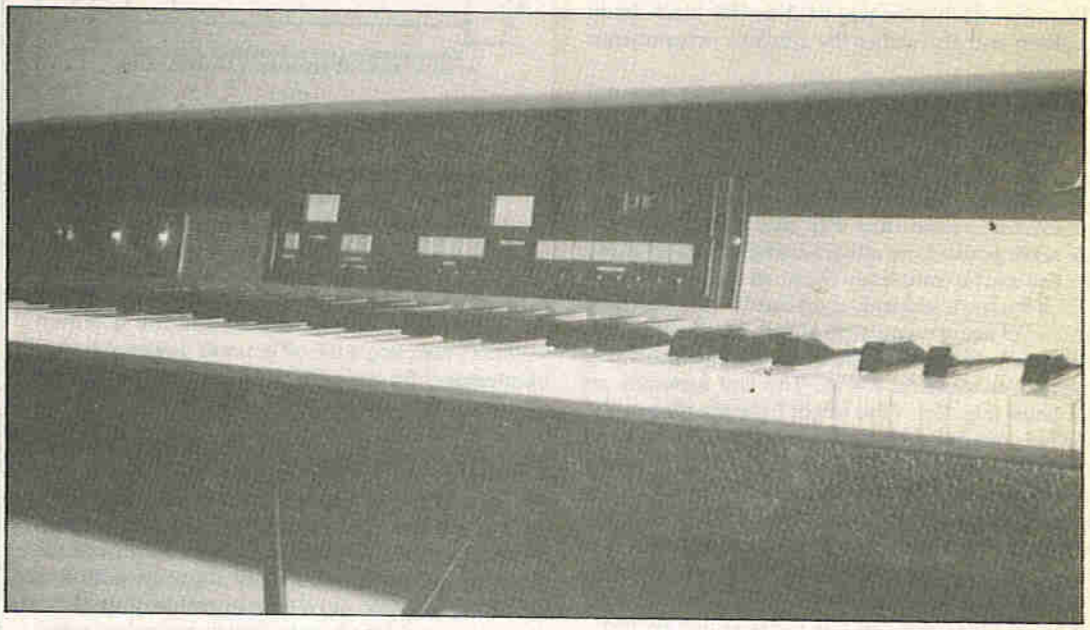
Once the resistor is connected into a circuit, whether it be as a permanent part of one of your own devising or as a temporary part of one you've bought (named oscilloscope or spectrum analyser or whatever), it's the characteristics of the circuit as a whole that count. The ETI bench scope won't hack the pace much beyond 10MHz, so I still have to take it on faith that the resistor is hissing away at frequencies above this. If I want to calculate noise voltages, currents, powers and have the results bear some relation to what I see on the screen, the bandwidth figure I have to use is that of the scope. The formula is not asking you to do something as improbable as to calculate the bandwidth of a resistor, thank goodness!

There's already one tentative (but absolutely correct) inference we can make: in any sensitive circuit, the bandwidth should be restricted to that needed by the signal. If you allow more than necessary, all you're doing is increasing the gap available for noise to make its way through. For many purposes the means of limiting the bandwidth needn't be anything more complicated than a resistor and capacitor.

Another deduction it is tempting to make is that for low noise circuits all the resistor values should be as small as possible, to limit the noise voltages they produce. Unfortunately there is no such simple rule — in some cases it turns out that some resistor values should be as high as possible! There's more to noise than meets the ear.

ETI

HOW TO MIDI A PIANO



John Brockhurst explains the key to converted keyboards

PROJECT

Over recent years there have been considerable advances in the level of technology available to the working musician. There are however still occasions when that favourite old keyboard or piano sound would still be best suited to the music but the absence of MIDI means either having no synthesiser part or working as a one handed pianist. Lack of adequate funds is a saddeningly common problem that precludes the purchase of one of the latest fully-equipped keyboards.

The project presented here is the solution to the problem. A stand-alone MIDI processor tailored to the needs of the pianist that is both inexpensive and relatively undemanding from a constructional point of view. It handles up to 88 notes — that's over seven octaves, certainly enough for any keyboards and about right for most pianos.

The unit consists of three modules: the CPU/PSU section, the control/display panel and the keyboard contact assembly. The first two will be common to all constructors. The keyboard contact arrangement however will need a certain amount of customising to whatever instrument it is fitting — obviously no single design could be presented to fit all pianos, synths and stylophones. The photographs and illustrations shown here use the example of a Fender Rhodes piano and will be helpful as a guide.

Please note that it is much easier to produce MIDI note information without the velocity information. This system does handle this velocity information but it should be noted that such a system does require a reasonable level of mechanical competance.

Much has been written in these and other pages over recent years regarding the MIDI specification and those who are unfamiliar with the techniques involved would probably benefit by reading through those ETI back issues (you do keep them don't you?). Also recommended in this respect is *The ETI Guide to Making Music* from last autumn, which also looks at the subject in some detail.

Processor Prelude

Okay so where do we start? Clearly we will need some means of recognising which keys are being played and how hard. We also need to know if the sustain pedal is being used. Realising that not all synthesisers are equipped with a sustain function, we must find a means of providing this. It would also be nice if we can select the sound that the synth produces, and provide visual indication of the selected patch and MIDI channel in use.

We then have to set up a serial link conforming to the MIDI protocol. Clearly this is a task well suited to a microprocessor and this design uses the Z80A.

Much has been said about choosing microprocessors and it is worth mentioning the reasons for choosing the Z80A for this application. Most of the time, our processor will be scanning the keyboard to see which keys are being used and how hard they are being played (how long the key depression takes). This is a repetitive task with speed being of prime concern. However, fast processors are relatively more expensive and demand the use of fast peripheral chips.

A look at the specification sheet for a typical microprocessor shows that operations completed within the chip are usually much faster than those requiring access to external devices. The Z80 has 14 internal general purpose registers available to the programmer, enabling much of the work to be completed within the CPU. It is also one of the cheapest processors currently available and would appear quite well suited to the job.

By opting for the Z80A which runs at the increased speed of 4MHz we are able to allow ourselves the luxury of adding wait states to memory cycles, relieving the speed constraints on these chips and further reducing cost.

The Z80 also automatically includes wait states in all input and output instructions, thus placing lower demands on our peripheral chips.

Having decided on our processor we will need some memory, an ACIA and some ports to communicate with the outside world. This design uses the 6850 ACIA and 8255 PPI in these positions.

Finally, we have to decide if we will use interrupt driven timing routines for the keyboard scanning or rely on software techniques. We need to know the time taken to depress a key to determine how loud a note is. To achieve this, we must examine the key at regular intervals keeping these intervals as short as possible. The interrupt technique would certainly keep the timing constant but if we are to avoid the interrupt service routine being called whilst it is still being executed, the period between interrupts must be somewhat longer than the time required by the routine and this results in a reduction in speed.

This design uses a different approach. Since the hardware will handle 88 keys, the time spent examining any key is just over one percent of the total time — if we include the other routines the processor has to cope with, this figure falls quite a lot further. By keeping the time spent processing a key which is in use as short as possible, the difference in time required to process an active key is very nearly the same as for a dormant one and makes no difference to the subjective response of the keyboard.

Construction

The first decision to be taken is how the modules are going to be fitted to the keyboard, with particular reference to the keyboard contact assembly. The processor will handle keyboards with up to 88 notes and if the recipient keyboard is longer than this it will be necessary to decide which keys are to be excluded.

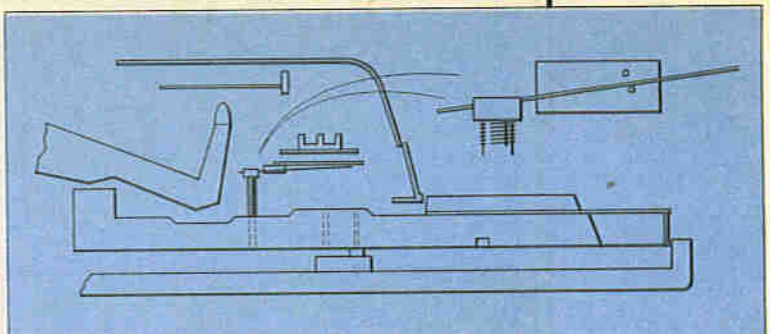
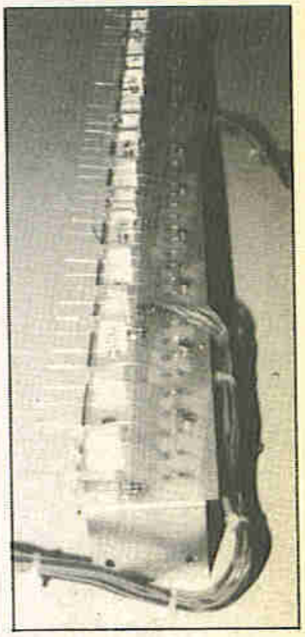


Fig. 1 Cross section of a piano showing the contact arrangment

Bear in mind that some synths or expanders only work within a limited range and either transpose or ignore notes outside these limits. A further point to consider here is that the software provided expects the lowest keyboard note to be E. Although facility is provided within the software to transpose the keyboard, if the power supply to the keyboard is interrupted the processor will default to the E setting. Any unused contacts need only be ignored, so provided there are sufficient spare positions available it would make sense for the unit to power up in tune!

Next a point must be found where there is sufficient clearance to accommodate the contact assembly. Ideally this would be either under the front of the keys, or above and behind the key pivot as in Fig. 1, at a point where the key travel is about 3 or 4mm. A layout for a keyboard PCB is provided in Fig. 2 but as the spacing between notes is not always the same from keyboard to keyboard and the errors are cumulative along the length of the instrument, it might be preferable to use stripboard. The PCB allows 164mm per octave.

The recommended contact construction (Fig. 3) uses bus-bars and contact wires since this is both



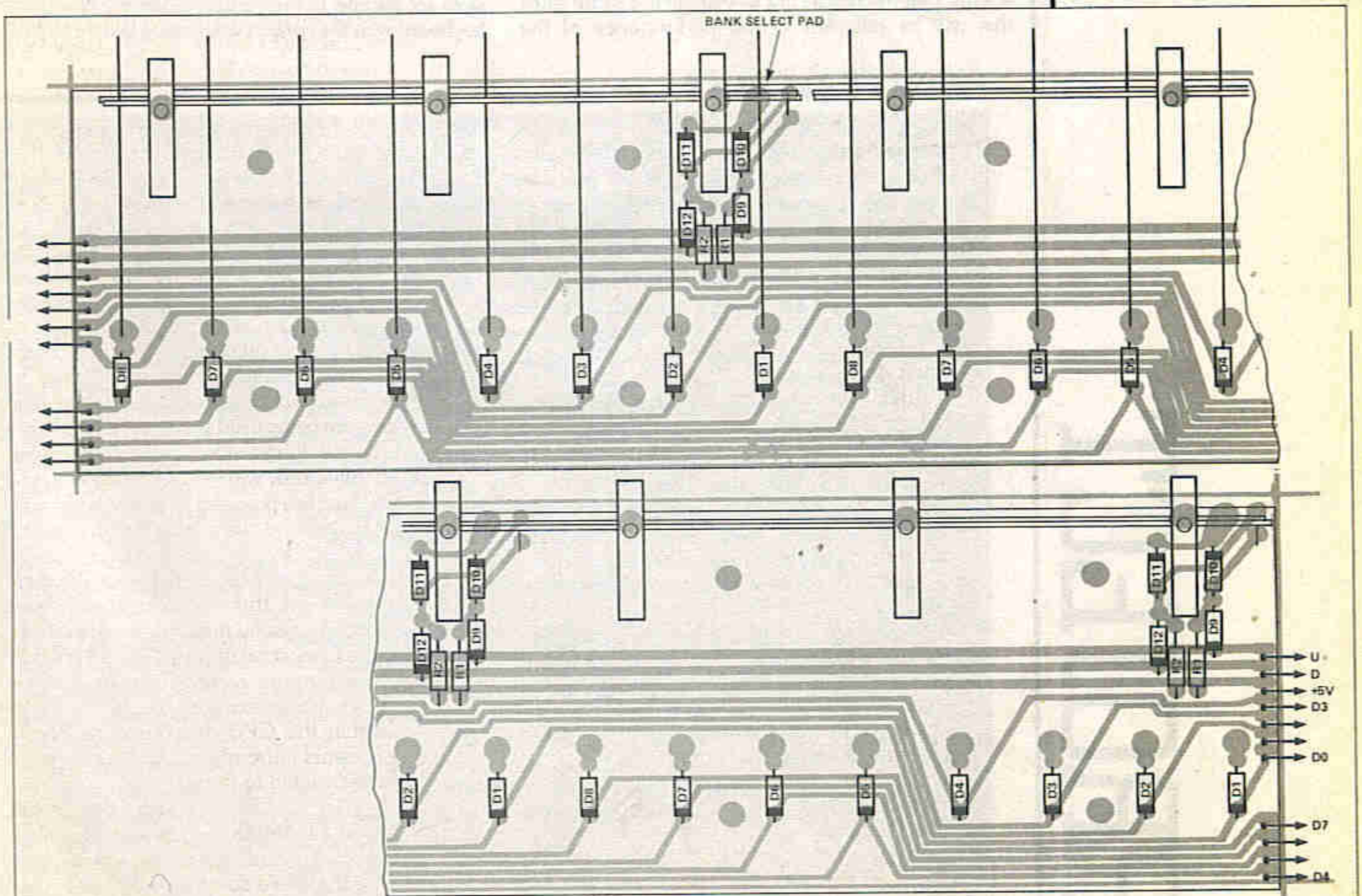


Fig. 2 Component overlay for a possible keyboard contact PCB

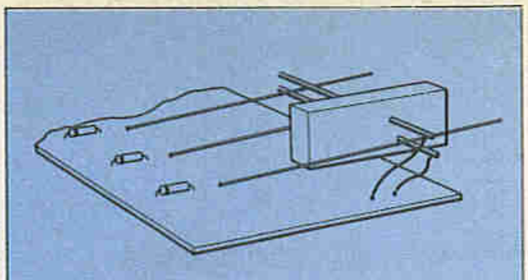


Fig. 3 Detail showing contact wire and bus-bar assembly

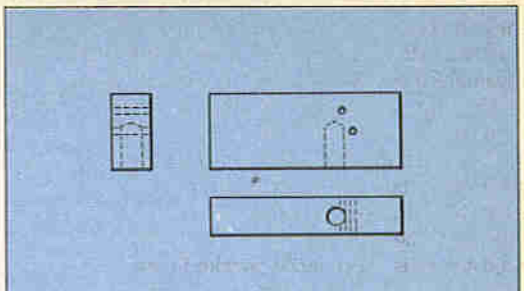


Fig. 4 Suggested design for support block

cheap and reliable and has the added advantage of being easily adjusted. However it might be possible to use single pole changeover switches provided these are not of the kind with tactile feedback (click action).

Whatever form of contact is chosen, it is important to realise that the completed contact assembly must be as rigid as possible. If the key travel is 4mm and the contact assembly moves by 2mm relative to the keys as a result of springing or vibration, then clearly most of the dynamics of the keyboard will be lost. A support brace made from extruded aluminium can be recommended here as quite substantial sections are easily obtained from the local hardware store and offer good support for minimum weight.

Assuming that you will be using bus-bars and contact wires, the bus-bars will need to be mounted in parallel with the PCB and cut to length to accommodate eight notes each. This requires that a large number of support blocks be made or purchased with a similar design to the one illustrated in Fig. 4 (three support blocks per key bank is suggested).

If these are to be made, it is strongly recommended that time is invested in designing a jig to ensure that the blocks are all exactly the same since this will be reflected in the performance of the completed unit. Such a jig need only consist of a piece of metal arranged to enable accurately positioned holes to be drilled in the support block.

The keyboard circuitry can now be assembled with the contact wires being brought out between the bus bars as shown, care being taken to check that there is sufficient spring in the wires to ensure reliable contact with the upper bus-bar when the key is at rest. Then check carefully for shorts and track continuity. The diodes can also be checked with a test meter at this stage, as once assembled within the depths of the piano these can prove time consuming to replace. Finally, the wires can be connected to the bank select pads and the keyboard bus tracks and arranged neatly to form the wiring loom.

The next stage is to fit the contact adjustment screws to the keys. These screws will probably be about 25mm long and should have a slotted head. 6BA brass cheese-head screws are recommended.

The keys should be drilled with a hole which will allow the screw to be threaded in or out of the key as required. Again, care should be taken to keep misalignment to a minimum.

The screws should be rotated until their head slots are parallel to the contact assembly fitted to the keyboard with the contact wires being laid through the

HOW IT WORKS

The Processor circuit diagram is shown in Fig. 5.

IC1a and IC1b form a crystal oscillator running at 4MHz and this is buffered by IC1c for use as the system clock. This signal is also buffered by IC1c and then divided by 8 in IC4 to provide a 500kHz clock for the ACIA IC11, where it is internally divided again by 16 to give the 31.125kHz MIDI clock.

IC3 and IC2c are used to insert *wait* states whilst the processor is accessing memory to ensure that slow devices will work without difficulty. IC2a in conjunction with C4, R5 and D5 provides a positive going reset pulse at power-up to reset the output ports IC12. This pulse is inverted by IC2b to reset the processor.

With the exception of IC6c which serves to buffer the output from IC11, all the remaining gates perform the address decoding for the processor. At first glance it might seem that IC7d does nothing but this gate is essential to meet the timing requirements for IC12.

The port outputs of IC12 are used to connect the keyboard and control panel to the processor, PA and PC being configured as outputs and PB as input. Output ports are only rated to source 1mA or sink 1.6mA and this means that the circuits connected here should have a high impedance.

Unfortunately, because of the necessarily long leads required to connect the keyboard contact assembly, this would mean both reduced noise immunity and slower rise times for the keyboard scanning signals, particularly true in the case of PC3 and PC4 which switch between the upper and lower bus-bars and see all 11 contact banks in parallel. This problem is removed by buffering these data lines and this is the purpose of Q1 and Q2. Resistors R9 and R10 in the MIDI output circuit serve to protect the unit from failure in the event of a short arising in the MIDI lead.

With reference to the circuit diagram for the control panel (Fig. 6), PC1 and PC2 are used as enable signals for latches IC2 and IC4. IC1 is a BCD to decimal decoder which is used to decode the address output by the microprocessor on PA0 to PA4 and held in IC2.

Darlington driver array IC3 provides the segment drive current sink for the displays LED1 to LED4. Q1 to Q6 provide the corresponding source currents for the display and the switch array. Diodes D1 to D8 prevent the data output bus PB being shorted in the event of more than one switch being pressed at any one time.

D6 and R16 (which are mounted on the CPU panel) and the circuit around Q7 serve to cancel the effect of capacitance in the lead connecting the sustain foot switch to the processor which, if mounted externally, will probably be several feet long. When the processor switches Q1 on via PA, the capacitance in this lead is seen in parallel with the switch and because of the high frequencies involved pulls PB7 high indicating that the switch is closed. However, Q1 also turns Q7 on via R20 taking PB7 low via R23 and D9 cancelling this effect. When the switch really is closed D6 allows Q1 to pull PB7 high and signal the processor accordingly.

In the circuit diagram of the keyboard contact assembly (Fig. 7), the key contacts are arranged in groups of eight and read into the processor via PB.

The circuit comprising D1 to D12 is repeated every eight notes as many times as necessary to cover the length of the keyboard. As we are examining up to 88 notes in groups of eight, we could have 22 bus-bars. To avoid the expense of another port these busses are diode AND gated onto PB. In order for a key to pull the data bus PB high we need simultaneous logic high signals on both on the bank select line PA1-7 or PC5-7 and on U or D which decide whether the key is being tested to be in the upper or lower rest state, allowing the bus to be pulled high by R1 or R2. Any key which does not pull the bus high is deemed to be in use, but as unused positions never reach a high level false MIDI triggering can not occur.

slots of the screw heads ensuring precise control of the contact both vertically and laterally. A piece of thin stiff wire with a small hook formed in the end can be invaluable here to lift the contact wires in or out of the slot in the screw head whilst the screw is being adjusted.

A correctly adjusted contact wire should leave the upper bus-bar when the key is about 15% depressed and should make contact with the lower bus-bar as the key nears the end of its travel. This final adjustment is most easily checked when the unit is fully assembled using a synth sound with a short attack and decay envelope as the contact points can then be accurately assessed.

The effect of any dimensional errors in the bus-bar support blocks will by now be apparent and any unacceptable errors can be rectified. When you are quite sure that the contacts are correctly adjusted, a small application of contact adhesive to the screw head will ensure that the wire does not come adrift.

The processor and power supply are assembled on a double sided PCB (Fig. 8). There are several links between the upper and lower PCB tracks and these will need to be fitted first. Some of these links are

PROJECT

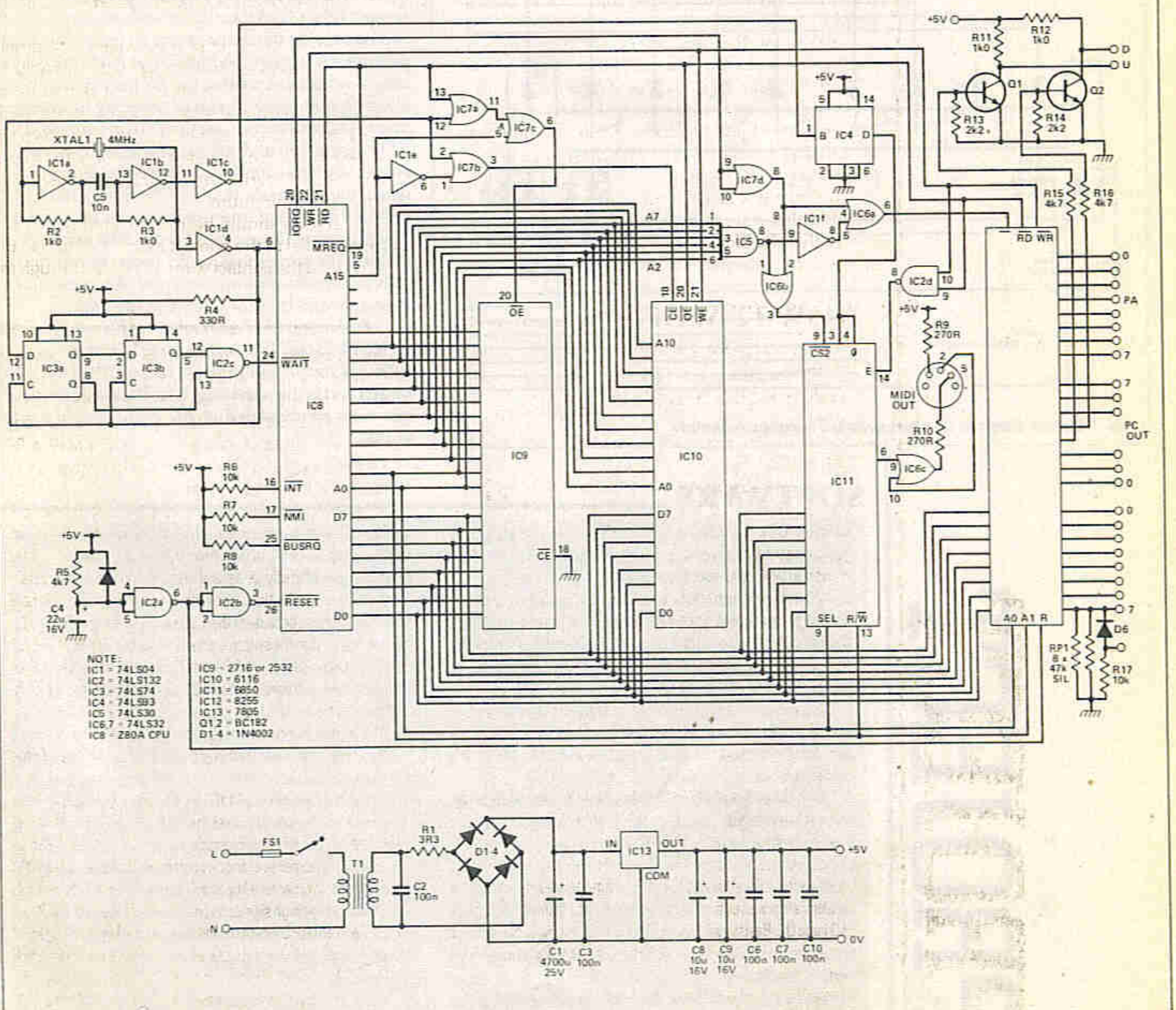


Fig. 5 Circuit diagram for the processor

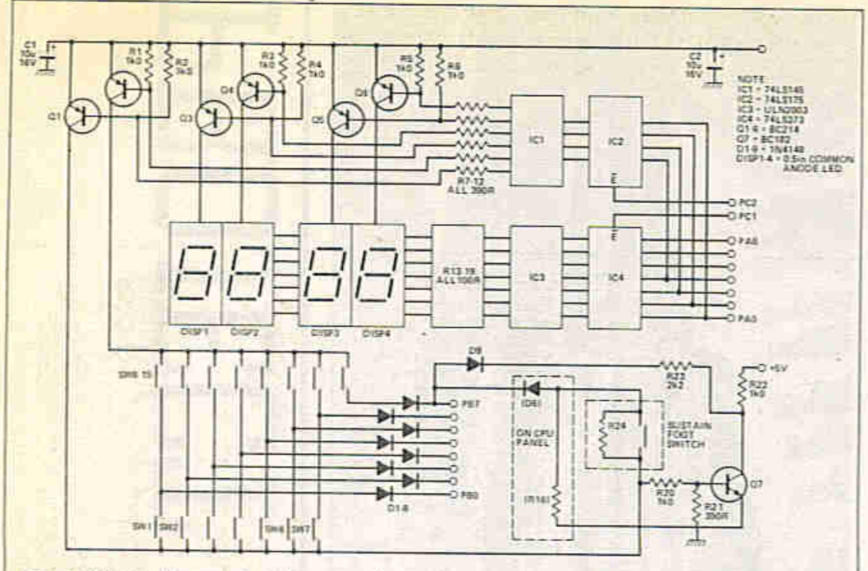


Fig. 6 Circuit diagram for the control panel

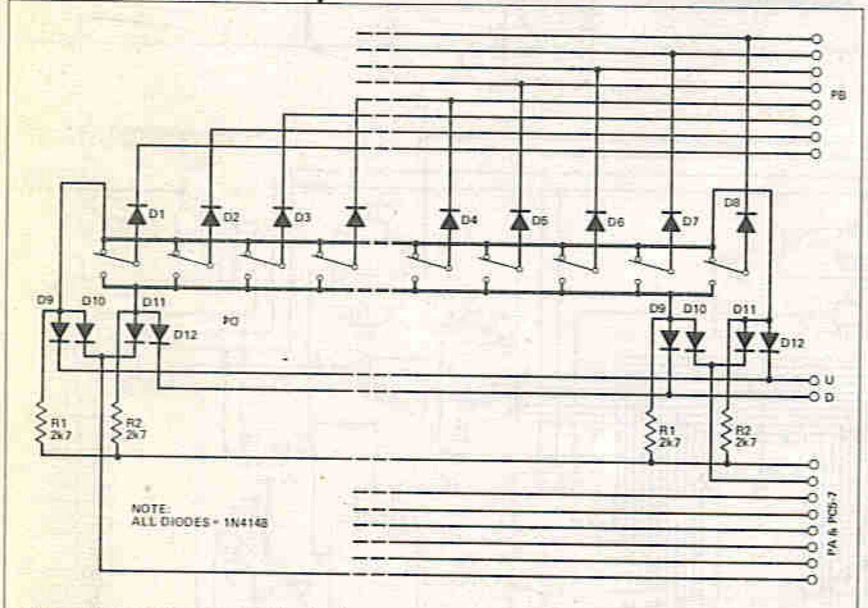


Fig. 7 Circuit diagram for the keyboard contact assembly

beneath IC sockets and it is well worth a second check to be quite sure that all of these links have been soldered correctly.

Next fit the diodes and capacitors (observing polarity), resistors, transistors, IC sockets, connectors and power supply components. The regulator should be mounted on a small heatsink but it does not lead a hard life and will not need heatsink compound.

The board can now be powered up after checking for shorts to ensure that the power supply is giving +5V and that this is present at the respective pins of the IC sockets. If all is well, disconnect and discharge the power supply using a suitable resistor and fit the crystal and the TTL ICs. Care should be taken when fitting the crystal as the wires can short to the case if they are bent too close to the body. (This would not be good practice in any case).

Testing

Next if you have access to an oscilloscope, there is an easy way to check the operation of the microprocessor. Push short lengths of fine tinned copper wire into pins 9 to 17 of the EPROM socket and join them all together, temporarily shorting D0-D7 to ground.

Now fit the processor observing static precautions. When the unit is powered up the processor will sequentially count through its address range and this can be seen on the scope giving an indication that the processor is working. Address lines A0 to A6 will have refresh addresses present but A7 to A15 should have clean square wave signals of reducing frequency on them. This works because the Z80 op code &00 is the NOP instruction and tells the processor to do nothing. As the data bus has been shorted to ground by the wires, the processor reads NOPs from what it thinks is the EPROM and interprets these as program data. The processor thus scans its entire 64K memory map looking for something to do (poor thing) and this activity is easily seen on the scope. Any problems can be diagnosed far more easily at this stage.

Assuming all is well, remove the wires from the EPROM socket (observing static precautions as the EPROM socket is connected to the CPU by the PCB tracks) and fit the remaining ICs. The completed panel can now be mounted in the piano ready for final testing.

SOFTWARE

A hexadecimal listing of the software for the unit is given in Listing 1. Operation of the keyboard supported by this code is as follows:

On power up, the unit defaults to operation on MIDI channel 1 with the selected synth patch as bank 1 program 1. This will be indicated on the display. At this time, the default tuning for the keyboard is that the lowest note will be E (middle C is the 33rd note on the keyboard).

Pressing SW2 or SW3 will advance or lower the MIDI channel and this will be displayed on LED1 and LED2.

Program selection on the active channel is provided by switches, SW4 to SW15, giving access to the first 32 patch memories of the synthesiser being used. These are arranged as four banks of eight, the last selected sound being displayed on LED3 and LED4.

If the MIDI channel is changed whilst the keyboard is being played, any notes which are in use will be turned off to prevent these notes latching on. Notes are not turned off when the program is changed.

When the channel is changed, the program selection is stored and recalled when the channel is next selected. Pressing SW1 toggles between MIDI modes 1 and 3 (OMNI on POLY and OMNI off POLY) and corresponding MIDI messages are sent on all 16 channels. This enables all instruments to be played either individually or coupled together. In mode 1, selection of a program will be accepted by all active instruments capable of receiving program change data although the keyboard will still be transmitting on the displayed channel. The unit does not update its memory for other channels as this greatly speeds access to sounds when returning to mode 3.

SW1 has a second function. When pressed simultaneously with SW4 the processor will scan the keyboard and assign the first key press it encounters to be middle C. Whilst it is primarily intended that this transpose function should enable the synth to be in the same key as the piano, thickening effects can be obtained when transposing by an octave or a fifth. Since the software suppresses 'illegal' notes, the range of tuning is limited only by the receiving synthesiser.

To enable maximum compatability with other equipment, the software does not use 'running status', and sends genuine note off messages. Active sensing is not used.

Finally, a word about sustain. Many expanders do not have a sustain function, whilst some manufacturers use a dedicated MIDI code to access sustain routies provided within their equipment. To gain the best of both worlds, the software emulates the sustain function by not turning notes off until either the pedal is released or the key is re-struck. Sustain will therefore be provided up to the polyphonic limit of the synth being used, and thereafter will be dependant on the synth's own operating system.

Assembly of the control panel (Fig. 9) should present few problems. Care should be taken to avoid overheating the push switches when soldering them in as the plastic supporting the leads melts easily. Otherwise, apart from observing correct orientation of components and careful checking for shorts, this should be a routine operation.

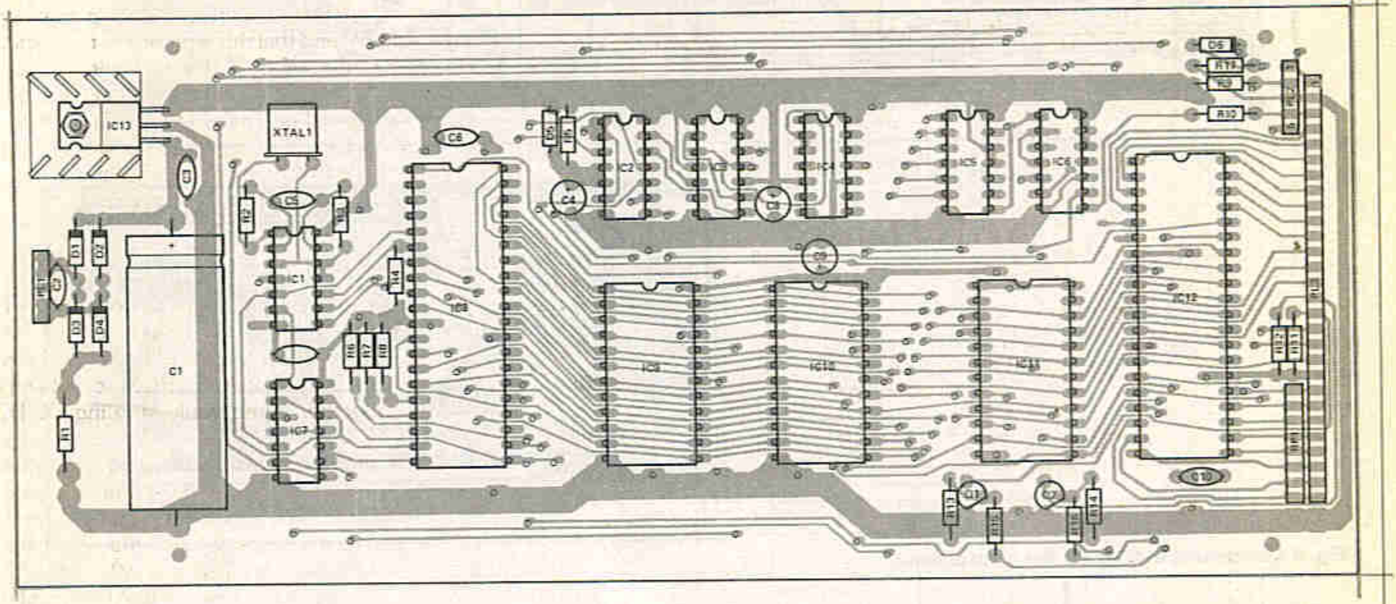


Fig. 8 Component overlay for the processor and power supply

```
0000      C3 A0 00 00 00 00 00 00 D9 68 26 81 77 14 04 D9
0010      C9 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0020      32 F6 80 CD F4 80 C9 00 00 00 00 00 00 00 00 00
0030      00 00 00 00 00 00 00 00 DB FE CB 4F 28 0F D9 7A
0040      FE 00 28 08 26 81 69 7E D3 FD 0C 15 D9 C9 01 08
0050      10 02 08 10 04 08 10 08 08 10 10 08 10 20 08 10
0060      40 08 10 80 08 10 00 88 90 00 48 50 00 28 30 00
0070      3F 06 5B 4F 66 6D 7C 07 7F 67 00 00 00 00 00 00
0080      00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00 00
0090      00 00 00 00 FD 7E 00 C9 DD 7E 00 C9 DD 77 00 C9
00A0      3E 82 D3 03 3E 03 D3 FC 3E 15 D3 FC 31 FF 87 21
00B0      00 80 0E 07 06 FF 36 00 23 10 FB 0D 20 F8 06 58
00C0      21 00 80 36 1F 23 10 FB 01 18 00 11 E8 80 21 88
00D0      00 ED B0 D9 06 00 48 50 D9 CD 62 02 00 00 00 00
00E0      CD 00 01 FF FD 21 E0 07 CD 41 01 CD FE 01 FF CD
00F0      2D 02 CD 99 02 18 E9 00 00 00 00 00 00 00 00 00
0100      21 57 80 11 4E 00 06 0B 1A D3 00 1C 1A D3 02 13
0110      1A 2C 71 08 00 DB 01 4F DB 01 B9 20 FA FE FF 28
0120      16 08 D3 02 13 1A 2C 71 08 00 DB 01 4F DB 01 B9
0130      20 FA 08 10 D4 71 C9 2C 71 08 1C 1A 4A 10 CA 71
0140      C9 21 00 80 11 59 80 0E 01 06 58 1A A1 28 11 CB
0150      76 20 29 36 1F 2C CB 01 30 03 FF 1C 1C 10 EC C9
0160      1C 1A 1D A1 28 28 CB 76 20 07 CD B1 01 CB F6 18
0170      E4 CB 7E 28 E0 CD D0 01 CB BE 18 EE 3A 79 80 E6
0180      80 28 07 CD D0 01 36 1F 18 CB 36 DF 18 C7 CB 7E
0190      28 0E 3A 79 80 E6 80 28 07 CD D0 01 7E E6 1F 77
01A0      7E D9 67 E6 C0 6F 7C E6 1F 28 01 3D B5 D9 77 18
01B0      A4 C5 D5 3E 58 90 47 3A E8 80 80 CB 7F 20 0E 4F
01C0      3A F0 80 F6 90 CF 79 CF 7E E6 1F E7 CF D1 C1 C9
01D0      C5 3E 58 90 47 3A E8 80 80 CB 7F 20 0B 4F 3A F0
01E0      80 F6 80 CF 79 CF AF CF C1 C9 21 00 80 06 58 CB
01F0      76 28 07 CD D0 01 7E E6 1F 77 2C 10 F1 C9 3E 01
0200      D3 00 3E 1C D3 02 3E 18 D3 02 DB 01 4F DB 01 B9
0210      20 FA 32 79 80 3E 02 D3 00 3E 1C D3 02 3E 18 D3
0220      02 DB 01 4F DB 01 B9 20 FA 32 77 80 C9 DD 21 7C
0230      80 3E 1A D3 02 AF D3 00 3E 18 D3 02 3A 74 80 32
0240      FA 80 C6 03 D3 00 D6 02 E6 03 32 74 80 3E 1C D3
0250      02 AF D3 00 3E 1A D3 02 CD F8 80 D3 00 3E 18 D3
0260      02 C9 C5 D5 E5 FD 21 70 00 21 7C 80 11 F0 80 1A
0270      FE 09 30 08 36 00 23 3C E7 77 18 07 36 06 23 D6
0280      09 E7 77 13 23 1A E6 18 0F 0F 0F 3C E7 77 23 1A
0290      E6 07 3C E7 77 E1 D1 C1 C9 21 79 80 7E E6 7F 2B
02A0      46 77 B8 C5 D5 E5 C4 CA 02 E1 D1 C1 2B 7E 2B 46
02B0      77 B8 C8 D8 06 FF 04 1F 30 FC 3A F1 80 E6 18 B0
02C0      32 F1 80 CD 62 02 CD 82 03 C9 4F 90 30 0E 3A 7A
02D0      80 FE 01 C0 CD CC 03 AF 32 7A 80 C9 3E 01 B9 20
02E0      04 32 7A 80 C9 3C 32 7A 80 CB 41 20 3F CB 49 C4
02F0      30 03 CB 51 C4 59 03 CB 59 28 05 06 00 CD 1C 03
0300      CB 61 28 05 06 08 CD 1C 03 CB 69 28 05 06 10 CD
0310      1C 03 CB 71 28 05 06 18 CD 1C 03 C9 3A F1 80 E6
0320      07 B0 32 F1 80 CD 62 02 CD 82 03 C9 CD 97 03 C9
0330      DD 21 D8 80 3A F0 80 FE 0F C8 57 32 FE 80 3A F1
0340      80 CD FC 80 CD EA 01 7A 3C 32 F0 80 32 FA 80 CD
0350      F8 80 32 F1 80 CD 62 02 C9 DD 21 D8 80 3A F0 80
0360      FE 00 C8 57 32 FE 80 3A F1 80 CD FC 80 CD EA 01
0370      7A 3D 32 F0 80 32 FA 80 CD F8 80 32 F1 80 CD 62
0380      02 C9 DD 21 D8 80 3A F0 80 32 FE 80 F6 C0 CF 3A
0390      F1 80 CD FC 80 CF C9 C5 CD EA 01 CD A9 03 47 3E
03A0      3C 3D 10 FD 32 E8 80 C1 C9 CD 00 01 21 5A 80 0E
03B0      01 06 58 7E A1 20 0E CB 01 30 02 2C 2C 10 F4 CD
03C0      2D 02 FF 18 E4 3E 58 90 6F 36 00 C9 3A 7B 80 FE
03D0      00 20 0B 16 7C CD E8 03 3E FF 32 7B 80 C9 16 7D
03E0      CD E8 03 AF 32 7B 80 C9 06 10 78 3D F6 B0 CF 7A
03F0      CF AF CF 10 F5 C9 00 00 00 00 00 00 00 00 00 00

0400-07D0 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

07E0      01 02 03 04 05 06 07 08 09 0A 0B 0C 0E 10 12 14
07F0      16 18 1A 1D 20 24 28 2D 33 3B 46 53 60 6D 7F 7F
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Listing 1 Hex dump for the CPU EPROM

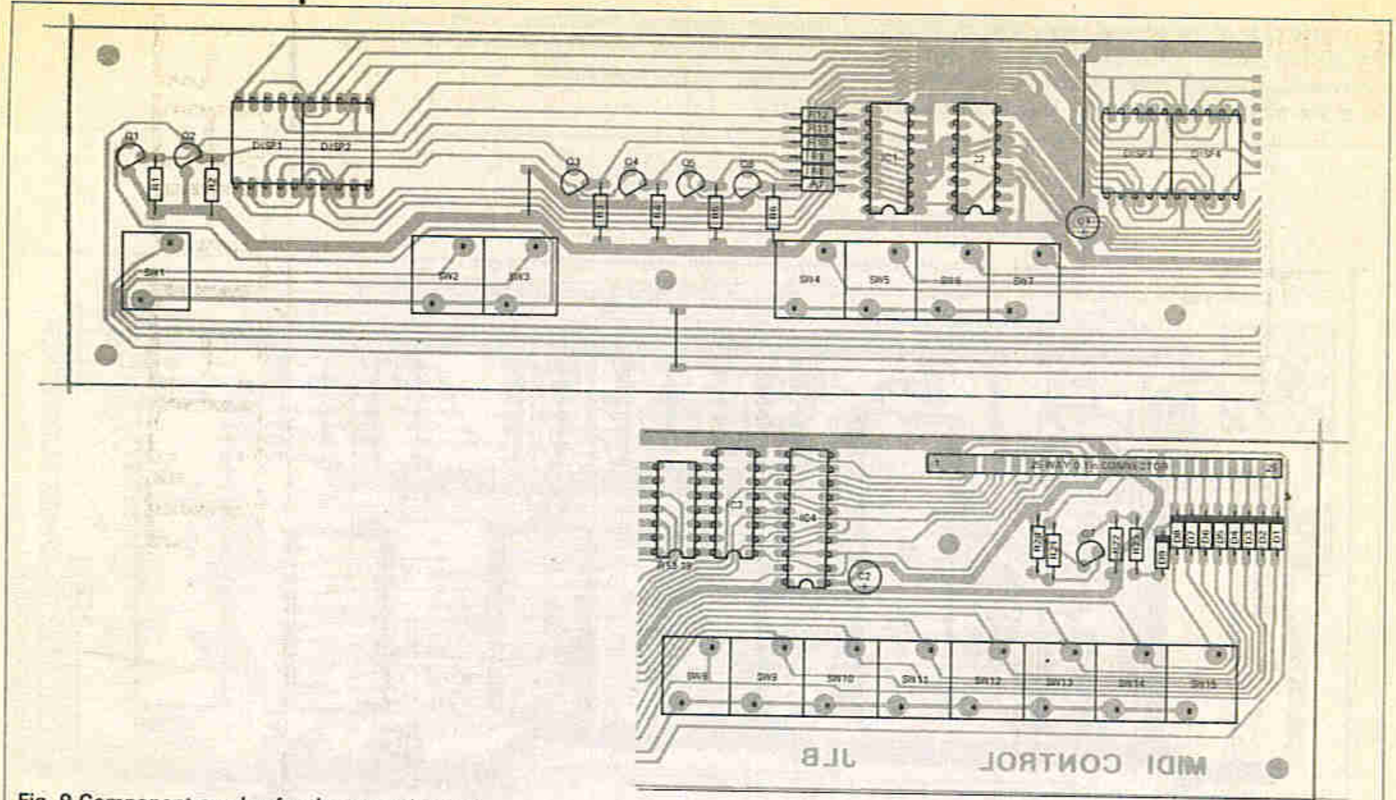


Fig. 9 Component overlay for the control panel

PARTS LIST

CPU

RESISTORS (all ¼W 5% unless specified)

R1	3R3 2.5W w/w
R2,3,11,12	1k0
R4	330R
R5,15,16	4k7
R6-8,17	10k
R9,10	270R
R13,14	2k2
RP1	8×47k SIL network

CAPACITORS

C1	4700µ 25V
C2,3,6,7,10,11	100n
C4	22µ 16V tantalum
C5	10n
C8,9	10µ 16V tantalum

SEMICONDUCTORS

IC1	74LS04
IC2	74LS132
IC3	74LS74
IC4	74LS93
IC5	74LS30
IC6,7	74LS32
IC8	Z80A CPU
IC9	2716 or 2532
IC10	6116
IC11	6850
IC12	8255
IC13	7805
Q1,2	BC182 or similar
D1-4	1N4002

MISCELLANEOUS

PL1,2	5-way 0.1in connector
PL3	30-way 0.1in connector
T1	9V 1A transformer
XTAL1	4MHz crystal

PCB. Heatsink (21°C/W). Wire. PCB pins.

Control Panel

RESISTORS (All ¼W 5%)

R1-6,20,22	1k0
R7-12,21	390R
R13-19	100R
R23	2k2

CAPACITORS

C1,2	10µ 16V tantalum
C3	220µ 16V tantalum

SEMICONDUCTORS

IC1	74LS145
IC2	74LS175
IC3	ULN2003
IC4	74LS373
Q1-6	BC214
Q7	BC182
D1-9	1N4148
DISP1-4	0.5in common anode LED

MISCELLANEOUS

CONN1	optional 25-way 0.1in connector
WS1-15	SPST (see Buylines)

PCB. Wires. Mounting screws.

Keyboard Assembly

RESISTORS (¼W 5%)

All	2k7

SEMICONDUCTORS

All diodes	1N4148

PCB or stripboard. Adjustment screws. Wires. Bus bars and support blocks (see text).

INTERCONNECTIONS

Since the positioning of the modules for this project will largely be determined by the keyboard to which they are to be fitted, it is not possible to give concise details of the interconnecting loom. Instead, here are the wiring details in tabular form.

If the connecting wires between the CPU panel and the control panel are more than about six inches long, it is recommended that C3 (220μ 16V) is fitted to (or close to) the rear of the control panel with the case connected to pins 1-3 and the positive terminal connected to pins 15-16.

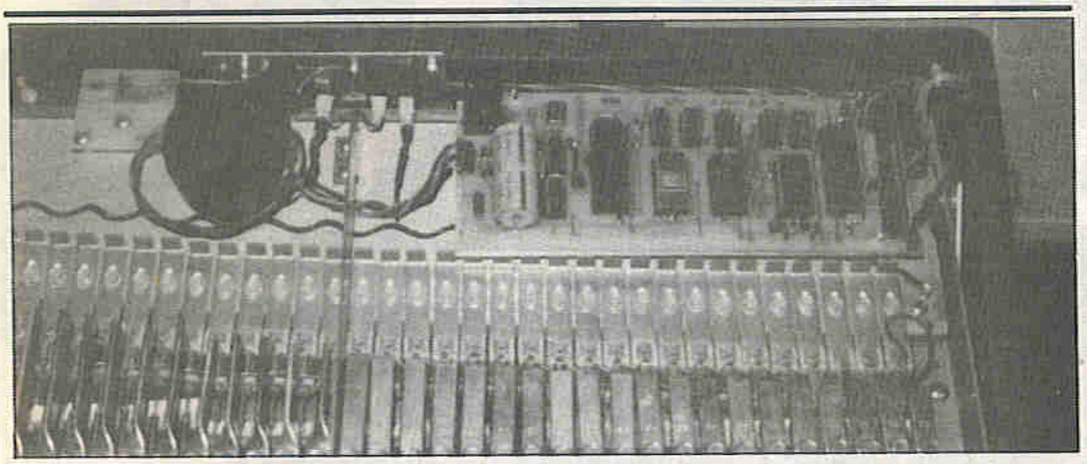
Note: This table shows the data and address wiring for the control panel coming via the keyboard contact assembly. In some cases it may be preferable to re-route these wires directly to the CPU panel if this will give shorter or tidier wiring.

The connections to the 5-pin connector PL2 are as follows:

1 Footswitch screen
2 MIDI +ve to pin 4 or MIDI socket
3 MIDI ground to pin 2 of MIDI socket
4 MIDI output to pin 5 of MIDI socket
5 Footswitch inner.

CPU Connector Pin Number.	Control Panel Connector Pin Number.	ContactAssembly Connection Point.
1 Wired to	17	
2 Not used		
3 Not used		
4 Wired to		Bank select pad 1
5 Wired to		Bank select pad 2
6 Wired to		Bank select pad 3
7 Wired to		Bank select pad 4
8 Wired to		Bank select pad 5
9 Wired to		Bank select pad 6
10 Wired to		Bank select pad 7
11 Wired to		Bank select pad 8
12 Wired to		Bank select pad 9
13 Wired to		Bank select pad 10
14 Wired to		Bank select pad 11
15 Wired to		Keyboard U bus
16 Wired to		Keyboard D Bus
17 Wired to	11	
18 Wired to	12	
19 Not used		
20 Wired to	15	
21 Wired to		Keyboard D7 line
22 Wired to		Keyboard D6 line
23 Wired to		Keyboard D5 line
24 Wired to		Keyboard D4 line
25 Wired to		Keyboard D3 line
26 Wired to		Keyboard D2 line

CPU Connector Pin Number.	Control Panel Connector Pin Number.	ContactAssembly Connection Point.
27 Wired to		Keyboard D1 line
28 Wired to		Keyboard D0 line
29 Wired to	1	
30 Wired to	2	
	1,2	(already connected)
	3 Not used	
	4 Wired to	Bank select pad 7
	5 Wired to	Bank select pad 6
	6 Wired to	Bank select pad 5
	7 Wired to	Bank select pad 4
	8 Wired to	Bank select pad 3
	9 Wired to	Bank select pad 2
	10 Wired to	Bank select pad 1
	11,12	(already connected)
	13,14	Not used
	15	(already connected)
	16 Wired to	Keyboard +5V line
	17	(already connected)
	18 Wired to	Keyboard D7 line
	19 Wired to	Keyboard D6 line
	20 Wired to	Keyboard D5 line
	21 Wired to	Keyboard D4 line
	22 Wired to	Keyboard D3 line
	23 Wired to	Keyboard D2 line
	24 Wired to	Keyboard D1 line
	25 Wired to	Keyboard D0 line



BUYLINES

Most of the components are available from Maplin and other major suppliers. The ACIA 6850 is available from Farnell (tel: (0532) 636311) or Trilogic (tel: (0274) 684289). The control panel IC3 (ULN2003) is available from Electromail (tel: (0536) 204555).

The author has a small quantity of keyboard materials and, subject to availability, can supply gold plated contact wire at £2.75/metre and keyboard bus bar (about 0.9m long) at £1.50 each.

The author can also supply pre-programmed EPROMs at £15.00. Contact J. Brockhurst, 57 Berwick Road, Rainham, Essex RM13 3XQ.

Two alternative versions of the software are available. The first is a cut-down version allowing operation of the unit without the control panel, supplied with details of the small hardware modification necessary. The second is an enhanced version allowing simultaneous operation on two MIDI channels with selectable cutoff points and keyboard response. This permits layered sounds and velocity crossfading, plus control via MIDI of volume and channel selective MIDI mode.

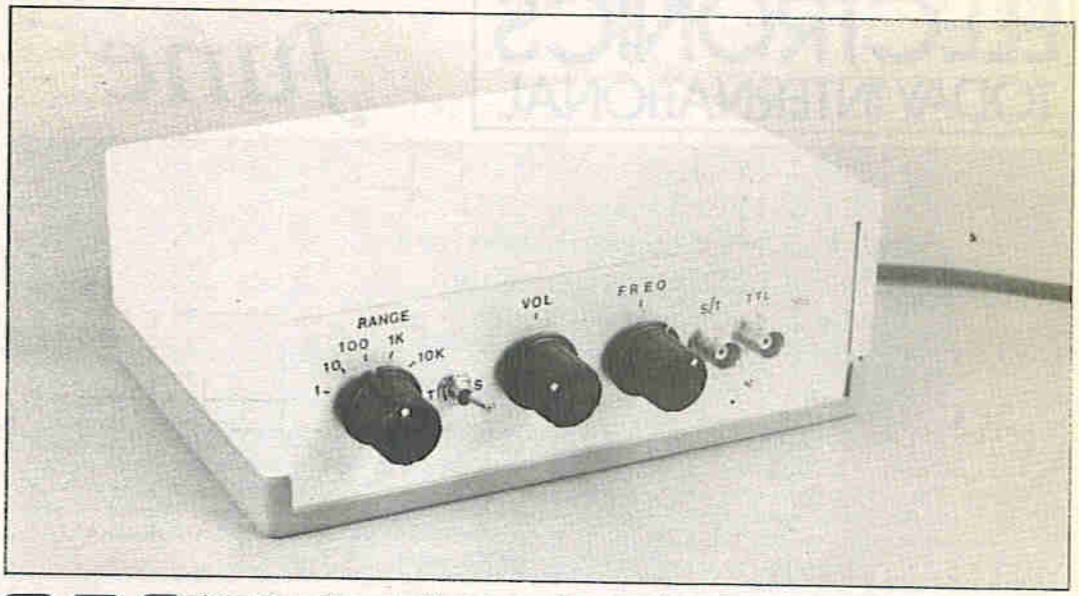
Both alternative versions cost £20 and include software routines and system variable lists.

The moulded plastic cover for the control panel (see photographs) is available from the author for £17.50 including the printed label.

AF SIGNAL GENERATOR

David Silvester describes a simple signal generator to adorn your workbench

PROJECT



Working alongside an oscilloscope, an AF signal generator is an invaluable tool but unlike the scope it is easy for the hobbyist to construct. The unit to be described uses a dedicated signal source chip along with a few other components to give an instrument having sine, triangular and TTL compatible square wave outputs with frequencies from 1Hz to 100kHz. The sine wave is for normal amplifier testing with an oscilloscope whilst the triangular waveform is well suited to crossover distortion testing in class B amplifiers as the slightest bend in the linear rise or fall shows up distinctly. The square wave output was made TTL compatible for logic experimentation.

A frequency range of 10-100000Hz was chosen although the frequency range of the ICL8083 waveform generator IC used in the project extends from 0.0001Hz to 300kHz with output voltages related to the supply voltage. The sine wave output signal is derived from the triangular waveform by the use of a non-linear circuit within the IC and consequently the sine wave output is more distorted than the output of a pure sine wave generator such as the Wein Bridge oscillator. Although this distortion can be reduced to about 0.5% using the external adjustment potentiometers the remaining distortion appears as a lack of curvature on the sine wave peaks.

This distortion is too high to enable this signal generator to be used for audio power amplifier distortion testing but as it is most likely that the constructor will require a signal source for amplifier repairs the small amount of distortion produced by the signal generator can be ignored.

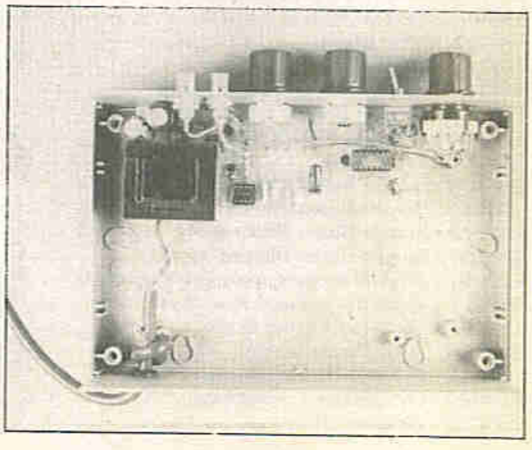
The whole signal source and power supply is built on a single sided PCB making the project extremely easy to construct and test.

Construction

All of the components are mounted on the single PCB shown in Fig. 2. The two IC sockets are optional but if used they should be mounted first to aid in the location of the other components. In either case, do not insert the ICs at this stage. Construction may then proceed as chosen by the constructor but note that the transformer must be attached last as it covers part of the power supply section of the circuit (the rectifier and regulators cannot be installed after the transformer).

The two potentiometers should have their leads bent to lower the potentiometer body towards the board and to ensure that the mounting nuts are beyond the board edge. For reasons of safety it is suggested that the mains live tracks on the PCB be covered with a section of tape.

The front panel of the case should be drilled next to accept the switches, potentiometers and output sockets. Both front and rear aluminium panels can be removed from the case for drilling. The PCB fixes to the front panel by the potentiometer nuts. The rear case panel is drilled with a single hole for the mains input cable and its grommet. To prevent strain on the potentiometer leads two screws are placed in the back of the PCB and each has two nuts, one on either side of the board to control the screw length. During final assembly the screw heads are stuck to the bottom of the case and the nuts locked in a position to take the strain of the weight of the transformer.



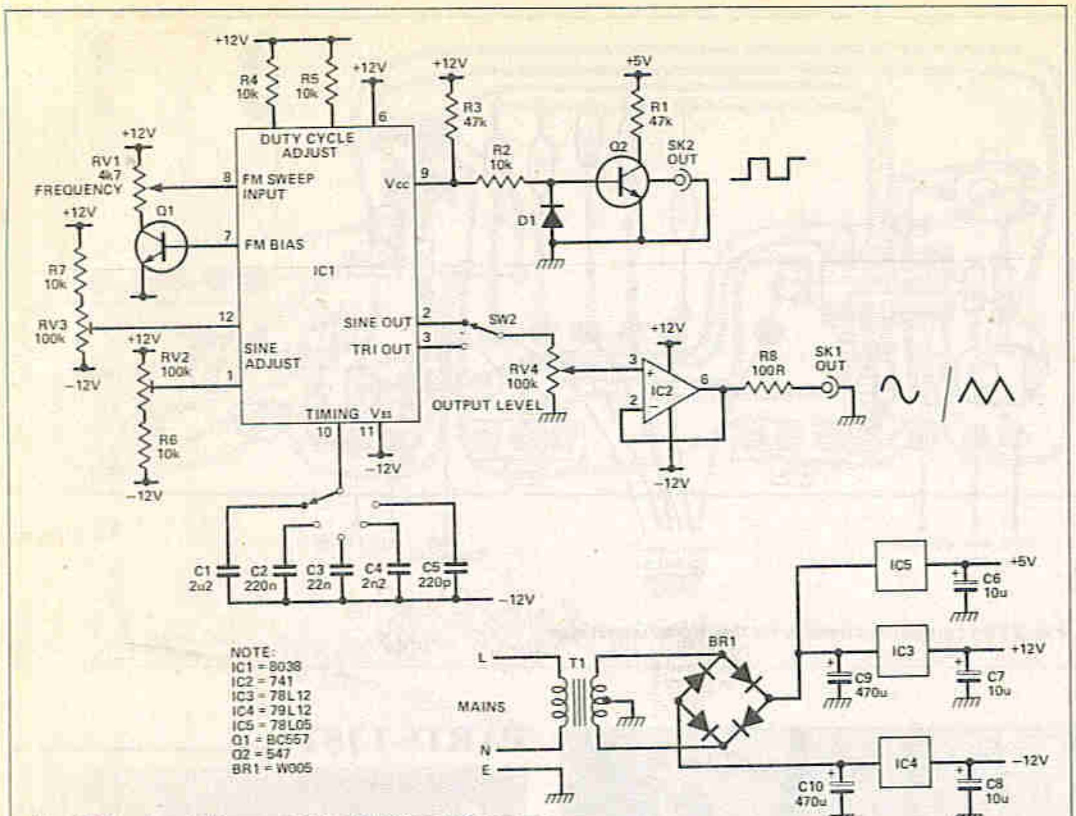


Fig. 1 The circuit diagram of the AF Signal Generator

HOW IT WORKS

Fig. 1 shows the full circuit diagram of the signal generator. IC1 is the ICL8083 waveform generator chip that is the heart of the whole unit and it produces the basic three waveforms in the following manner. One of the external capacitors C1 to C5, is selected by SW1 and connected to pin 10 of IC1 is charged and discharged by two current sources with charge and discharge currents selected by the resistors R4 and R5. During the charge cycle the voltage across the capacitor increases linearly with time — it falls linearly with time during the discharge due to the constant current sources used. In addition, two voltage comparators monitor the voltage across the capacitor and switch from charge to discharge at ⅔ supply voltage and from discharge to charge at ⅓ supply voltage.

The voltage across the capacitor is a triangular waveform with equal rise and fall times if R4 and R5 are of the same value, as they are in this project. The voltage is sent via a buffer amplifier to the triangular waveform output pin 3. There is no reason why the charge and discharge resistors need to have the same value — the charge and discharge currents and consequently the slopes of the triangular waveform can be made different. Thus the waveform generator can be used to produce sawtooth waveforms with varying rise and fall times.

In addition to the resistors R4 and R5 which set the basic range for the constant current generators a second voltage is put on pin 8 of the ICL8083 to vary the current generators and to fine tune the oscillation frequency. In simple fixed frequency operation a reference voltage available on pin 7 is linked directly to pin 8.

In this project the reference voltage on pin 7 drives a potentiometer via an emitter follower as the drive from the IC is insufficient for the pot chosen. The voltage at the slider of the pot varies from 0.6V above the reference to the positive supply voltage. This varying voltage gives the 10:1 tuning range needed to cover the steps given by the selection of the range capacitors.

The switching of the two current sources gives a useful signal to produce the square wave output. However the IC output is an open collector transistor and needs a resistor connected between IC1 pin 9 and one of the positive supplies. The output voltage will vary between the lowest supply voltage −12V to the voltage of the positive power supply (+12V as was used in this case). Although we can directly connect the resistor from the IC to the 5V supply the output would then go from +5 to −12V not the 0 to 5V needed for TTL compatability. R1, R2, R3, D1, D2 along with the 5V supply rail are used to provide level shifting to give the TTL output. Diode D1 and the current limiting resistor R2 protect the transistor when the output of the IC on pin 9 falls to −12V since by conducting it will hold the base at only −0.6V with respect to ground, whilst damage to the transistor will not occur until the base-emitter voltage exceeds −5V.

The sine wave signal is derived from the triangular wave output and the circuit includes R6, R7, RV2 and RV3 to allow alterations to the non-linear elements in the IC to reduce the distortion to the lowest value possible. An oscilloscope is an asset in setting up the sine distortion potentiometers and with the completed signal generator makes a highly efficient fault diagnosis setup. However if a scope is not available, the two potentiometers may be set to their mid point with only a small residual distortion being left on the sine wave.

The sine or triangle wave output is selected to SW2 but as the output is around 1kO at the sine output pin, a 100k potentiometer needs to be used as a 'volume' control so the circuit is not unduly loaded. This is followed by IC2 a unity gain buffer with high input impedence. The 100R resistor R8 connected between the output of IC2 and the output socket is to provide some protection against accidentally shorting the output to ground.

Switch SW1 selects a range of capacitors from 2μ2 to 220p to provide the five decade ranges normally needed although an extra range of 1 to 100Hz was included in the prototype. The linearly varying voltage from RV1 produces a linear frequency change from all of the output waveforms. With the system shown all of the decade ranges can be covered in full with some overlap to allow output for component tolerances.

The power supply unit uses standard 78L and 79L integrated circuit regulators. The mains input is converted to 15-0-15 volts by the transformer T1, rectified by the bridge BR1 and smoothed by capacitors C9 and C10. The regulator chips are fed from these capacitors and give the outputs of +12V, +5V and −12V being followed by further capacitors C6-8 for additional smoothing and noise rejection.

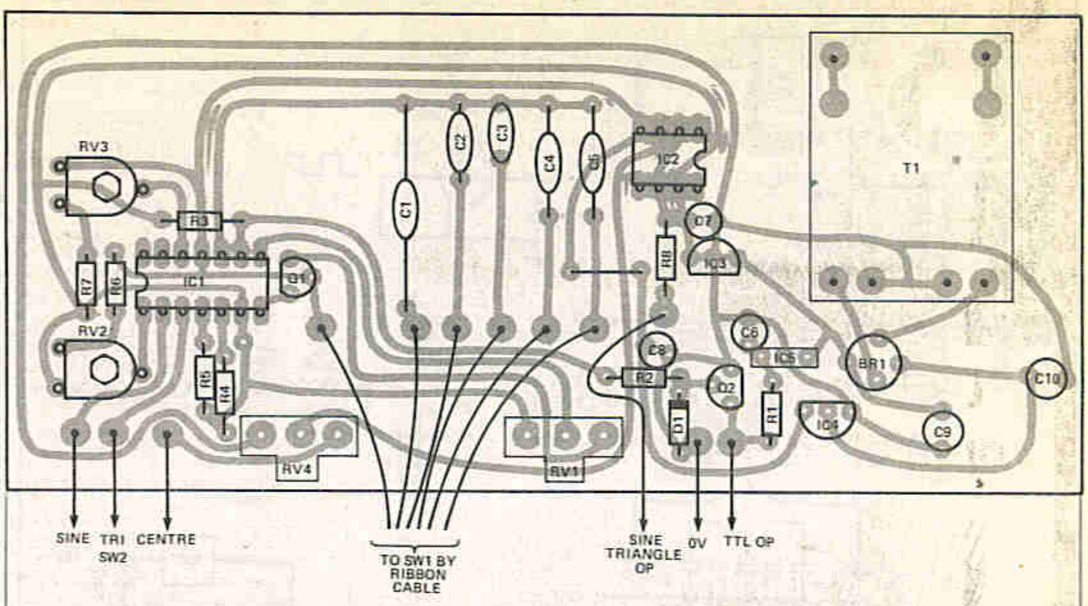
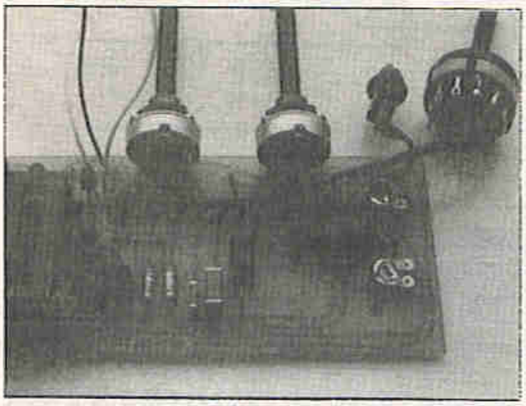


Fig. 2 The component overlay for the Signal Generator



Testing

Whilst in the construction stage and before installing the generator in its case the unit should be tested. Connect the mains to the PCB but ensure that IC1 and IC2 are not inserted. Check the voltage at the output of the three regulator ICs. As the reservoir capacitors used are of the single ended type it is rather easy to reverse mount the capacitors and short out the supply. Allow the circuit to run for some time, pull out the mains plug and touch each of the PSU components. None should be warm to the touch.

With the power to the unit turned off, allow the voltages to decay to zero before inserting IC1 and IC2. The output may now be examined on an oscilloscope if this is available. RV2 and RV3 can be rotated for the minimum distortion of the sine wave output but if you do not have a scope the pots can be set to their mid point. You should be able to vary all of the frequencies linearly by rotating RV1 and in $\times 10$ steps with SW1, whilst RV4 varies the amplitude of the sine and triangular waveforms. Remember that the square wave is fixed at TTL levels.

Finally the board with its attached front panel and the rear panel with the mains cable and grommet can be inserted into the remainder of the case and the halves screwed together. The prototype's front panel had the potentiometers and switches marked with rub-down transfers although other methods may be used if the constructor prefers.

ETI

PARTS LIST

RESISTORS (all ¼W metal film)	
R1,3	4k7
R2,4,5,6,7	10k
R8	100k
RV1	4k7 lin
RV2,3	100k preset
RV4	100k lin
CAPACITORS	
C1	2µ2 electrolytic or polyester
C2	220µ polyester
C3	22µ polyester
C4	2200p polycarbonate
C5	220p polycarbonate
C6,7,8	10µ 25V tantalum
C9,10	470µ 35V electrolytic
SEMICONDUCTORS	
IC1	ICL8038CC
IC2	741C
IC3	78L12
IC4	79L12
IC5	78L05
BR1	W005
Q1	BC557 (or any small signal PNP transistor)
Q2	BC547 (or any small signal NPN transistor)
D1	1N4148 (or any small signal diode)
MISCELLANEOUS	
SK1,2	BNC socket
SW1	12-way single pole rotary switch
SW2	SPST switch
T1	0-15 0-15 PCB mounting mains transformer

PCB. Case. Knobs. Wire. Nuts and bolts.

BUYLINES

The parts for this project are easily available from most stockists. In case of difficulty, Maplin can supply the tricky bits: ICL8038CC (YH38R), T1 (YJ55K) and the case (LL06G). The PCB is available from the PCB Service as detailed in the back of this issue.

EASi

Pat Alley closes the EASi alarm loop with a further selection of alarms and applications

The EASi system (Event Alarm System installation) protects your main premises and outbuildings against *hazards* 24 hours a day, against *intruders* whenever you consider it necessary, and will monitor *events* continuously. Typical examples of hazards are fire, flooding and personal attack — situtations where a general alarm is justified. Intruder protection includes door and window sensors, pressure mats, photo-electric, infra-red and ultrasonic sensors that you might want deactivated during the day. *Event* is a general term covering any occurance where it is desired that the warning be confined to your own household and does not warrant waking up the whole neighbourhood — from smoke and gas detectors to freezer faults, smaller water leaks and so on.

In the April issue we covered the main control box and power supply. Last month we examined modules to expand the basic EASi detection loop — a delayed entry/exit unit, the fitting of pressure mats, a fire detector, panic switches, freezer sensor, light beam sensors and gas and smoke sensors. This month we conclude the EASi series with a further selection of expansion possibilities.

Water/Steam/Rain Sensor

The sensor illustrated in Fig. 1 is the same as the freezer sensor last month except the thermistor is replaced by an interweaved copper track on a second PCB. Any resistance of less than 50k across the copper tracks will result in an *event* alarm. Indeed it is so sensitive that merely breathing on the copper track is sufficient.

This sensor can be plugged into any socket in the loop wire and its uses are many. Place it in a position to sample steam from the kettle to avoid boiling it dry. Use it to detect a water leak or flooding. Place it outside a window to warn you that it is raining and time to bring in the washing. A PCB layout is shown in Fig. 2.

Readers will (or should!) have gathered by now that any sensor can be made to give an *event, intruder* or *hazard* alarm according to whether an oscillator, an LED or nothing is shunted across its output. Although *event* sensors monitor for 24 hours a day as do the *hazard* sensors it may be felt a more strident warning is required. For example if your home is in jeopardy of flooding then you will definitely want this sensor to give a *hazard* alarm. In this case remove the oscillator, increase R2 to 2k7 and reduce R1 to reduce sensitivity.

Before leaving this very useful Schmitt trigger circuit it is worth mentioning that you could use it to sense a low greenhouse temperature or combine a two and three transistor version to give an *event* alarm to warn of a fish tank getting too hot or too cold. Indeed one might say it is a case of deciding what you wish to be warned about and there is every chance it can be arranged.

PARTS LIST

R1,3	1k0
R2,4	10k
RV1	10k
C1	20n
C2	200n
Q1,2	AC142
Q3,4	BC546

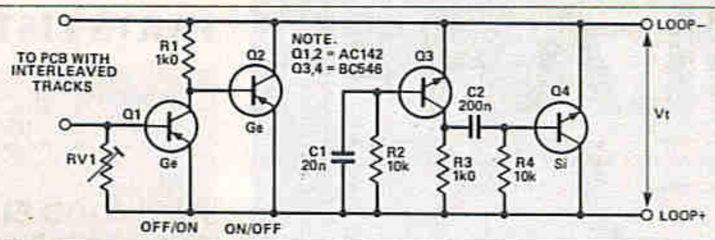


Fig. 1 Circuit diagram of the water/steam/rain sensor

THE PROTECTION RACKET

What if the burglar is really clever and . . . fill in the rest of the sentence yourself. In a multimillion pound industry it pays dividends to heighten the public's anxiety level in the never ending quest to sell intruder alarms.

This anxiety level is not reduced by BS4737, exalted by the media but actually organised hypocrisy at its worst — its rules being formulated in the main by those with vested commercial interest.

No system can comply with BS4737 unless it is installed and maintained (on a lucrative contract) by a duly authorised professional member — perhaps what Bernard Shaw had in mind when he defined professional bodies as a "conspiracy against the public".

Secondly BS4737 lays down such rigid specifications that one wonders whether the aim is to deter any sort of flexibility of competition or perhaps to avoid giving professional burglars any anxiety or confusion.

Lastly BS4737 destroys its credibility by insisting on the ingenious sharks, crocs and snakes being hidden in the castle moat and then brazenly omitting to specify that the moat should fully encircle the castle.

In its foreword it happily disclaims any liability by admitting that no system is foolproof. Certainly this is true when most sabotaged systems are inside jobs perpetrated on a four wire system which holds no fear for someone with a voltmeter and a copy of BS4737 under his arm. How would the saboteur know that it was a four wire system? Because no insurance company would insure it otherwise and there lies the blame. Insurance companies do not want the owner to be familiar with the system as they fear an inside job more than a genuine burglary.

The system has also become standard for domestic use and is as much of a deterrant to the DIY installer because of its complexity. Surely technology and astuteness should be given rein to confound the baddies with endless variations. If Joe Bloggs installs his own system and its secrets stay within the family, then sabotage is far more difficult — particularly if a few backup devices are added to the armoury.

In spite of this, if readers feel the need to add an anti-tamper loop then EASi can provide the facility.

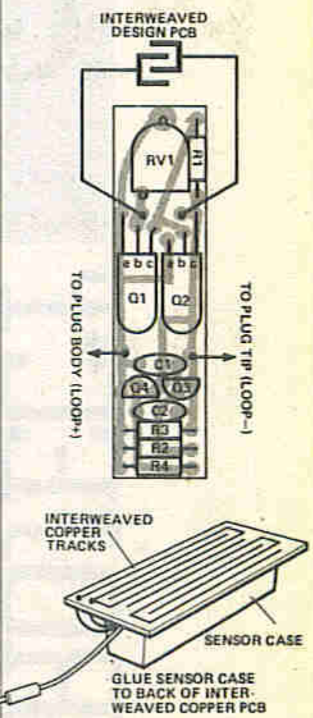
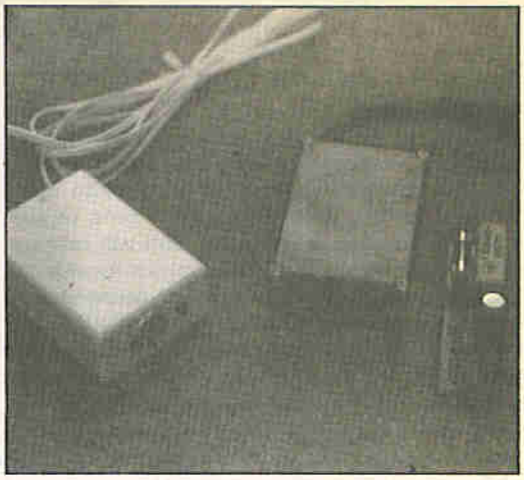


Fig. 2 Component overlay for the water/steam/rain sensor

Ultrasonic Transmitter-Receiver

After making several prototypes I finally decided that the simplest and lowest cost method was a miniature transmitter powered direct from the loop. When the control box keyswitch is selected to *full*, anyone breaking the invisible beam between transmitter and receiver would cause a main alarm.

The transmitter circuit is illustrated in Fig. 3. Q1 and Q2 are used in an oscillatory circuit with the transmitter transducer connected in the feedback loop to give a high Q resonant frequency of 40kHz. To miniaturise and in the process save the cost of, a transformer, a low power capacitive PSU is employed.



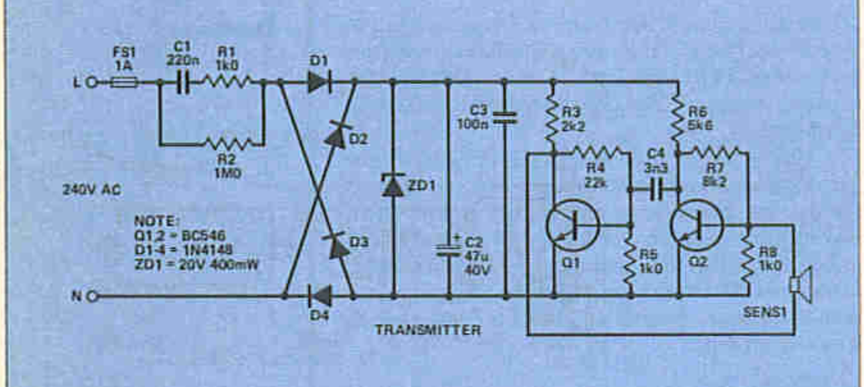


Fig. 3 Circuit diagram of the ultrasonic transmitter

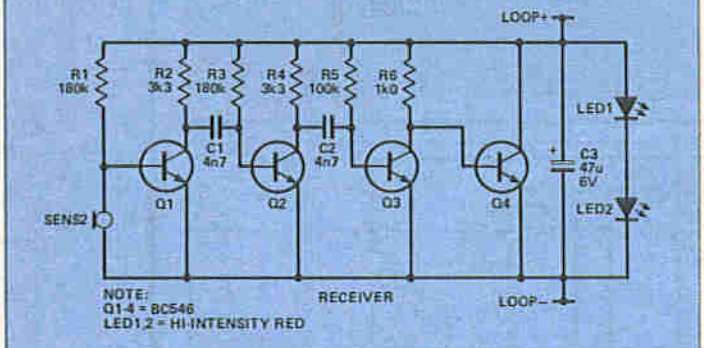


Fig. 4 Circuit diagram of the ultrasonic receiver

The C1 regulates the mains AC current flow which is approximately $250V \times 2\pi fC = 17.3mA$. This is fully rectified then regulated and smoothed via ZD1 and C2 respectively. R1 gives protection against surge current at switch-on and R2 provides a discharge path for C1 at switch-off. Since C1 is in fact a mains dropper it does not provide insulation from the mains voltage thus the whole circuit including the metal canned ultrasonic transmitter must be securely fastened inside an insulated box and incapable of being accidentally touched by hand. Fuse FS1 gives overall protection against excessive current. In fact the circuit is no more dangerous than one employing a transformer in so far as mains power is still present and itself would need to be fully insulated inside a box.

The receiver circuit in Fig. 4 is powered from the loop. The transmitter signal is amplified via Q1-3, ending up at Q3 collector as a well developed squarewave. This squarewave is rectified by the base-emitter of Q4 and smoothed by C3 to prevent signal feedback, establishing its own voltage at about 0.75V. A momentary loss of signal results in Q4 switching off, whereupon rail voltage rises rapidly until caught by the LEDs.

Although the circuit appears to have no temperature compensation or negative feedback this is catered for by the substantial DC feedback afforded by Q4 rectification and C3. As a result the receiver circuit is extremely stable and tolerant to the kind of signal reduction caused by, for example, a bird flying through the beam.

Protection from the ultrasonic system is lost when the mains fails so it is arranged for the control box circuitry to be inhibited at the instant mains failure occurs and once again on restoration of the mains.

The transmitter and receiver are small enough to be hidden out of sight but as is common to all ultrasonic systems you should avoid places where there are any warm draughts (such as those directly above hot air ducts).

PARTS LIST

TRANSMITTER

R1,5,8	1k0
R2	1M0
R3	2k2
R4	22k
R6	5k6
R7	8k2
C1	220n 250V AC
C2	47µ 40V
C3	100n
C4	3n3
Q1,2	BC546
D1-4	1N4148
ZD1	20V 400mW
FS1	1A fuse
SENS1	Murata MA40A3/S

RECEIVER

R1,3	180k
R2,4	3k3
R5	100k
R6	1k0
C1,2	4n7
C3	47µ 6V
Q1-4	BC546
LED1,2	hi-intensity red LED
SENS1	Murata MA40A3/R

Construction

Both units use identical containers, the only difference being the holes to be cut or drilled. No actual dimensions are given for spacing the holes in the receiver case since the PCB is much smaller than the case and space is not at a premium. Only one LED need be brought out of the front of the case and for this drill a 5mm hole.

The transducer needs a much larger hole of 16mm diameter.

A spot of glue or double sided adhesive applied to the rear of the PCB will locate the transducer and PCB in position. Drill a 3mm hole between the case and its lid at the rear to bring out the two wires which can be either hardwired into the loop by soldering or connected by plug and socket.

The PCB layouts and case layouts are shown in Fig. 5. Solder R1 and the two short wires to the transducer on the copper side of the board. The metal cased transducer is a push-fit into the far end of the plastic tube. This is necessary to prevent any metal surfaces being accidentally touched. It is emphasised that although under normal circumstances the transducer's metal case is not live, capacitor C1 does not give the acceptable isolation from the mains as would an isolation transformer. Since C1 normally only passes about 16mA of current the fuse can be from 100mA to 1A.

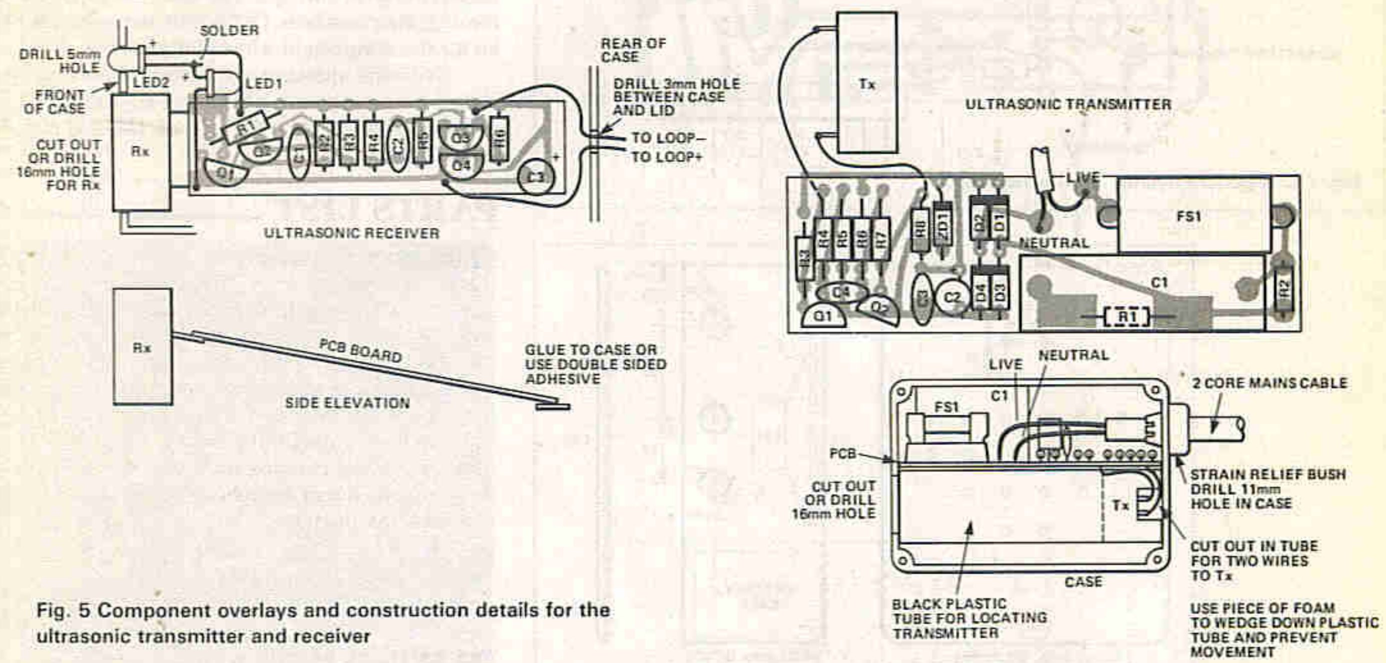


Fig. 5 Component overlays and construction details for the ultrasonic transmitter and receiver

Intercom System

Stunningly versatile as it may seem, the EASi loop may be used as a connection system for a series of intercoms around your home. Indeed, this application is so useful that readers may abandon the whole concept of EASi as an alarm system and install a loop in office or home just as a communication line. Intercoms can be used as door phones or continuous monitoring of children. As you move around you can just plug your intercom into a different loop socket.

There are two listening positions. The silent position is so called because the usual hum of an intercom is eliminated and only sounds above a preset level are heard. On normal position you hear everything. The opening of door and window switches does not affect the volume.

The circuit diagram is shown in Fig. 6. Each intercom is powered by 4AA batteries and interfaces to the EASi loop via a miniature 6V mains transformer in the role of an audio transformer. All switches in Fig. 6 are shown in the silent mode.

There is no on/off switch since quiescent current flow is less than a microamp. Transistors Q3 and Q4 will remain unbiased until an audio signal exceeding 20mV comes through the loop — sufficient to foward bias Q3 once it is transformed by T1. The sound through the speaker is distorted since presently Q3,4 are amplifying in class C but it conserves power and serves its purpose in alerting the listener to select normal mode.

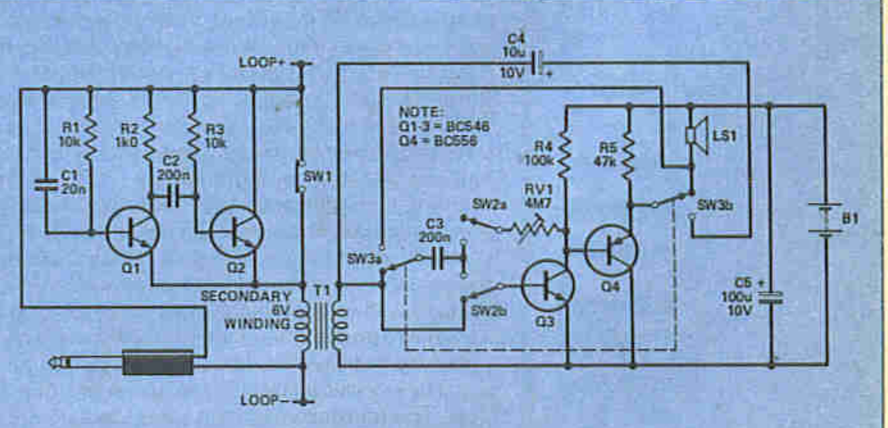


Fig. 6 Circuit diagram for the intercom

The intercom has three push-button switches. SW1 when pressed allows the tone oscillator of Q1,2 to transmit a tone to other intercoms. This may also cause a momentary *event* alarm at the control box but anyone listening would instinctively realise this was not a true alarm. Pressing SW2 allows Q3 to be biased into class A via RV1 and also connects Q3 base to the secondary of transformer T1 via C3 for normal listening. Current consumption in this mode is about 30mA.

When SW2 and SW3 are pressed simultaneously the speaker becomes a microphone and is connected to the base of Q3 via SW3a. An amplified voltage appears at low impedance from the emitter of Q4 where it is fed via C4 to the transformer and via this into the loop at a lower voltage and impedance. Current consumption in the *transmit* mode is only 100μA so together with the zero current consumption of the other intercom when in the silent listening mode, this makes for an economical use of power.

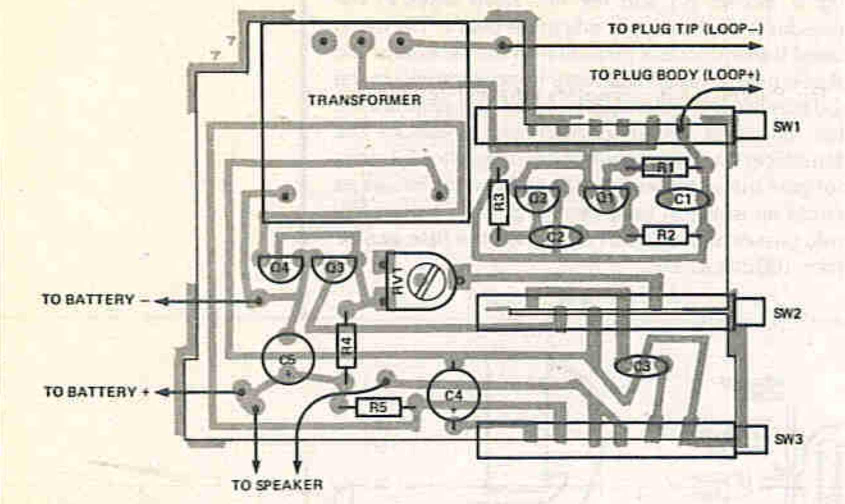


Fig. 7 Component overlay for the intercom

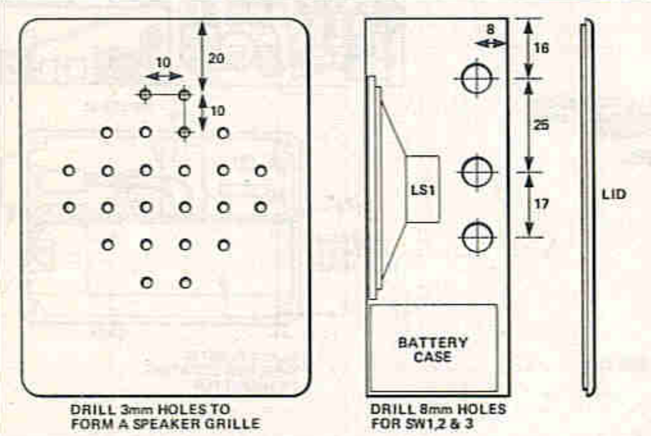


Fig. 8 Intercom case construction details

The PCB layout is shown in Fig. 7 and the case drilling in Fig. 8. The board fits snugly into the case from Mulberry (see *Buylines*) and after the speaker is connected by a couple of short wires it can be held behind the grille with tape. The switches can be guided through their case hole. Drill a 3mm between case and lid for the connection wires to the loop.

Once the intercom is constructed, setting up is simply a case of pressing SW2 and adjusting RV1 for a 3V reading across the c-e of Q4 for class A amplification.

PARTS LIST

INTERCOM	
R1,3	10k
R2	1k0
R4	100k
R5	47k
RV1	4M7
C1	20n
C2,3	200n 12V
C4	10μ 10V
C5	100μ 10V
Q1-3	BC546
Q4	BC556
BATT1	4×AA batteries
SPK1	64R loudspeaker
SW1	push-to-make
SW2,3	double pole changeover
T1	6:240 transformer

Donor System

Infra-red detectors and other back-up devices in conventional hard-wired systems normally require a power source. This is invariably supplied by two extra wires from the control box which further complicates and adds to the number of installation wires. In the never ending quest for providing the owner with convenience of installation, manufacturers have produced stand-alone devices such as smoke alarms, ultrasonic alarms etc. which are powered from a 9V PP3 battery. Radio alarm manufacturers are in the same boat in their need to power a detector and its associated transmitter from a small battery and they too have usually chosen a PP3.

Typical products in these fields have been FM Security's IFM-125 Passive Infra-Red detector which uses a miserly 22μA of current, and Black & Decker's Smoke alarm which uses an even more miserly 7μA, giving them both a useful life in excess of 12 months.

Unfortunately stand-alone devices have their problems. Each has to be provided with its own alarm sounder and although piezo devices are very efficient they still consume current at a rate several orders greater than the detector, which can severely reduce battery life through over-enthusiastic testing or if triggered off accidentally. Not surprisingly this compromising low power source also means the sounder is not so loud as the bell or siren of a conventional hard-wired system and is unlikely to be heard by a neighbour. Being stand-alone, small and accessible, they are too easily silenced by an intruder and stolen along with the other valuables. Radio alarm detectors have one big disadvantage. Each needs an expensive transmitter to interface with its control box.

EASi's loop can afford a milliamp or two but it can't afford the 9V to power such devices. However it is relatively simple and inexpensive to interface a battery powered detector to the loop. For this the 9V PP3 battery only has to power the detector alone thus guaranteeing that life of the battery will never be impaired by the sounder. EASi's main alarm is much louder and not easily silenced which overcomes the main disadvantage of the stand-alone device, besides saving the cost of the built-in sounder.

Take as an example the interfacing of FM Security's IFM-125 Infra Red detector. In the non alarm condition the sensor's output is 0V and in the alarm condition is −9V. The interface circuit is illustrated in Fig. 9. In the non-alarm condition Q1 is switched off and Q2 is biased on by R2 and Vt is about 0.35V. When the detector goes into the alarm condition its −9V excursion induces a pulse via C1 into the base of Q1 switching it on momentarily. This switches Q2 off momentarily, hi-intensity LED1 ensuring a 1.5V pulse to sound the alarm.

Note the use of the silicon transistor for Q1 which does not raise Vt in this instance because it receives its bias from the detector's pulse. C1 is provided so that no DC current flows when the detector is in the alarm condition hence no power is consumed from the detector's battery. Note also that only one power rail of the donor detector is connected to the loop. In this case it is the positive rail.

Interfacing the Black & Decker smoke alarm involves a few more components as can be seen in Fig. 10 because in the non-alarm condition its IC output is +9V and in the alarm condition oscillates between 0-9V. This is why the interface circuit to Q1 base is in the form of a diode pump arrangement. Since the smoke alarm will be classed as a *hazard* detector, a pulse exceeding 6.5V is required and this is catered for by LD1 and ZD1. Meanwhile the detector's sounder is superfluous.

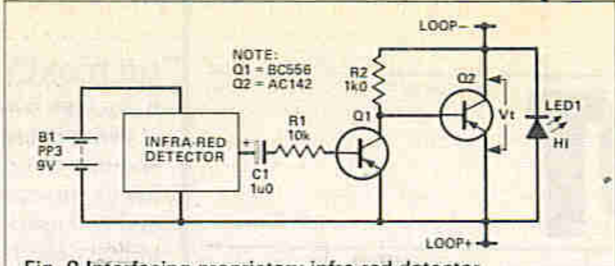


Fig. 9 Interfacing proprietary infra-red detector

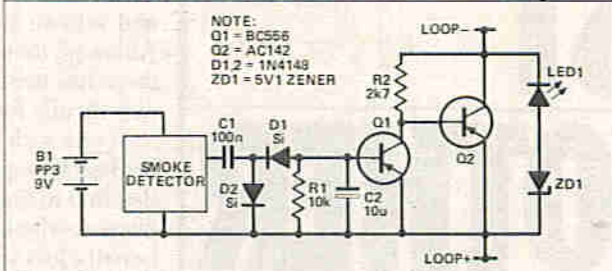


Fig. 10 Interfacing a proprietary smoke detector

Metal Detector

Another unlikely use to which my EASi loop has been put was discovered the day I needed to drill holes in the kitchen wall without hitting the plumbing behind the wall. Within an hour I was in business using the circuit in Fig. 11.

The circuit consists of an RF oscillator tuned to a frequency in the LW band by winding about 100 turns of 36swg enamelled wire onto a 400m length of 10mm dowelling. The board with the components can be clipped to this (see photograph). A wooden platform can be used to hold a small transistor radio.

Just plug the oscillator into the nearest loop socket and tune the radio to the same frequency as the oscillator to obtain a heterodyne whistle from the radio. Shed a few coils if you find yourself on top of Radio Gdansk and find a free area. When the coil is placed near metal pipes the note of the whistle changes as the metal affects the oscillation frequency.

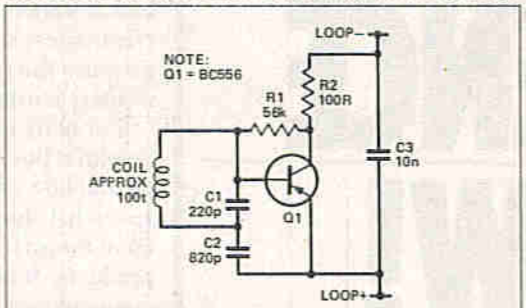


Fig. 11 Circuit diagram for the EASi metal detector

In Conclusion

Having now used EASi for several years I should perhaps mention the *event* system has hidden talents which I found by accident.

The loop wire is susceptible to RF interference but only of the more powerful variety. About six months after installing the system I experienced a series of about five or six *event* alarms lasting about three seconds each time, coinciding with the operation of the washing machine. I soon cured that by slugging the alarm.

The next time the washing machine was used I examined the signals coming through the loop wire to the control box with an oscilloscope and found them to consist of sporadic 'hash' of no particular frequency, the peaks of which only occasionally reached 0.8Vpp (hence the intermittent alarm). On investigation I found the washing machine motor brushes had worn down to the commutator resulting in a vivid display of fireworks. Fortunately renewing the brushes had the motor working normally again and the 'hash' shown on the oscilloscope was barely perceptible at a few millivolts.

The alarm had given a warning. Not long afterwards a friend had a similar instance but this time associated with a loose and dangerous mains wire in a vacuum cleaner. Based on these experiences I removed the slug on my own alarm. Occasionally during a thunderstorm there may be a rather feeble 'beep-beep' lasting two or three seconds but is so rare as to be insignificant and in any case is obviously a false alarm.

BUYLINES

Mulberry Electronics can provide materials and components for the EASi alarm system at the following prices.

Control Box: metal container (predrilled and artwork) £14. Main PCB £12. PSU £1.70. Internal siren £6.50. Transformer £1.60. Relay £1. Battery (2.6AH) £16. All other components £22.50.

Kits: door/window sensor £1.10, magnet £0.85, house protector £0.85, panic switch £0.60, fault probe £0.80, fire sensor £3.50. Loop socket £0.60 (without LED £0.48, plug £0.18), pressure mat sensor £1 (pressure mat £4, stair mat £2), freezer sensor £4.55 (PCB only £1.50), gas sensor £16.10 (PCB only £4.00, TGS sensor only £6.95), delay entry/exit £7.50 (PCB only £4), watersensor £6.35 (PCB £1.50, interweaved PCB £3), intercom £10 (PCB £4), ultrasonic tx/rx £12.90 (PCB £4, transducer pair £4.50).

Bell 12V 6in £18. Red bell cover £9. 100m reel of single 7/0.2mm white wire £2.40. LDRs for light detectors £0.60.

Prices include VAT but please add £1.50 p+p.

Contact Mulberry Ent Limited, Squirrel Leap, Hagley Road, Fleet, Hants GU13 8LH. Tel: (0252) 621505.

WARNING BLEEPER

1st CLASS

Paul Chappell proposes a myriad uses for a simple bleeping circuit

I hate to let a good circuit go to waste. In last year's Burglar Buster alarm project, a circuit based on the 1458 dual op-amp played a supporting role as an exit delay warning. It was a simple circuit — easy enough for a first project for a raw beginner, yet incredibly versatile. So here it is, starring in its own show. Take it away, warning bleeper!

The Circuit

The circuit is shown in Fig.1. If you look at it carefully you'll see that the two halves, around IC1a and IC1b, are almost identical — they differ only in the capacitor values and the direction the diodes are pointing. Each section is an oscillator — a circuit which produces a voltage which goes regularly up and down.

The second section's output varies at a frequency within the audio range so when fed into the piezo sounder you can hear the result as a continuous tone. The first section goes much slower because of the larger capacitor and through diode D2 it turns the second section on and off about twice a second. The result is that the sounder produces an interrupted tone — a 'bleeping' noise.

Building The Circuit

If you've built projects before, just look at the overlay in Fig.2 and get on with it! If you haven't, this is what you do. The master plan is Fig.2 — it shows where all the components go on the PCB. You can buy a PCB specially made for this project from our PCB service.

Begin with the resistors. The components list tells you all the values: R1 is 100k, so find a 100k resistor, look at Fig.2 to see where it goes, bend the leads so that they can be posted through the holes in the plain side of the PCB, trim the wires so that about 2mm pokes through on the track side of the board, then solder the ends to the metal pads surrounding the holes. It's much easier to see with a diagram and Fig.3a shows a cross-section of the proper result.

A word about soldering. Beginners often try using some grotty old iron that's been knocking around the car boot for years. Others reckon that if a 15W iron is good, a 150W iron must be ten times as good. What you want is a 15W iron with a thin pencil bit. Antex irons are the best I've found, and lots of suppliers sell them in complete soldering kits, with a stand, two or three bits, a cleaning sponge and even a length of solder to get you started. Not very expensive and with the right tool for the job, your circuits will work!

The most important thing to do when soldering is to melt the solder straight onto the joint you're making. Solder for electronic work has lines of flux running through it like the lettering in seaside rock. The flux is to clean up the metal you're soldering so the solder can stick to it properly. If you melt the solder onto the iron and try to do the molten metal onto the wires it may not stick very well and you'll end up with a dry joint — one that won't conduct electricity and will stop your circuit working.

Figure 3a shows about the right amount of solder to use. Too much and you'll end up with a blob (Fig.3b), or even worse, a blob between two adjacent tracks (Fig.3c) which will join two parts of the circuit that shouldn't be joined. If you don't use enough solder (Fig.3d) the joint will be weak and might break or crack — the break might not be easily visible and can cause all kinds of puzzling faults.

Two finer points for expert constructors: solder spikes as you lift the iron from the joint usually means the iron is too hot. A dull, grainy joint means either the solder is cooling down too fast or the lead has been moved during cooling. The spikes make the PCB look untidy and there's danger of shorts if the spike bends or breaks off. Grainy joints, where the solder has become crystalline, have higher resistance and are bad news in sensitive circuits.

Right, once you've soldered in, carry on with the rest of the resistors in the same way. In this project they are all the same value so you don't even need to be able to read the colour code! For the moment leave R9 out altogether — whether you need it or not depends on what you want to do with the circuit, as I'll explain later.

Now the capacitors. C2 can go in either way around, so solder that one in first. C1 has to go in the proper way around. One lead is the positive (+) lead and the other is the negative (−) lead. One or other will be marked on the body of the capacitor. The + lead has to go into the + hole and the − lead into the other hole. Got it? Good.

Diodes next. These have to go the right way around too. In Fig.2 you'll see that one end of each diode drawing is a thick black line. Look at the real diodes and you'll see a black band around one end. Match the diode's band with the Fig.2 band and it will be pointing in the right direction. Diodes get unhappy if you heat them up too much for too long, so try to complete the solder joint in one confident operation. If it looks like taking more than about twenty seconds, let the diode cool down before trying again.

The IC also has to go the right way around. The U-shaped notch in the drawing indicates the end of the IC that (depending on who made it) might have a notch itself, or a little indentation by one of the pins. Overheating also can spoil the IC, so let it cool between soldering each pin.

Finally, the wires to components that don't go on the board. The wires attached to the piezo sounder X1 go in the holes shown. The battery connector is soldered in with its red wire to the hole marked $+V_{cc}$ and its black wire to the hole marked 0V.

Now to see if it works. Plug in the battery and it should bleep away. If not, check your soldering carefully — in particular, make sure that no solder lies between two tracks on the PCB. Also check for any joints where the solder may not be gripping the component lead solidly — if you can wobble the lead, the

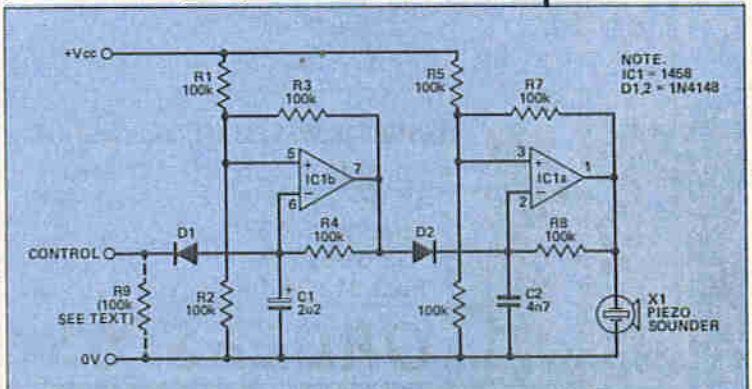


Fig.1 The circuit

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,2,3,4,5,6,7,8	100k
R9	(100k) see text
CAPACITORS	
C1	2µ2 electrolytic
C2	4n7 ceramic
SEMICONDUCTORS	
IC1	1458 (LM1458, MC1458, etc.)
D1,2	1N4148
MISCELLANEOUS	
B1	9V battery
X1	Piezo sounder
PCB. Battery connector. Wire.	

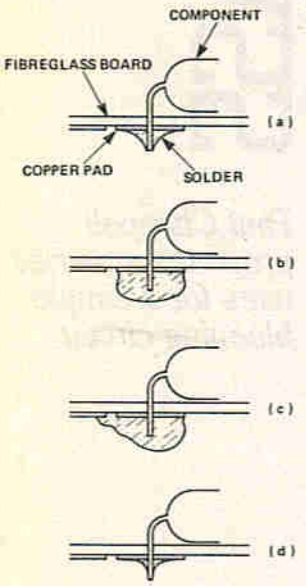


Fig.3(a) A good solder joint; (b) Too much solder; (c) Much too much solder — it's joining two adjacent tracks on the PCB; (d) Not enough solder.

joint's no good. Finally check that all components are in their proper places and the right way around. It's working? OK, beginners class over. You can join the big boys for the rest of the project.

Liquid Level Alarm

The bleeper has two modes of operation. Without R9 it is normally on and is turned off by grounding the control input (or taking it anywhere below about $\frac{2}{3}V_{cc} - 1V$). With R9 in place it is normally off and turned on by taking the control input to the positive supply voltage (or anywhere above about $\frac{2}{3}V_{cc} - 1V$). The two modes are demonstrated by the liquid level sensors of Fig.4. In the first configuration, Fig.4a, an alarm is given if the level falls below the sensor. In Fig.4b the circuit sounds when the level rises too high.

The sensor needn't be anything more elaborate than a pair of pins stuck through a cork — even bared wire ends stuck into a glass of water if you just want to experiment. The best use I've found for my circuit is to show when the car wash-bottle is nearly empty — living in the country, my windscreen gets splashed and dirty very quickly. Apart from the inconvenience of driving without being able to see much, you can get fined for it too!

The circuit will be perfectly happy to run from 12V but a car power supply has all kinds of over-voltages on it, so as a precaution against popping the IC I'd recommend fitting the extra components shown in Fig.4c for any car application. The components can be wired to the terminals where you pick up the supply.

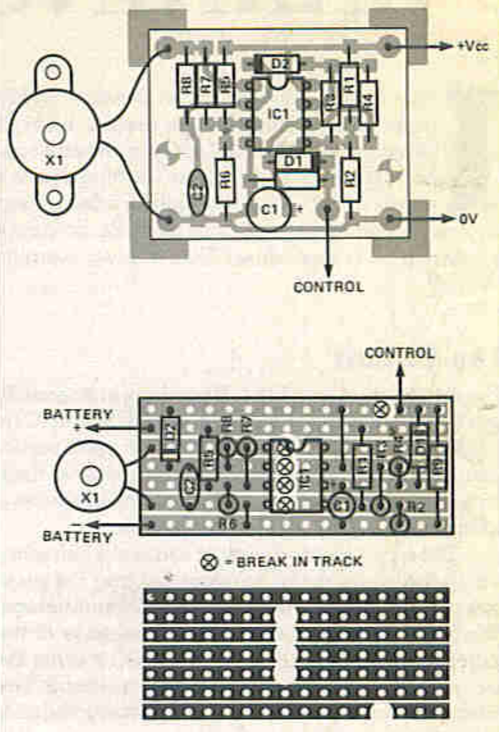


Fig.2 The component overlay

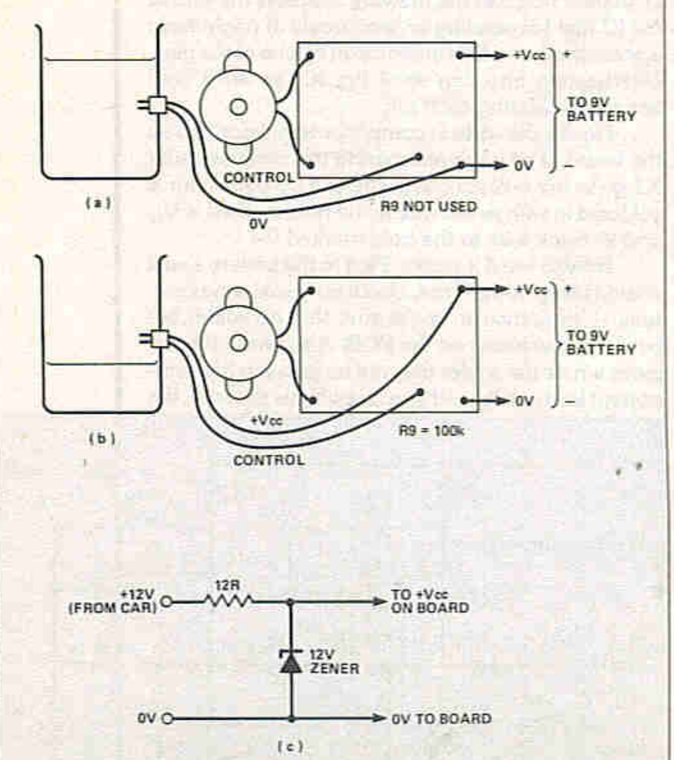


Fig.4(a) Liquid low detector (also detects dry soil — could tell you when your plants need watering!); (b) Liquid high alarm; (c) Additional components to run the project from a car supply.

Battery Alarm

On most bits of equipment a battery alarm is superfluous. If your portable tape recorder starts to run at half speed, you bin the batteries and get new ones. If it runs OK, you don't and that's all there is to it.

Sometimes though, it may not be so obvious that the batteries are flat. It may also be important to know. I'm thinking of things like battery powered test meters and instruments, which might be giving duff readings without you knowing about it. Pagers and cordless phones — you might be missing calls. Battery memory backups on computers — nice to have some warning before all your data disappears.

For most applications, all you need to do is reduce the value of R9 and add a zener to the circuit, as shown in Fig.5. The zener will have to be chosen by a cut-and-try method — the way you'd go about it is this:

Decide on the minimum voltage the device you want to protect will work at. Let's say it runs from a

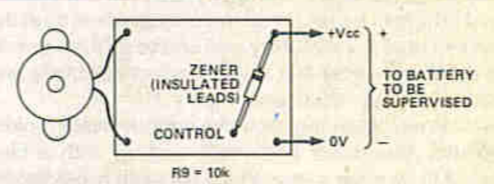


Fig.5 Battery supervisor

nominal 9V and works OK down to about 7V. To be on the safe side, you want the battery alarm to sound at 7½V. Divide by three: gives 2½V. Add 1V and use this as your starting point to test out the circuit. Since there are no 3½V zeners you'll have to go for a 3.3V one. If the circuit triggers at too high a voltage, reduce the zener voltage. If it triggers too low, use a higher voltage zener.

The bleeper circuit is quite happy to run at voltages up to about 30V as long as C1 is suitably rated

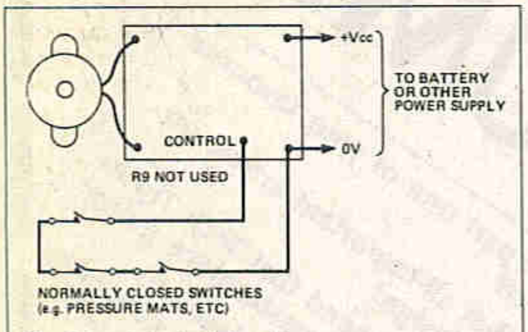


Fig.6 Psychological alarm!

and the process for finding the rough zener value is always the same: divide the trigger voltage by three, then add one. This should give the value to within 1V.

For critical applications you can use the bleeper in conjunction with a voltage detector circuit like the ICL7665. This will monitor both under and over voltages and has an accurate bandgap reference built in. Available from Electromail for about £3 if you want one — they can also supply a data sheet to tell you how to use it.

Burglar Or Car Alarm

This is rather a speculative application but one you might like to try. I've been racking my brains for some time to come up with an alternative to bells and hooters as the noisy bits of an alarm system. Let's face it, people just ignore them and I'd guess that burglars are perfectly well aware of this. My best shot so far is a psychological alarm to put the fear of God into the bad guys.

My notion is that a burglar hearing a bleeping sound in the dead of night would wonder what it meant. It's too quiet to rouse the neighbours, so it obviously isn't an ordinary alarm. The warning sound can mean only one of two things: that something is about to happen, or that something (he knows not what) *already is* happening! If he hears an alarm or sees a video camera he can make a decision about what to do but if some unknown thing is happening — what then?

Results aren't guaranteed but I reckon it beats no alarm at all, or empty alarm wall boxes. The circuit is in Fig.6.

Capacitor Tester

The project will also function as a basic capacitor tester. For small capacitors it will give a go/no-go indication, at least to the extent of checking for shorts. For large capacitors it will tell you the value too!

The circuit is shown in Fig.7. For small capacitors, connecting them to the test terminals will give at most one bleep. If the circuit bleeps continuously, the capacitor is a dud. For large capacitors (above about 2µ2) it will give more than one bleep. Counting the bleeps will tell you the size of the capacitor.

First you have to calibrate the circuit. Connect a nice, new 100µ capacitor to the test terminals and count the bleeps. Let's say there are 50. Divide the

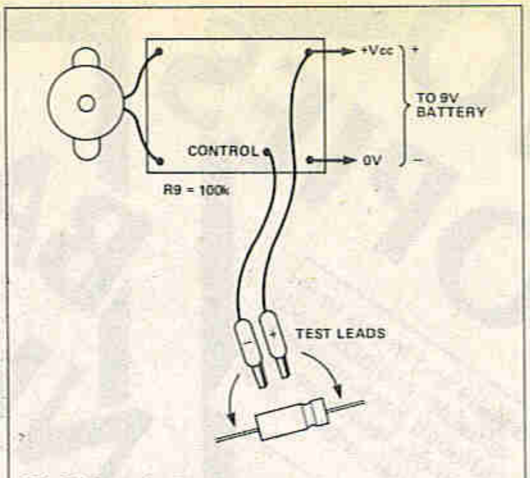


Fig.7 Capacitor tester

capacitor value (100) by the number of bleeps (50) and you've got the number of micro-Farads per bleep — two. Your capacitance meter is now calibrated.

To check on the value of a capacitor, connect it across the terminals and count the bleeps. Multiply the number of bleeps by your calibration number (two) and you've got the value of capacitor. If it gives five bleeps, it's 10µ, twenty five bleeps means it's 50µ, and so on.

Continuity Tester

Doing electrical repairs on an old car can be a frustrating business. Wires that were once nicely colour coded have now faded and become covered in grease and grime and the manual doesn't help in deciding what goes where: countless owners and garages have made alterations until it's unrecognisable! A continuity tester will tell you which wire goes where and will check for any breaks or faulty connections.

The circuit of the tester is shown in Fig.8. Connect one test terminal to the wire you want to trace and touch the other to different wires until the circuit sounds. For a bad connection test, connect the terminals across the part you're not sure of. If there's no connection or a very high resistance, the bleeper will not sound.

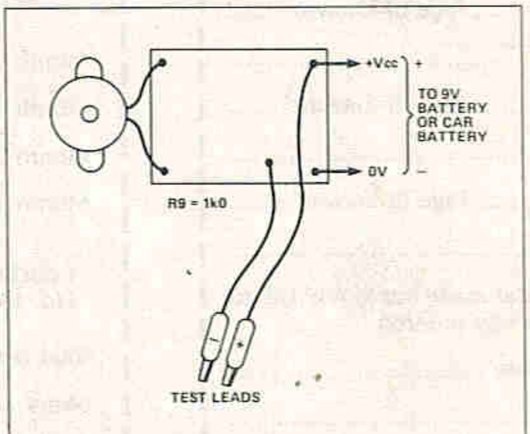


Fig.8 Continuity tester

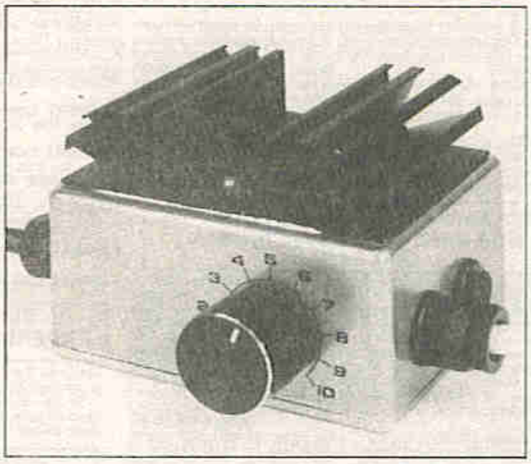
BUYLINES

All the components are readily available from ETI advertisers. The special PCB for this project is supplied by our PCB Service see the back of this issues for details.

A set of parts for the project (including the printed circuit board, sounder and battery connector but not the PP3 battery) can be obtained by sending £3 to: Specialist Semiconductors Ltd., Founders House, Redbrook, Monmouth Gwent NP5 4LU.

CARAVAN HOT WATER SYSTEM

Touring caravan sites last summer, Keith Brindley noticed a need for heated water from the limited power supplies. Here he describes a project to do the job — in time for the new season



It may surprise some readers to find out that holiday touring in the dark, or with an old car battery to light up the nights, is a thing of the past. Many camping/caravan sites now feature mains power outlets. After a flat-rate fee (around £1 or so) is paid in advance, it's up to the user how to use the available power. However, mains electric supplies on all caravan/camping sites are limited in current output — the site operators have to make a profit, I suppose, and limiting current supply is one way of making sure you don't run power-hungry appliances and use more electricity than you pay for.

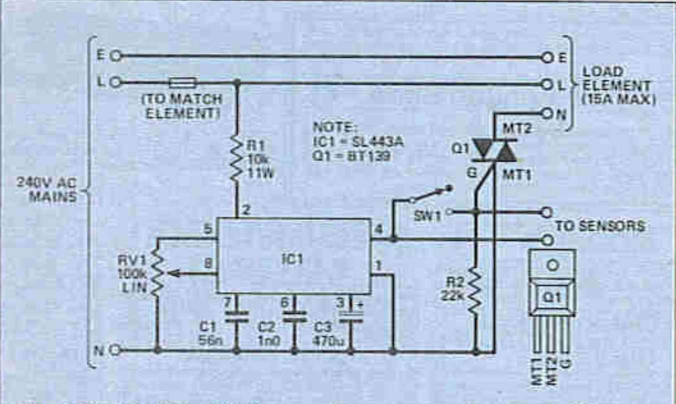


Fig. 1 Circuit of the ETI Caravan hot water system controller

European site electrical outputs should conform to BS4343 (corresponding to IEC 309/CEE17) which specifies a three-pole socket with recessed tubes, rated for a maximum of 16A. Most British sites do conform with this: easily recognised because of the blue socket (usually with a splashproof sprung flap), but a large number of foreign sites haven't yet been updated to the spec.

Typically, however, all socket outlets are protected with a mains circuit breaker (MCB) with a lower current rating than this. On many sites a 10A supply is the norm but some supplies can be 5A and even 3A supplies have been encountered. A fuse could be used here, but in respect of the position of the outlet (that is, outside) not many site wardens would be keen to replace fuses when it's chucking it down with rain at eleven o'clock at night — an MCB means power can be restored after a trip simply with the push of a button or the flick of a switch.

Incidentally, some sites (particularly those run by certain caravan and camping organisations) also protect outlets and supply users with a residual current circuit breaker (RCCB) at each outlet or group of outlets. This automatically isolates the outlet if a difference in current of more than just a few milliamps between live and neutral supply lines is detected.

Such an imbalance of currents could be encountered if, say, a user happened to touch a live terminal — current flows through the user's body to earth and so the live current and the neutral currents are different and the RCCB trips out, cutting off the mains power. Like the MCB, the RCCB allows power to be restored with a simple switch or push button.

HOW IT WORKS

Burst-fire power controllers apply power to the load for an integral number of cycles in every group of cycles. Thus, if a group of cycles is comprised of 100 total cycles and only 50 cycles are applied to the load in the duration of the group, 50% of the total power is applied to the load. If only ten cycles are applied in the duration, 10% of the power is applied. If 100 cycles are applied in the duration, 100% power is applied to the load. It is this fact that whole numbers of some cycles are applied to the load (unlike parts of every cycle — as in phase-triggered power controllers) which ensure little or no RF interference is created.

On the other hand, the implication of the fact that some cycles within a group are not applied to the load means that the load is regularly being turned on and off. This is no problem for heater circuits, but is in lamp-control circuits — the lamp would flash instead of being dimmed.

The circuit of the ETI Caravan Hot Water System Controller is shown in Figure 1. Integrated circuit IC1 is a zero voltage switch which, primarily, detects when the applied mains voltage crosses through zero.

The IC also creates a ramp, with a duration defined by capacitor C1. Ramp duration defines the number of cycles in a group. If the ramp is of 20 seconds duration (a typical time) then 1000 cycles (that is, 20 × 50Hz) comprise the group. When the ramp voltage exceeds the voltage at pin 8 of the IC, the triac is switched on (see later) so that power is applied to the load. So, the lower the voltage at pin 8, the more power is applied to the load. This is illustrated in Fig. 2, for three states; zero, half and full power. The pin 8 voltage is derived from a potentiometer arrangement, the voltage across which is derived from pin 5 — a 7V stable output.

At this point it's worth noting that although the *average* power applied to a load is over *all* the ramp's duration, the *total* power is applied to the load for *part* of the time. So, for 50% power, the total power would be applied for half of the ramp time. If a 5A MCB was in circuit at the mains outlet, and a 10A element had 50% power applied with a ramp time of 20 seconds, it may be the MCB will trip (as 10A passes through it for 10s). To prevent MCB trips due to this effect, the ramp time of the project is lowered to about 2.5s. (Actually, at twice an MCB's current capacity, most MCBs will take between 10 to 40 seconds to trip, so it's possible the MCB won't trip, anyway — lowering the project's ramp time to well below this merely *ensures* it won't.)

At every zero crossing of the mains voltage when a cycle is to be applied to the load, a pulse is generated at pin 4 of the IC, to trigger the triac. If switch SW1 is open, the pulse must pass through whatever sensors are connected to the project. Thus, say, a thermostat can define that the triac is triggered when water temperature is below that required or not triggered when temperature is above. Switch SW1 overrides the sensors, passing the triac trigger pulse through to the triac gate at all times.

Current Affairs

It doesn't take an Einstein to calculate that not many household electrical gadgets can be connected to the circuit before the maximum of 10A is in use — even fewer if MCBs of 5A or less are in the circuit. Table 1 lists a few of the gadgets you may wish to take when you tour, with typical powers and resultant current ratings at 240V. The heaviest drain in current is a conventional kettle — some varieties will trip out the MCB on their own. With this in mind special caravan/camping kettles are available with a lower-power element (say, 750W — just over 3A at 240V). These take considerably longer to boil water, though. Lights are not listed in Table 1 because most touring caravan lights are of 12V nature (fluorescent), run by the caravan's internal battery (or external, if the touring car is connected). However, these present a significant drain on the battery, so a battery charger is often used as well.

Now We're Cooking

If caravanners want hot water in their vans, there are two alternatives: a kettle (electric if enough power is available, camping type — heated on a gas ring if not) or a gas-heated tank. The first option means only a limited amount of water is available. The second, although allowing about two gallons of water to be heated, is quite expensive, about £300 when fully fitted, and drains your gas cylinders rapidly.

This project allows a conventional kettle element (of around 10A — the exact current rating is not critical) to be used as the heating element of a water tank arrangement, to give a hot water supply costing much less than gas-heated tanks. Further, the tank is heated by the site's electric supply — not your gas! With such a hot water system, you'll definitely more than get your value from a night's supply of electricity.

By controlling the power to the element within well defined limits, the project ensures the average MCB current rating is not exceeded and so the MCB is not tripped. Alternatively, average power consumption of an ordinary kettle can be similarly controlled with the project to give smaller quantities of hot water.

An important feature of the project is the inclusion of a sensor connection, whereby a number of sensors can be added into circuit for various reasons. For example, the temperature of the heated water can be controlled using a cylinder thermostat sensor (readily available from DIY stores and plumbers' merchants). You may also like to ensure the element does not operate if no water, or insufficient water, is in the tank — a float-type sensor can be used for this purpose.

Whole Cycles

Of course, power controller projects aren't new. The conventional lamp dimmer is just one example of a power controller where power to a bulb is controlled and restricted, thus defining the bulb's brightness. Lamp dimmers work by turning the power to the bulb on at a defined time in each half mains cycle.

A triac is at the heart of such circuits and simple triggering of the triac allows current to be switched through the lamp. By varying the defined time (that is, the phase angle of the mains cycle) at which the triac is triggered, more or less current will be switched through the lamp and so brightness can be varied.

Such phase-triggered power controllers, although simple in theoretical operation, can't easily be used in practice to control high current loads like kettle elements because of the interference they generate. Switching a triac on part-way through a cycle generates significant RF interference. In the likes of a lamp dimmer, total power isn't very much anyway so a small LC filter arrangement is used to reduce RF interference to acceptable levels.

With a high current load (a kettle element) on the other hand, LC filters become big, bulky and expensive, and may not even manage to keep the interference below an acceptable point. RF interference will be particularly noticed if a radio or a television is in proximity and more so if the device is powered from the same mains supply (which, in a caravan, it must be).

An alternative technique of power control is known as *burst fire* control, sometimes called *integral cycle* control, in which whole cycles of mains current are applied to the load in a controlled manner. To ensure the triac is only switched on at the start of a mains half-cycle, some sort of zero-crossing detector is required. Obviously, little or no RF interference is generated by this method and so no RF filter is required.

The outcome of using the ETI Hot Water System is that average current levels applied to the heating element can be chosen by the user from, say 1-10A, simply by dialling the required current on a potentiometer.

Construction

The PCB overlay of the ETI Hot Water System is shown in Fig. 3. Although construction is quite easy, there are a few points of note. First, the triac requires a substantial heatsink. At the project's maximum designed load current (10A) the heatsink must be of no greater thermal resistance than $2.5°CW^{-1}$ so the triac cannot overheat and be destroyed.

It's worth mentioning that the triac (a BT139) can

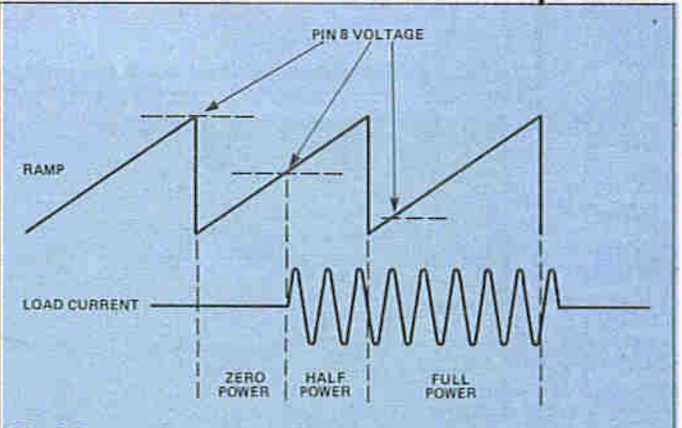


Fig. 2 Ramp voltage and pin 8 voltages, showing different power available by varying pin 8 voltage

Device	Power (Watts)	Current (Amps)
Kettle	2000-2800	8.3-11.7
Fan heater	2000	8.3
Caravan kettle	750	3.1
Toaster	1300	5.4
Microwave oven	800-1200	3.3-5.0
Colour TV	80-300	0.3-1.3
Monochrome TV	100	0.4
Battery charger	100-200	0.4-0.8
Refrigerator	125	0.5
Hairdryer	300-1000	1.3-4.2

Table 1 Comparing household appliances, power and current ratings at 240V

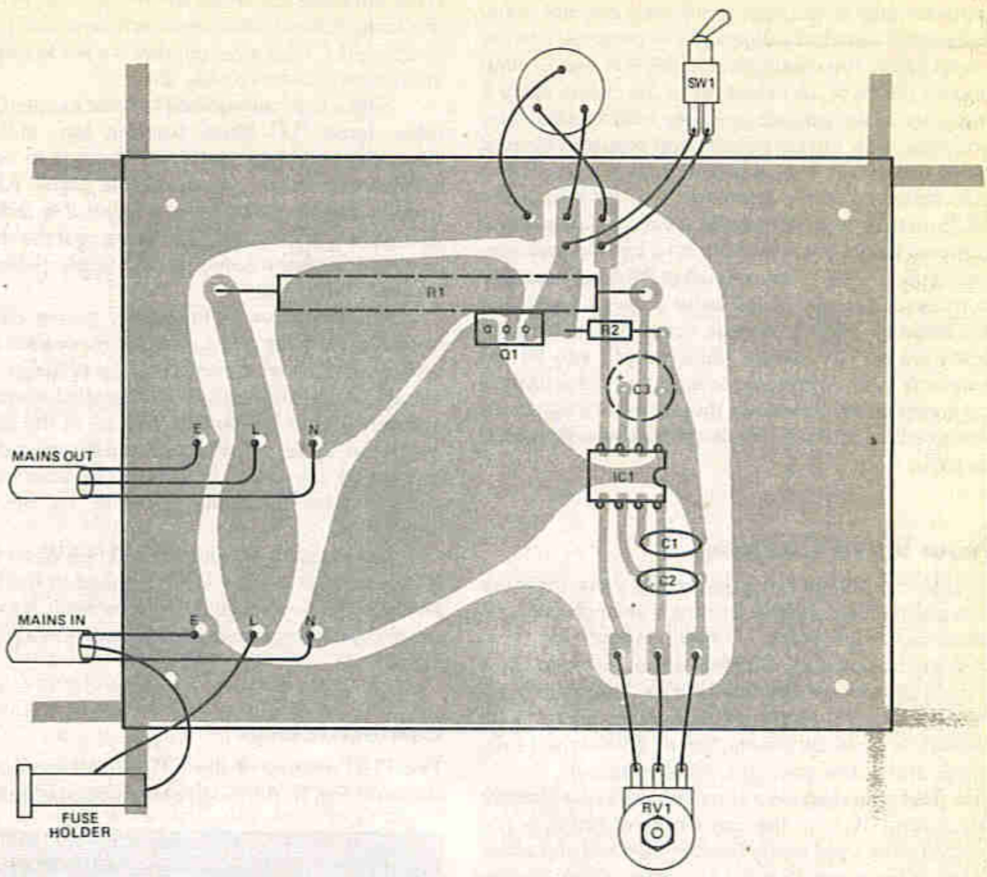
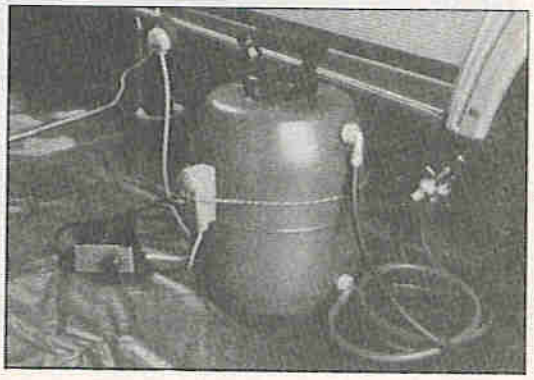


Fig. 3 PCB overlay, component layout and wiring diagram



PARTS LIST

RESISTORS (all ¼W 5%)

R1	10k 11W
R2	22k
RV1	100k lin pot

CAPACITORS

C1	56n miniature layer polyester
C2	1n5 miniature layer polyester
C3	470µ 16V radial electrolytic

SEMICONDUCTORS

IC1	SL443A
Q1	BT139

MISCELLANEOUS

SW1	miniature toggle switch

Cable glands. Knob. PCB. 10A fuse and holder. Miniature mains three-pole outlet plug and socket. Mica washer and insulating bush. Heatsink ($2.5°CW^{-1}$). Diecast case (110 × 85 × 55mm). Nuts and bolts. 13 amp heat-resistant cable. 10 amp kettle element and fittings.

control a load current up to 15A (that is, a load of up to 3600W) and so the project could be used to control such a load if an adequate heatsink (no greater than $1°CW^{-1}$) is used.

As a direct consequence of this requirement for the triac to be mounted on a heatsink a slightly unusual method of construction is used, illustrated by a cross-section of the case in Fig. 4. The heatsink must be first mounted to the top of the diecast case and the triac mounted to it before the PCB is fitted into the case. Further, not all components are mounted on the usual side of the PCB. Resistor R1 and capacitor C3 are mounted on the copper-side of the PCB — also after the board has been fitted into the case. So, the main steps of construction have to proceed generally in the following logical order:

Drill the heatsink in three places (for two fixing bolts and one triac mounting bolt) and drill the case for all fitment mounting holes — potentiometer, cable glands, fuse holder, switch, sensor socket, heatsink,

BUYLINES

All the electronic parts are fairly standard items and should be available at most electronic outlets. The particular heatsink used in the prototype is available from Electromail, although any heatsink with thermal resistance of $2.5°CW^{-1}$ or less is suitable, providing an adequate mounting method between the triac and heatsink is possible.

Kettle elements are obtained from most hardware/electrical appliance shops but vary considerably in price — shop around. The element used in the prototype cost £4.95.

Plumbing parts are available from most DIY stores and any plumber's merchants. Similarly, a cylinder thermostat will be found at these outlets (the prototype's thermostat is available from Electromail). Many suitable equivalents can be found at caravan/camping accessory shops.

The PCB is available from the ETI PCB Service.

PCB mounting bolts. Next, countersink the PCB mounting bolt holes — the bolts must not be proud of the surface, otherwise the heatsink will not mate correctly to the case top.

Fit the four PCB mounting bolts to the case and after smearing the top of the case and the underside of the heatsink with heatsink compound to ensure good heat flow, fit the heatsink to the case.

Carefully bend the triac connecting leads at right angles to the body and fit the triac to the inside top of the case. Make sure you use a mica washer and insulating bush to electrically isolate the triac from the case. Also smear heatsink compound over all mating surfaces between triac and case. Electrical isolation is imperative as the case is earthed while the tab of the triac is at neutral potential. Any electrical connection here will prevent the project from working correctly and will trip the RCCB.

Fit components IC1, C1, C2, R2 to the PCB and then fit the PCB to the case ensuring the three triac leads go through the PCB holes.

Solder the three triac leads to the PCB then fit and solder resistor R1 and capacitor C3 to the copper side of the board. Allow a space of around 6mm between the resistor and the board to ensure air flow.

Fit the remaining parts (cable glands, potentiometer, fuse holder and fuse, switch, sensor socket) then solder all mains input and output connections to the PCB and fuse holder, and connections from the controls and socket to the PCB.

Water Works

So ends the electronics construction of the project. Remainder of the construction work is plumbing — all pretty straightforward, using caravan-type and/or washing machine fittings.

The main parts of the prototype system are illustrated in Fig. 5 — new parts are labelled. This layout can be adapted to suit requirements, or totally rearranged to suit. It's all common sense, really.

First, your element needs to be fitted to some sort of tank. The prototype project, which works very well and is now in regular use at caravan sites around the country, uses a beermaker's home-brew pressure barrel. Readers may have other ideas for a suitable tank, however, you should remember the caravan's water pump (a Supersub 88 submersible pump was used in the project) exerts a fair pressure. Typically, beermaker's barrels feature a pressure relief valve of 15psi — above the pressures most pumps will generate. If you have any thoughts about using a standard caravan water container, say, a rolling barrel type of tank, don't bother! They will just not be able to maintain the pressure and will distort severely.

It's not a good idea to fit the element direct to a plastic barrel (for obvious reasons) so it's best to either fit it first to a metal plate which is then fastened to the barrel, or (probably best) use an aluminium barrel. Although slightly more expensive than plastic counterparts, an aluminium pressure barrel can be bashed with a rubber mallet to give flat areas to allow addition of the element and water inlet/outlets much more easily. Inlet and outlet connections can be made with any proprietary water tank connectors.

In Use

Not much to be said here. If you use, as advised, a 10A element, then you can simply label the potentiometer power control from 0 to 10. Then you simply dial-up the average current you require and the controller does the rest. If your element is other than 10A or if you intend to use the controller with more than one different powered elements (see later), you should label the potentiometer in percentages from 0% to 100%. A simple calculation of percentage of whatever the element's current is will suffice to ensure you don't trip the MCB.

If you use sensors like the prototype's cylinder thermostat, simply set the required water temperature, then you don't even have to go near the arrangement again. Unless you use a metal tank of some description, it's probably not advisable to maintain a temperature too high for the plastic tank. Typically, around 50°C is more than hot enough.

If your element has the same type of connector as your kettle, then you can use the power controller to boil water in your kettle, too. An alternative arrangement here is to use a standard 13A three-pin trailing socket on the power controller output lead, then kettle or water tank element can be plugged in as required.

One point to note if you intend using the controller with a kettle — the kettle cannot be a microchip-controlled one with push-button on/off switches. Any cessation in applied current automatically turns such kettles off and, as the controller works by switching on and off applied current, the kettle will therefore turn off at the end of the first applied current burst. Any kettle with a bimetallic or mechanical on/off switch arrangement or no on/off switch at all will function ideally.

ETI

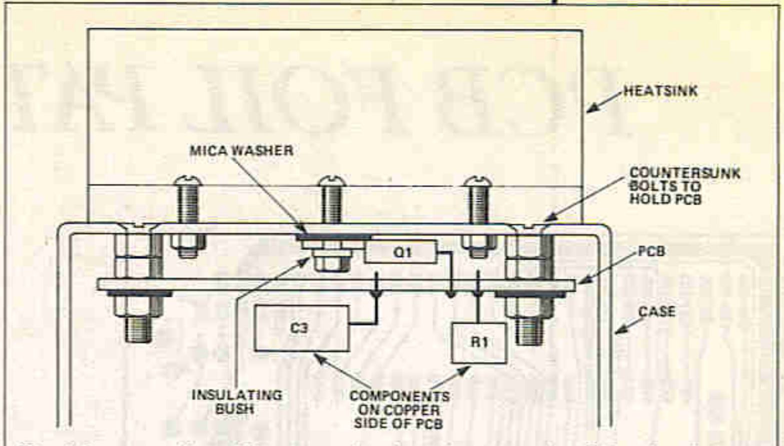


Fig. 4 Cross-section of the case, showing triac, capacitor C3 and resistor R1 mounting

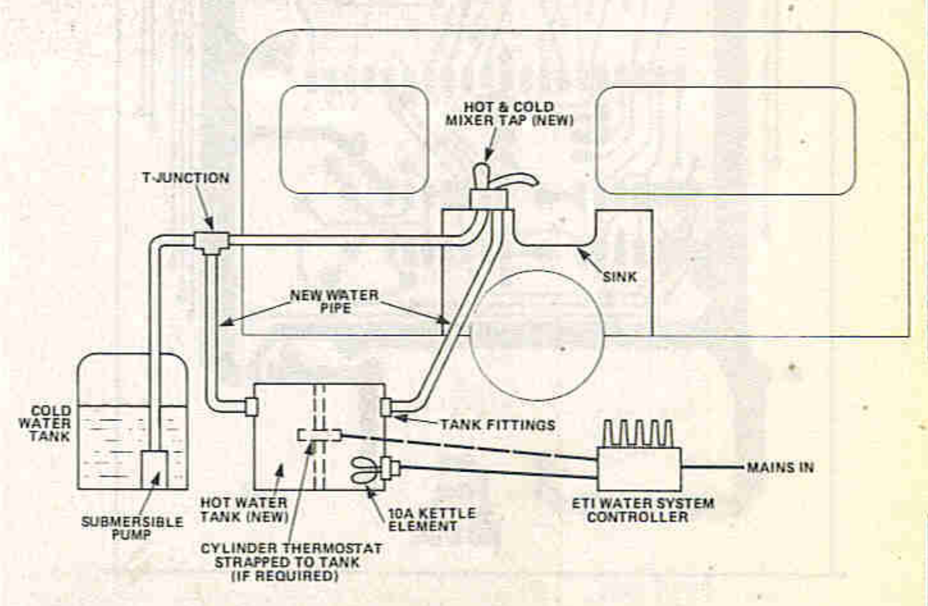
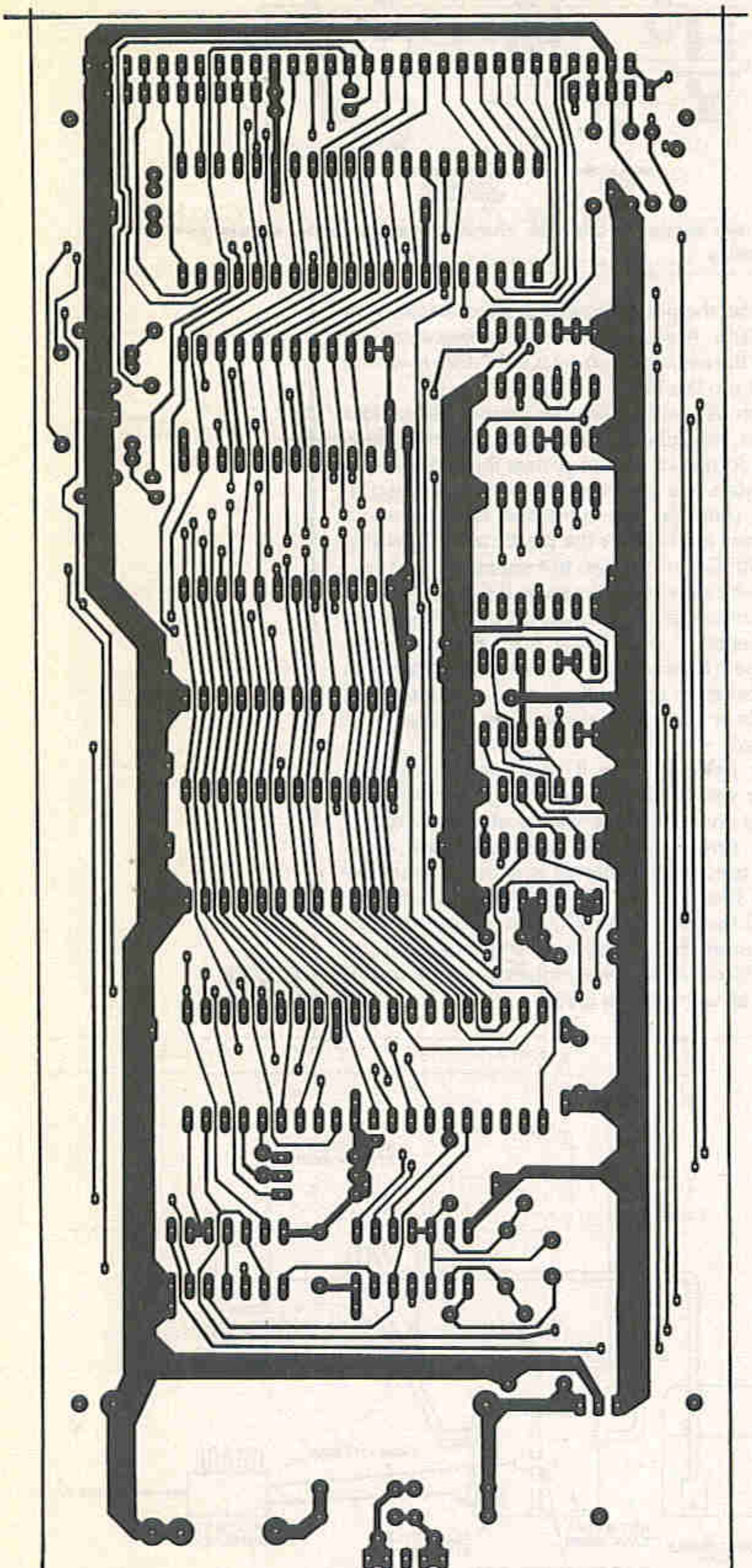
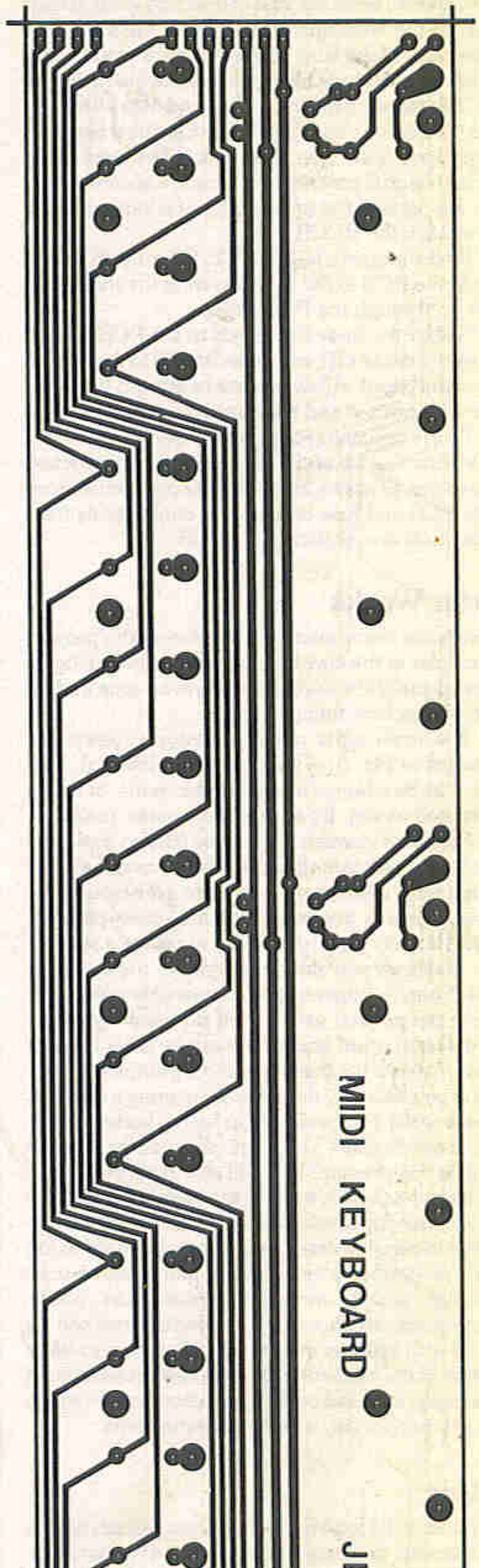


Fig. 5 Typical application of the ETI Caravan hot water system controller, shown in conjunction with a caravan's cold water-only system

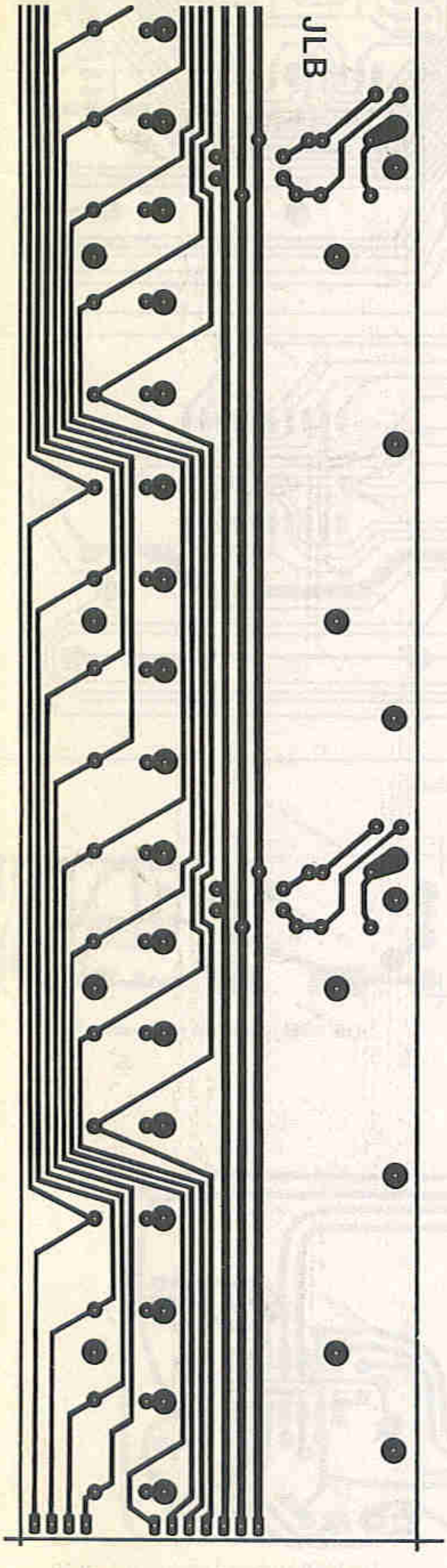
PCB FOIL PATTERNS

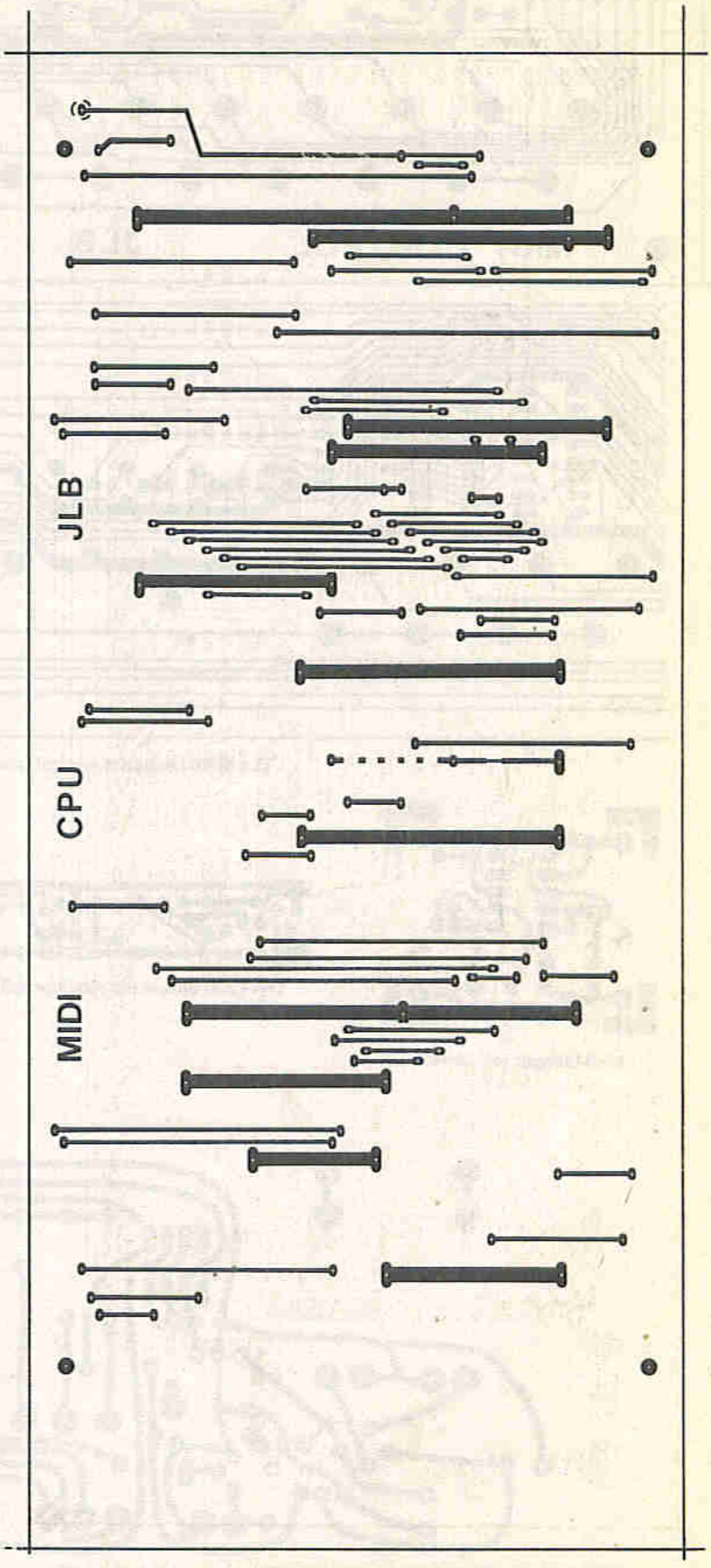


The MIDI keyboard processor and power supply foil pattern solderside

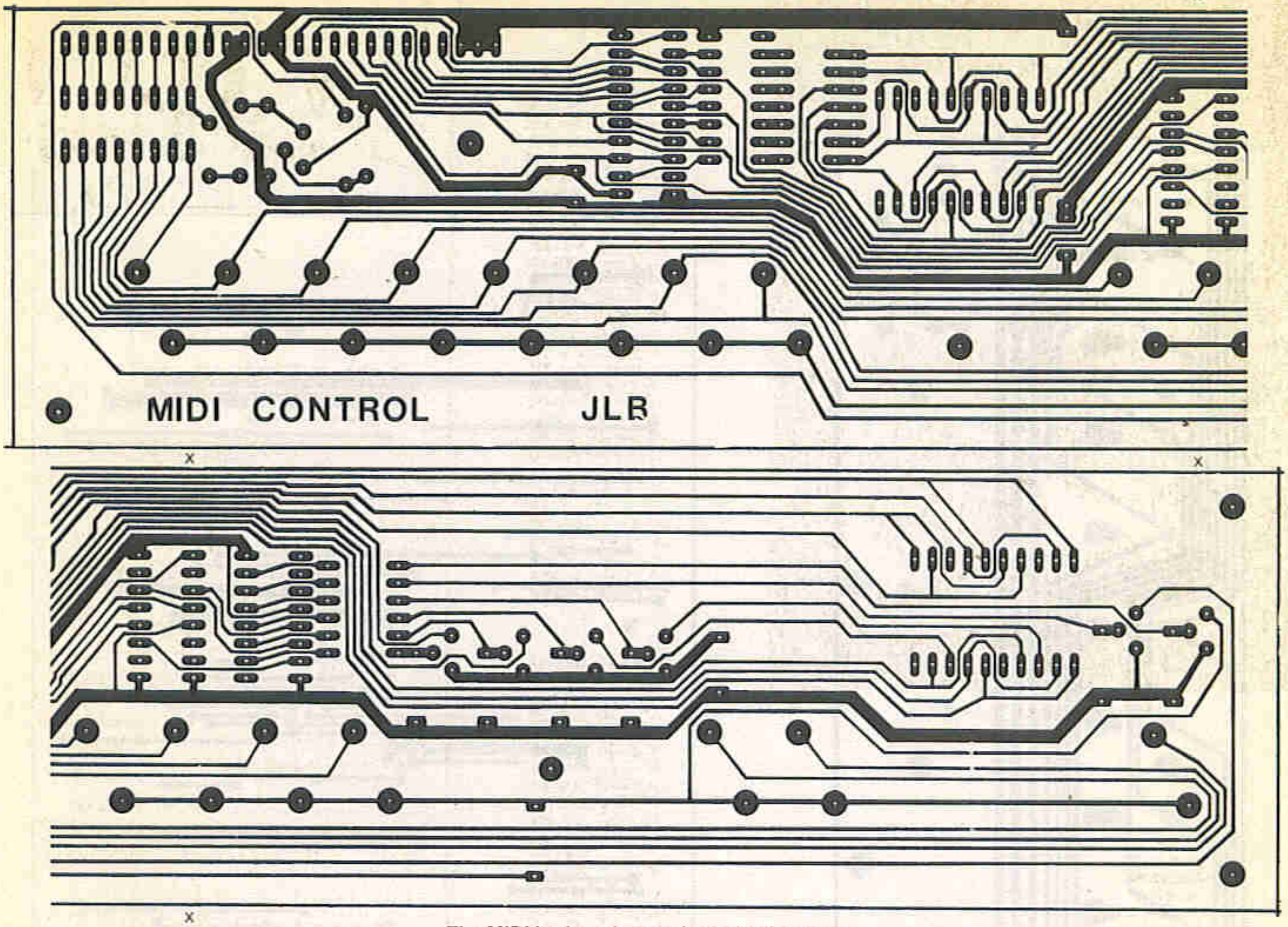


The MIDI keyboard contact foil pattern

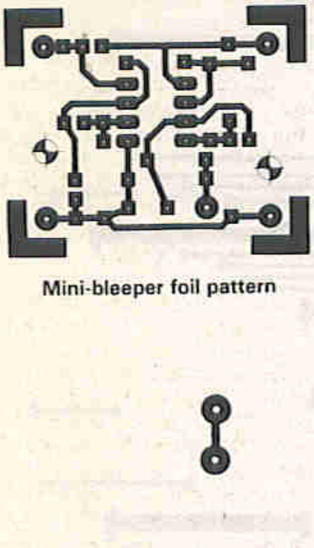




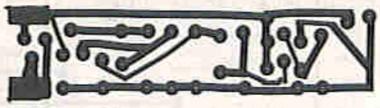
The MIDI keyboard processor and power supply foil pattern topside



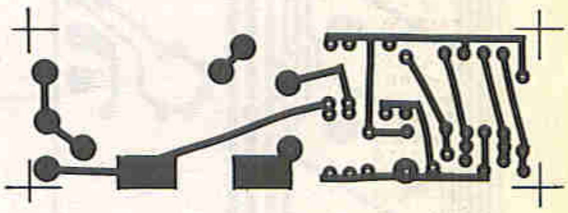
The MIDI keyboard control panel foil pattern



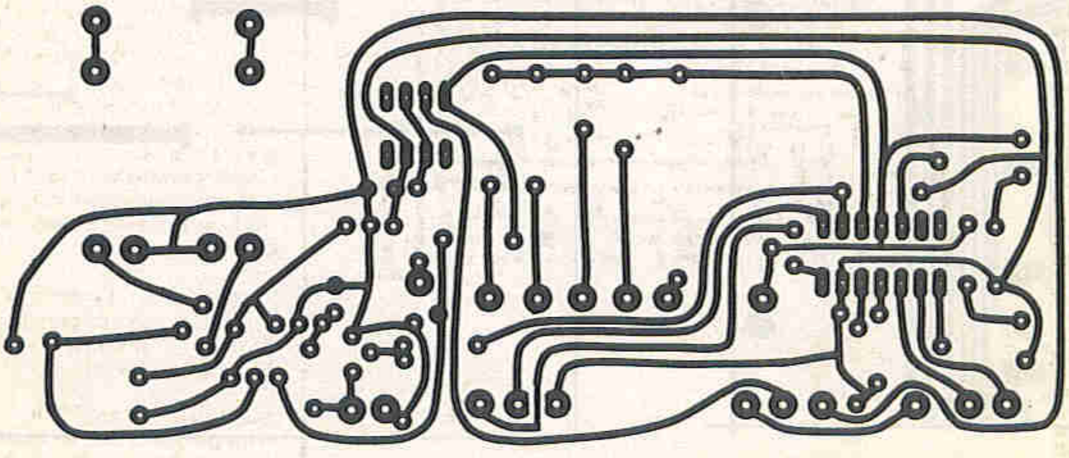
Mini-bleeper foil pattern



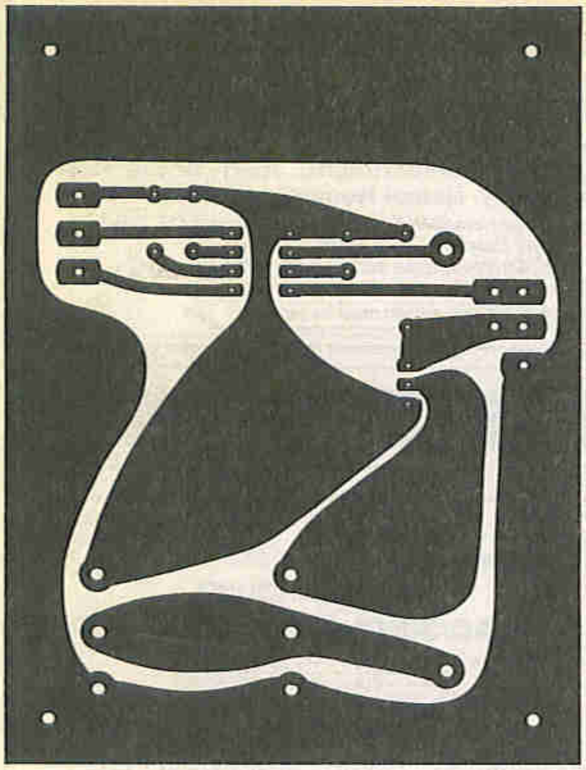
The EASi ultrasonic receiver foil



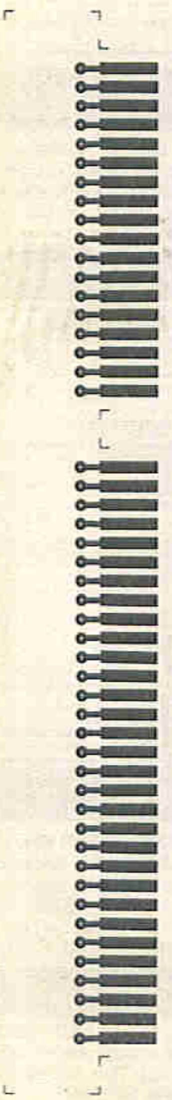
The EASi ultrasonic transmitter foil



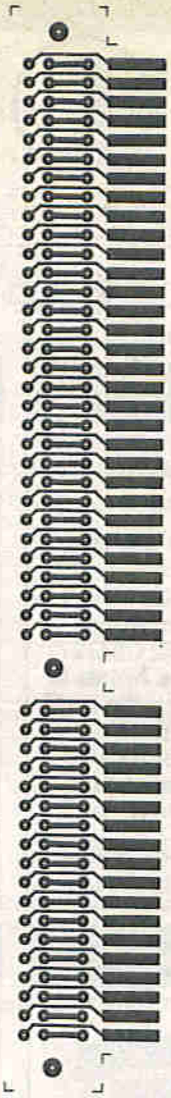
AF signal generator foil pattern



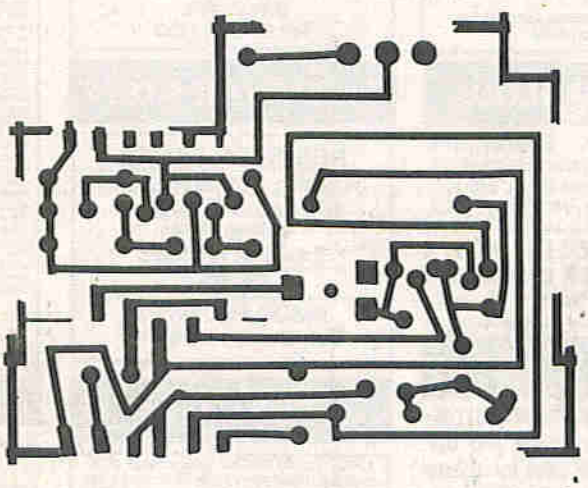
The water heater foil pattern



The PC edge connector foil pattern topside



The PC edge connector foil pattern solderside



The EASi intercom foil

OOPS!

Bicycle Battery Dynamo Backup (June 1988)
C1,2 are incorrectly given as 22µ in the Parts List. The value of 220µ given on the circuit diagram (Fig. 1) is correct.

QWL Loudspeakers (August 1988)
Some dimensions were missing from Fig. 7. The bass driver port centre should be 3¾in above the base of the baffle panel. The notches in the side of the tweeter cut-out are ½in wide. The top plate is missing from the cutout diagram (Fig. 6). This is 7×4⅝in.

EEG Monitor (September 1987)
The wiring for the switch SW1 in Fig. 5 shows all the wires for selecting Alpha and Beta waves swapped. A_1 should read B_1, A_2 should read B_2 and so on. The easiest remedy is to swap the front panel labelling shown in Fig. 6 so that the switch labelling reads Theta, Beta, Alpha.

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.

Next Month in

ETI ELECTRONICS TODAY INTERNATIONAL

The July ETI – out June 2nd

"It all comes", said Pooh in a thoughtful sort of voice, "of too much learning. Too much learning and . . ." (he looked at Owl with his sternest stare), "not enough honey."

"You ate all the honey Pooh," said Rabbit sternly. "And it isn't Owl's fault he leaves his key outside his door."

"Nor," said Owl, "was it Owl's fault that a certain honey-filled Bear fell against Owl's door locking us all in."

Pooh closed his eyes and thought. "Perhaps," he said an hour later, "We should telephone Christopher Robin and ask for help."

Owl swivelled his head to face Pooh. "It may have escaped your attention," he said, "that BT and Mercury have yet to start supplying equipment to stuffed toys."

"Dumb bear", said Rabbit.

Pooh thought again. "Then it would seem likely" he said slowly. "that we are all going to . . ." Pooh stopped, a terrified expression coming to his face.

"What?" said Rabbit. "What are we all going to do?"

"We are all going to get very hungry," said Pooh.

"Wait!" said Owl. "Someone is coming."

The three of them ran to Owl's window. At the bottom of Owl's oak tree was the 100 Acre Wood postman.

"I've brought your July copy of ETI, Owl," he called up at the relieved faces peering down.

Pooh sat down in Owl's rocking chair and sighed a very relieved sort of sigh. "Good old ETI" he said. "I've always said that learning can be a very good thing. Unless of course" he added, suddenly wondering whether postmen ever delivered honey, "one is a Bear of very little Brain."

Surveys have shown that ETI readers are not of very little brain. Nor, with very few exceptions, are they bears. So the July issue of ETI should provide plenty of learning for everyone.

We will be taking a look at the world (or should we say universe) of relativity — special, general and all — in an attempt to understand what happens when you turn your headlights on.

We examine the art of designing reflex loudspeaker enclosures and explain how to ensure the optimum shape and size is obtained before you put saw to timber.

Plus there will plenty to keep your soldering iron smoking through the summer. A multi-relay board that can be operated by any computer or equipment with an RS232 port. A deluxe TV signal amplifier. The latest beginners' project to switch the electronic camera trigger. Plus all the news, views, columns and style that you expect from your favourite electronics, science and technology monthly.

The above articles are in preparation but circumstances or blustery days may prevent publication.

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