ELECTRONICS &
Wireless world

NOVEMBER 1985 95p

Robot design tutorial

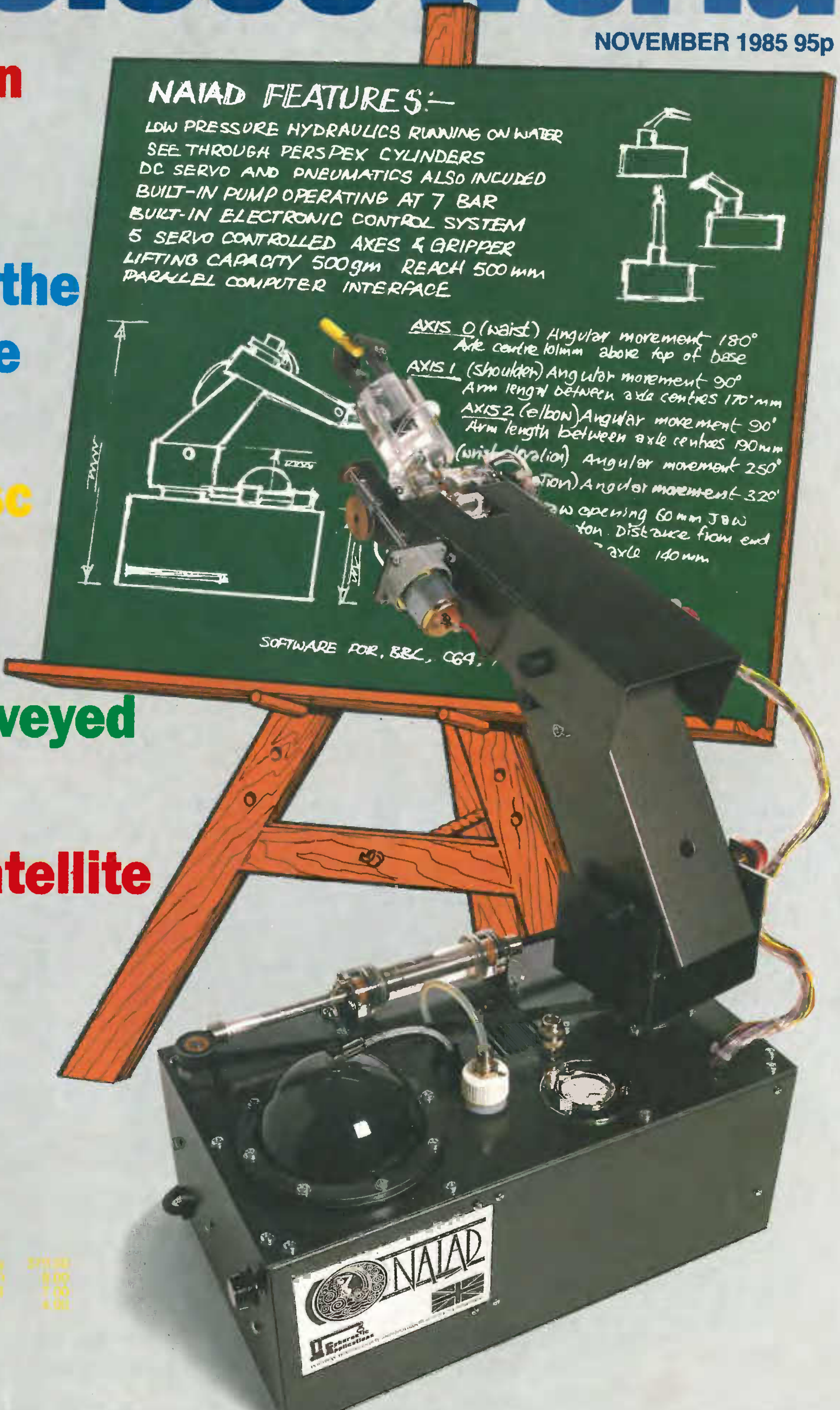
Broadening the stereo image

Compact Disc players

Modems surveyed

Receiving satellite broadcasts

Kaycomp interfacing



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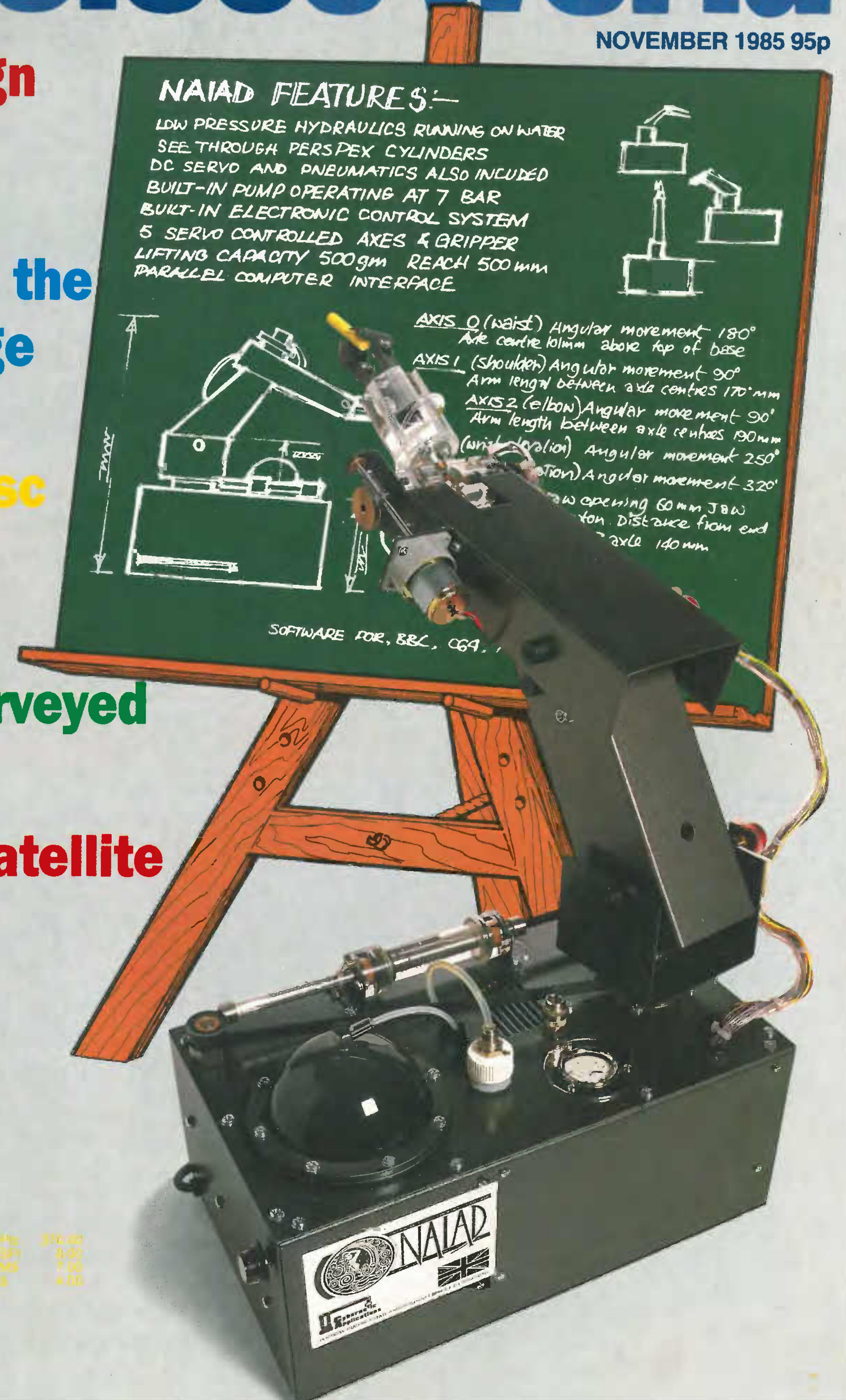

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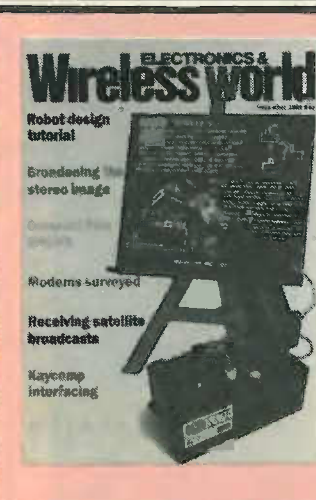
CONTENTS

November 1985

Volume 91 number 1597

FEATURES

REGULARS



Cybernetic Applications' Naiad robot, whose description starts on page 46, is a desk-top micro robot designed to give experience in robotics, safely and cheaply. Cover design by Richard Newport.

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Digital control desk

Neve's computer-controlled all-digital sound mixing desk has been incorporated into a BBC outside broadcast vehicle. Manufactured by Neve Electronics the desk is the result of collaboration between them and the BBC's Engineering Research department, whose Copas digital audio processor has been further developed by Neve and forms the heart of the new console. All its functions are assignable and it has been ergonomically designed after extensive field trials with operational staff. A large number of experimental features have been included in the design particularly the flexibility of configuration, fibre-optic communication for remote use, and digital processing mixing and routing.

The desk has four different configurations built in to it, available at switch-on. It may be used as two multi-track desks, an outside broadcast desk or a studio desk. Further arrangements can be programmed, with the configuration stored on disk to be easily recalled. The 48 faders can be single or grouped and once set up, can have their settings transferred to any bank of faders on the desk. Input channels can be used in stereo pairs or monophonically. Any imbalance can be corrected but all other functions and the faders are used in tandem pairs. Each channel can be labelled electronically and any processing module assigned to it will automatically receive the same label which will follow it even when moved about.

The desk is based on 16-bit d-to-a and a-to-d converters, but at various points the dynamic range capacity varies. The input channel is ranged within an 18-bit 'window' by the use of a system whereby the channel fader also affects the input gain. The main mixing signals are 32-bits wide to allow headroom for summing and extremes of equalization. The signal is reduced to 16-bits before the output stage. A maximum of 128 mixed signals can be produced but, unless processing is required beforehand for the control of specific groups, the mixes are not formed at all until the final output stage.

Processing racks are mounted permanently in the o.b. trailer but the control panel can be taken out and linked back to the processor by up to 150m of optical fibre. The trailer has expandable sides to incorporate an acoustically treated listening/control room with stereo speakers, v.d.u. for the Neve system, a tv monitor and additional loudspeakers. A separate area contains two Mitsubishi stereo digital tape recorders with provision for two further analogue recorders and a digital multi-track machine.

Neve have sold digital signal processing (DSP) desks to CTS Studios in Wembley, and for disc mastering, to Tape One Studios. A fourth is going to the British Library National Sound Archives and a fifth to WDR in Cologne. "The application and know-how incorporated into the desks puts Neve and Britain some years ahead of anyone else in the field" says Laci Nester-Smith, Neve's m.d. "we intend to ensure that Britain keeps this lead."

Neve's digital signal processing (DSP) desk is the first of its type in the world. It used a fast audio-processing computer to control up to 128 channels which may be assigned to any part of the desk.

After being vandalised by burglars at the Greater London Council's welfare benefits office, this Husky Hunter computer retained all its software. The l.c. display was smashed, the main p.c. board levered out with a screwdriver, the inside sprayed with 'silver' paint, and the computer appears to have been jumped on several times. Yet its stored program and data were found to be still intact and could be downloaded through the communications port. The central processor and operating system were also found to be fully operable.

More time please

While welcoming the two-year community radio experiment, the Community Radio Association is critical of its timetable and scale: "We are delighted that genuine community radio will have a chance to prove itself" says Evan Jones, chair of the CRA. "A third tier of broadcasting in Britain is long overdue and we are glad that the Home Secretary's announcements seem to exclude the miniature versions of ILR as practised by pirate stations.

"We are asking the Home Secretary to extend the deadline for licence applications to the first of December and to increase the number of frequencies available by introducing a rolling experiment. We have over 200 members nationwide, yet areas as large as Scotland are virtually excluded".

Ricky McCarthy of Brixton's Afro-Carribean Radio Project says "Ethnic broadcasters are disappointed both by the number of experimental stations permitted and by the limits on transmission areas. We want to be able to reach more than a minority of a minority."

The Association's own code of practice defines community radio as one that will "enable the development, well being and enjoyment of their listeners through meeting their information, communications and cultural needs, and encourage their participation in these processes through providing access to training, production and transmission facilities".

Computers could bridge class barriers

Educational computers are sadly underused, according to E.D. Berman, chief executive of the Inter-Action Trust. "Everywhere you look in education there is a waste of the resources", he says. "Instead of dual use of equipment between schools and youth centres, there are micros in schools sitting idle for 20 to 30 useable hours a week. Instead of joint or voluntary statutory projects, there is little or no cooperation on a systematic basis." Yet by using existing systems in various ways it is possible for young people who cannot afford to have their own computers to have the balance redressed, "we are wasting money, equipment and human talent uunder the present system."

Molly Lowell, director of the Community Computers illustrates Berman's theme: "We have visited 20 cities to show the authorities how cost-effective community computer clubs can be set up at very little extra cost: about 200 have been started up over the past two years", she says "Our computerized occupation-matching system for careers officers and young people gives choices to those who at present feel that they have no choice."

"The irony is", adds Lowell, "that only a few education authorities on their youth services have been willing to look at the potential. There is still great prejudice based on ignorance or 'techo-fear' by the generation in charge that computers simply mean games or science and maths."

Inter-Action is a charitable trust involved in the development of youth training and assessment schemes which include the Occupation Preparation Systems (OPS). They give young people an opportunity to try a specific enterprise, for example making badges, to give them a taste of a cooperative business.

Community Computers offers an at-cost service to local authorities, national youth associations and others interested in the learning potential of computer activities across the educational spectrum.

Home-designed fault tracer wins prize

Ernie Huggins with the Mole locator, which can accurately pin-point faults in telephone cables and save money by reducing the number of holes to be dug. The invention is estimated by BT to save them up to £10 million a year, of which they give Mr Huggins £2000 and a silver salver as first prize in their New Ideas competition. Huggins at 59 is a BT engineer and developed the Mole in his spare time at home.

Acorn takes a risc

A 32-bit super-fast processing chip developed over the last two years has been sampled by Acorn Computers since last April. Called ARM for 'Acorn risc machine', it has used as a second processor for the BBC Micro, but according to Acorn this is purely for software development and evaluation. While they are expected to produce a computer incorp-orating this chip, Acorn say they are interested in selling it to independent manufacturers.

RISC (reduced instruction set computer) architecture was developed in the USA but has not yet been implemented by anyone else. The Risc processor is very fast because it incorporates a simple instruction decoder. ARM has many instructions which are sub-divided into five groups. It operates at 3 million instructions per second and used as a BBC second processor is said to perform the standard bench marks over ten times as fast as the IBM PC-AT 16-bit technical computer. It runs compiled code twice as fast as a VAX11/780 microcomputer.

In brief...

Field tests for transmitting data in addition to the normal sound transmission of LBC in London are designed to show whether either or both of two different auxiliary data systems, not unlike a form of teletext, interfere with normal reception of broadcasts. Early results from the IBA investigation have shown that few listeners noticed the presence of the data signals and this small number of reports received are to be thoroughly investigated. One of the systems on trial is the Radio Data System endorsed by the EBU which is intended to provide listeners with channel identification, automatic receiver switching and other facilities, as soon as the necessary decoders become available for domestic or mobile receivers. The other service could provide information to specific interest groups on a subscription scheme.

The use of advanced manufacturing techniques in small companies in the electronics industry is to be investigated on behalf of the DTI. The results will be used to promote the greater awareness of advanced manufacturing in electronics among small firms. The DTI wishes to encourage British electronics companies to take advantage of computer-aided manufacturing to improve competitiveness in international markets, and believes that small companies can benefit from th use of new technologies including c.a.d, automatic handling and assembly, and automatic testing.

The Institute of Acoustics have developed a video course to enable student in remote centres to study for their diploma in acoustics and noise control. The scheme is based on material recorded on 35 video tapes and incorporates written assignments together with a laboratory course undertaken at a selected college. Students taking the course take the same examinations as those studying conventionally.

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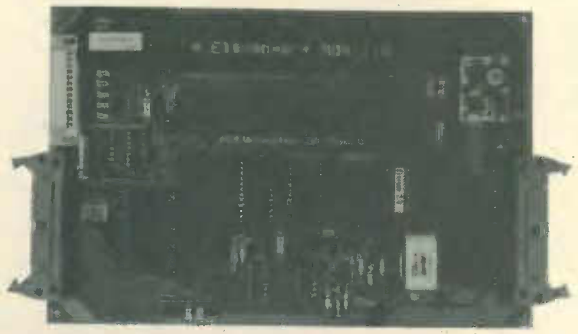

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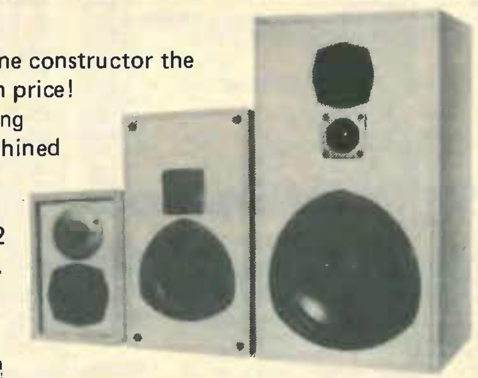

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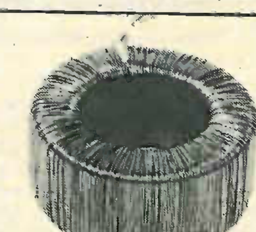
Toroidal Transformers



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Friendly r.f.

The long-drawn out controversy about the possible non-thermal biological effects of non-ionizing electromagnetic radiation continues in the correspondence columns of *The Lancet* and in the opposition of local residents to the long e.l.f. antennas due to be erected in Scotland. Less attention however is being given to the developing use of electromagnetic energy for theraputic purposes. This includes not only r.f.-induced hyperthermia which can sometimes eradicate malignant tumours but also the increasing successful use of pulsed l.f. energy for bone healing and experimentally for skin and nerve healing.

According to a recent survey by Robert Shupe and Ned Hornback of the Indiana University School of Medicine (*IEEE Spectrum*, June 1985) r.f. radiation for bone healing, since the technique received Food and Drug Administration (FDA) approval six years ago, is now widespread. It has already been used by 6000 orthopaedic surgeons to treat over 15,000 patients in the USA with a success rate close to 8%, although the bone fractures so treated had previously failed to heal over months or even years, often despite repeated surgery. Altogether it is claimed that over 60,000 patients with bone fractures have been treated by r.f. radiation in the US, many of these in the decade prior to FDA approval.

Currently two pulsed waveforms are favoured: one is a train of positive pulses lasting 200μs followed by 28μs second negative pulses for five milliseconds, repeated at 15Hz; alternatively a series of single 380μs second pulses repeated at 72Hz; both applied externally by inductive applicators. (For a detailed history of the early work see: The electrical stimulation of bone healing, by Joseph Watson, *Proc. IEEE*, vol.67 no.9, September 1979.) The reasons why weak pulsed r.f. fields stimulate bone healing and growth remain obscure, even though it is claimed that as early as 1841 it was noted that electric currents could sometimes help to heal non-union fractures. Apparently bones normally generate small pulses due to the piezoelectric effect and it has been claimed that such natural pulseds form part of a feedback system that modifies the shape and growth of bones — and this can be simulated by pulses generated externally. Other researchers, however, believe that, although the clinical value of electrical bone stimulation appears to be beyond doubt, the fundamental processes remain obscure.

In the UK, 65μs pulses of 27MHz radiation (peak power 975 watts, average power 11 watts) have been used experimentally on animals for nerve regeneration, although at this power thermal effects may have been involved. However, in the USA, similar nerve regeneration in rats has been achieved with very weak, low frequency pulses, similar to those used for bone simulation, where thermal effects would be neglible.

RF hyperthermia

World-wide experimental interest in the use of the heating effects of r.f. energy to raise the temperature of cancerous tumours has shown both the effectiveness (if carried out at an earlier enough stage) and the many problems of this technique. It is difficult to concentrate sufficient power on the more deep-seated tumours; proximity to larger blood vessels tends to result in parts of a tumour being cooled, with the result that the necessary temperature rise to kill the tumours completely (42-45°C) may not be achieved. This has led to work on 'whole-body hyperthermia' in which temperatures must by maintained above 40°C but below 41.8°C and also to elaborate computer modelling of the heating process. The combination of ionizing and non-ionizing radiation is also being used for localized heating. There is also considerable work being done on improved applicators, optimum frequencies (which are variously put at about 430 and 700 to 900MHz) etc. At 2.4GHz it is difficult to obtain sufficient depth of penetration. At h.f. it is difficult to concentrate energy on to the tumours, unless these are near the skin. Work is being done in the UK although the treatment is still considered experimental.

Two-way video

The recent formal opening of BTI's public international video conferencing service with West Germany underlined both the progress and the problems that still surround the age-old dream of the video telephone.

By using digital processing BTI can put 625-line colour pictures over a satellite link at a digital rate of 2Mbit/s. The quality, for talking heads, is more than adequate, though processed pictures degrade considerably in the presence of fast motion. Broadcasters tend to think in terms of 35Mbit/s for future international satellite links for news or sports, and over 200Mbit/s for studio operation with component rather than composite waveforms.

Bringing pictures down to 2Mbit/s means in effect that the transmission capacity is reduced to about 30 simultaneous telephone circuits compared with the 1000 or so required for good quality analogue pictures. For the videoconferencing links with North America the bit rate is brought down even further to 1.5Mbit/s and BTI have also used 768kbit/s.

For West Germany the videoconference transmission charges are £600 per hour, a cost that is reasonably economic for large multinational businesses with factories in both countries requiring frequent video conferences. The problem for the occasional user is the cost of the digital processing with the present BTZI codec (manufactured by GEC-McMichael) costing £41,000 (or £15,000 annual rental), significantly more than the colour twin monitor cabinet terminal (£29,500 six-shot, £23,700 three-shot).

Telecommunication companies, since the financial disaster of the Bell Labs Picturephone in the early 1970s, have lost faith in the original concept of the videophone but have insisted, with little practical evidence to support them, that there is a viable future for video conferencing — a television linking of meetings between individuals and groups whether formal or informal, spontaneous or pre-planned.

The history of video phones stretches right back to the gentle drawings of Albert Robida in the 1880s. In July 1936 public video boxes with 180-line 25-frame scanning (500kHz bandwidth) were opened between Berlin and Leipzig using a new co-axial cable and costing 3.50 Reichmarks for three minutes, but were less than fully utilised by the public despite being a heavily subsidised facility.

The Bell Picturephone service in the 1970s proved a major marketing disaster, the 5-by-5in, 1.5MHz-bandwidth system gave a black-and-white talking head at a three-minute cost of $19.50 from New York to San Francisco. British Telecom abandoned this concept and introduced instead their analogue Confravision service, though again this facility was under utilised and must have consistently lost money. Perhaps the national and international digital systems will prove more successful — otherwise the domestic videophone and even Robida-type public video cabinets may prove just a pipedream.

Technostress

A few years ago the consumer-electronics industry coined the word "technofear" to describe resistance to their high-technology products. They found that many people, particularly the elderly, were terrified by the arrays of knobs, sliders and other controls, welcomed by the young.

E.F. Schumacher, of "small is beautiful" fame, asked "Can we develop a technology which really helps us to solve out problems — a technology with a human face?" An IBM vice-president, however, was convinced that: "People will adapt nicely to (electronic) office systems if their arms are broken, and we're in the twisting stage now."

According to the Tokyo correspondent of *Nature*, the Japanese Ministry of Health and Welfare has recently been driven to launch a full scale inquiry into "technostress" — the stress-related and psychosomatic disorders induced by the introduction of high technology, particularly office automation.

Japanese workers, it seems, are increasingly affected by the stress of working at rhythms dictated by computers, spending hours looking at video monitors, and suffer severe loss of self-esteem if they are unable to master new equipment or find their working skills replaced by a matchbox-sized microprocessor. Medical practitioners and hospitals are finding that a high proportion of patients are suffering from stress-related diseases. The Japanese inquiry is directed towards finding out how stress, including "technostress", affects the incidence of disease at different stages of the life-cycle and the degree to which stress contributes to high blood pressure, ulcers, heart attacks and even cancer.

RDS in Sweden

The EBU-standardized radio data system (RDS) is being launched this autumn in Sweden as an operational service, initially carrying only fixed information such as programme and service identification and alternative frequency codes. In the UK the BBC is committed to introducing RDS. The IBA recently tested RDS simultaneously with an American SCA-type digital system on the LBC 97.3MHz transmissions to ascertain the extent to which both systems might affect stereo reception. During the first two weeks the presence of the data signals was not publicly announced and only a handful of listeners reported data buzz; even after LBC began announcing the tests the number of complaints remained low and appeared to be confined mostly to listeners using specific types of stereo decoder, though this remains under investigation. While RDS is seen as useful for such purposes as station identification, automatic switching, the SCA-type system, could provide, possibly on a subscription basis, financial or other information services. Subcarrier systems could also be used for wide-area paging services.

No-fault liability

As a result of Parliament recently recommending the adoption of an EEC Directive, the UK is committed to introducing tougher consumer protection legislation within the next three years. For the first time the UK will impose "strict liability" on manufacturers. This implies that, for example, manufacturers of radio and television products could be sued by users under the 'no-fault' liability already enforced in some countries should the products prove defective and cause damage or injury. While manufacturers could put forward the defence that thay had taken all reasonable steps to avoid defects, having regard to the current state of the art, — the onus of proof will be on them. This is very different from the existing situation in the UK, where, if the damage or injury is not sustained by the person who actually bought the goods, it is up to the user to prove "negligence".

Consumer protection thus seems bound to be considerably strengthened in the UK within the three year limit of the EEC Director. The existing Sale of Goods Act, which insists that goods should be of merchantable quality and reasonably suitable for the purpose for which they are sold, permits the actual purchaser to sue for breach of contract but does not extend to third parties.

Developments

Hughes Aircraft have developed an h.f. frequency-hopping system — "short term anti-jam (STAJ)" — as a retrofit kit for its existing standard tactical radio military communications systems.

West Germany is to begin to transmit video programme system (VPS) signals that enable unattended domestic video recording machines automatically to record wanted television programmes without dependence on actual time of transmission, based on teletext-type coded signals.

Philips Research Laboratories have developed an experimental 153MHz radio-paging receiver as a single chip plus 11 discrete components using direct conversion. Unlike the earlier one-chip direct-conversion pager developed by Ian Vance at STL, the Philips design incorporates the audio-frequency channel-selection filters on the chip using gyrators. It is claimed that direct-conversion chips can provide the necessary selectivity and dynamic range needed for professional pagers and are better for this application than the miniature one-chip superhet integrated circuits developed for consumer products. Direct conversion also eliminates the i.f. circuitry.

Meanwhile Motorola have added a 12-digit numeric liquid crystal display to its small pen-sized Sensar pager. The display provides the telephone number to be called and eliminates the need for the user first to call his office to obtain the number. The complete pager weighs only 1.75 oz complete with battery. Tone and numeric-display pagers have become a major, fast-growing market in the US.

Amateur Radio

DTI guide

First copies of the new 32-page booklet 'How to improve television and radio reception' began to roll off the presses at the beginning of September and copies should be available, free of charge, in the main Post Offices shortly. Part 1 is directed specifically at the householder and Part 2 and the nine appendices is "For the tv and radio dealer" called upon to identify, trace and cure problems. The booklet, which has been prepared by the Radio Investigation Service of the Department of Trade and Industry is likely to prove particularly useful to radio amateurs, c.b. operators and also to short-wave and television "long-distance" enthusiasts. While emphasis is on the high percentage of problems due to deficiencies or faults in radio and television sets, aerial leads or aerials, it does include sound advice on dealing with the problems of radio-frequency interference which arises both from domestic electrical appliances and strong local transmissions, including details of toroidal chokes, a combined braid-breaker and high-pass filter, and the fitting of ferrite beads and r.f. bypass capacitors.

The cures suggested should be fully adequate for coping with interference from legally-operated c.b. transmitters. Higher-power amateur transmissions nowadays tend to present problems mainly to audio equipment, video cassette recorders and electronic telephone amplifiers than with u.h.f. television, but the advice given in the booklet should prove useful for all but the most difficult cases of interference to radio and television reception.

28MHz opens

Sunday, October 27 is the 50th anniversary of the Sunday, October 27, 1935 when the late Miss Nell Corry, G2YL became the first person to contact amateurs in all six continents on 28MHz on the same day, heralding the approach of the 1937-38 sunspot maximum. A few long-distance contacts, including North America and India, had been made on 28MHz in 1928 in the declining phase of the earlier sunspot cycle but the band then went virtually dead for five or six years. At 9 a.m. she contacted VU2LJ Assam; at 10.30 a.m. VK4BB Queensland, Australia; at 11 a.m. CX1CG Uruguay; and then Europe, Africa and the USA all before 3.30 p.m.

In brief

The next Radio Amateur's Examinations are being held on December 2, 1985 and May 12, 1986 although applications must be made about three months in advance of these dates. City and Guilds have dropped the third (March) RAE introduced to cope with the very large number of candidates in the early 1980s.

The holding of official BTI* Morse Tests at popular amateur radio events has become well established, although the long-term future of the Morse Test remains obscure. Both RSGB and City & Guilds showed interest in taking over responsibility for the tests when BTI was anxious to give them up, but BTI have now also put forward proposals to continue providing them. The 1985 National Amateur Radio and Electronics Exhibition, organized by the Leicester Amateur Radio Show Committee is at Granby Halls, Leicester on October 25-26.

*The former Post Office tests are organized by British Telecom International.

From submarine to satellite

by Nigel Cawthorne

Equipment for communication with submarines from v.l.f. to e.h.f. was on show at this year's naval equipment exhibition.

Communication with submarines has always presented a major challenge to naval communicators. Radio signals at normal m.f., h.f., v.h.f. communication frequencies do not penetrate seawater to any useful depth. However, the energy absorbed by seawater decreases at lower frequencies.

British submarines currently receive transmissions at v.l.f. from Rugby (GBR) or Criggion (GBZ) in Wales. At these frequencies bandwidth and data rate present problems. Naval equipment uses four-channel minimum-shift keying to allow the simultaneous transmission of four 50 baud teleprinter channels on one carrier. Even at v.l.f. penetration of the sea water is not very deep. Extra low frequencies in the range 30Hz to 3kHz are needed if penetration is to be sufficient to allow the submarine to remain at a safe depth while receiving radio signals.

The Admiralty recently announced that it was looking at a site in Scotland to build an e.l.f. station. At e.l.f. antenna lengths are measured in miles: two e.l.f. installations currently being installed in Wisconsin and Michigan have antennas 28 and 56 miles long! For the Scottish e.l.f. station, the Admiralty is proposing to use a 12 mile-long antenna mounted on four-metre poles. At 100Hz wavelength is 3,000km. Classical ray theory radio wave propagation is no longer valid at these low frequencies. Even antennas measured in miles represent only a minute fraction of a wavelength at e.l.f. Global coverage can be achieved at e.l.f. with only a few tens of watts of radiated power, but because of the extremely low radiation efficiencies, several hundred kilowatts of transmitter power are needed to achieve this.

Higher frequencies

In the past, h.f. communication have played a key role in naval operations. Today h.f. radio communication provides a degree of operational independence not available with satellite systems.

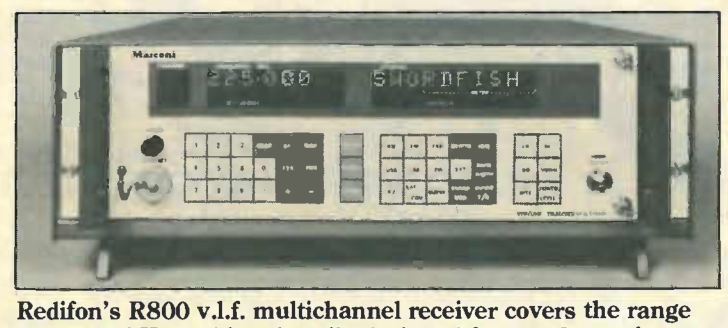
The lastest version of a wideband h.f. warship communication system was shown at the exhibition, which allows a number of different h.f. drive transmitters to feed into a common wideband 'power-bank'. The equipment, Marconi's ICS3, has been selected by the US navy for use on its new Wasp class (LHD1) assault ship — the US Navy evidently appreciates that satellites are more vulnerable to attack than more traditional h.f. communication system.

Marconi introduced a new h.f. receiver, the H2542, covering 15kHz to 30MHz and which is a development of Marconi's family of fixed station h.f. equipments, originally launched in the mid-70's as Marconi Fast Tune (MFT). Today's MFT2 range consists of an h.f. drive, and 10kW amplifiers, and the new receiver. The H2542 has a 1Hz read-out and can be used for c.w., a.m., f.s.k., s.s.b. and i.s.b.

Marconi also launched a naval marine transceiver called Swordfish designed to meet the v.h.f./u.h.f. communications requirements of smaller naval and para-military vessels.

Swordfish covers 30 to 400MHz in the three ranges 30 to 400MHz in the three ranges 30-88MHz, 108-175MHz and 225-400MHz and has an output of 100W on f.m./s.s.b. and 90W on a.m. Optional modules include continuous watch keeping facilities on the 121.5 and 243MHz distress frequencies.

Typical naval installations couple several transceivers together into one antenna, and to avoid interference from one set to another the transmitter's spurious noise output has to be very low. Marconi claim that the transmitter output at just 1MHz away from the 100W carrier is 160dB down on the main carrier.



Redifon's R800 v.l.f. multichannel receiver covers the range 10 to 200kHz and is primarily designed for naval use. As part of a contract to up-date the RN's v.l.f. facilities, Redifon are also supplying new v.l.f. transmitter drive units. EWW 300

MEL introduced their new ultra-compact h.f./v.h.f. tactical transceiver, the UK/PRC 319. The basic unit measures only 30 by 20 by 11cm and contains a 50W transceiver covering h.f. and up to 40MHz in the low v.h.f. range.

Satcoms

The launch of the UK's new defence satellite, Skynet 4, by the Shuttle in the summer of 1986 will mean that the UK will no longer need to rely entirely on US and NATO satellites for its satellite defence communications.

Skynet 4 will be carrying s.h.f. transponders for the full 500MHz of the military satcom bands at 7.25-7.75GHz (downlink) and 7.9-8.4GHz (up-link) as well as u.h.f. and e.h.f. facilities. To investigate propagation at around 45GHz there will be an e.h.f. up-link facility on Skynet 4 which will be cross-strapped to 7GHz for the down link.

The UK's previous defence communications satellite (Skynet 2) recently celebrated its tenth birthday in service. (Skynet 3 was cancelled by the government of the day before completion).

Skynet 4 will consist of three satellites, all three of which will be in orbit. Early Skynets had only 50MHz of transposer bandwidth, but Skynet 4 will access 135, 85, 65 and 65MHz-wide segments in the 7/8GHz band for use as earth cover, wide beam, narrow beam and spot beam applications respectively. There will also be a u.h.f. facility at 250-260MHz (up-link) and 305-315MHz (down-link).

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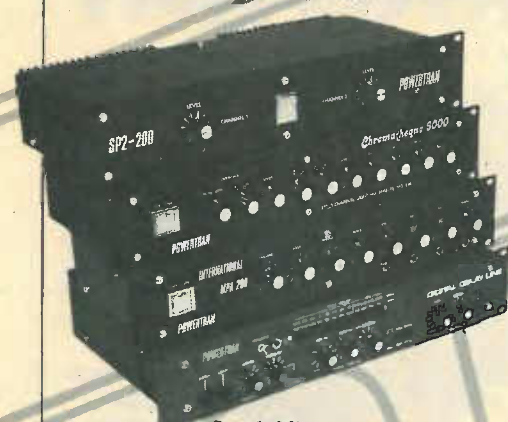

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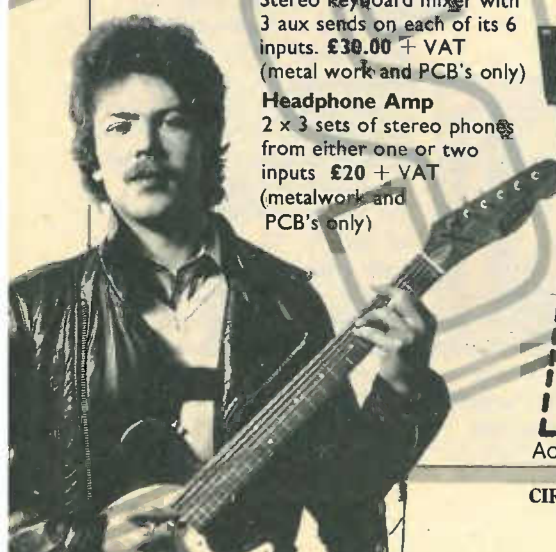

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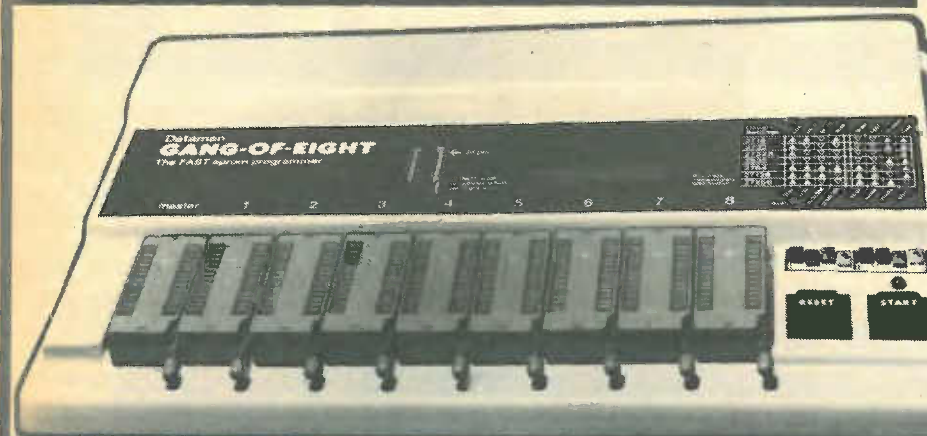

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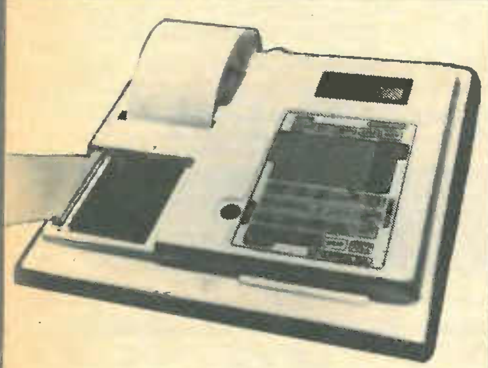

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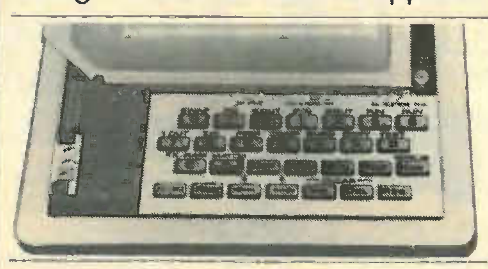

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VISA

PREAMPLIFIER DESIGN

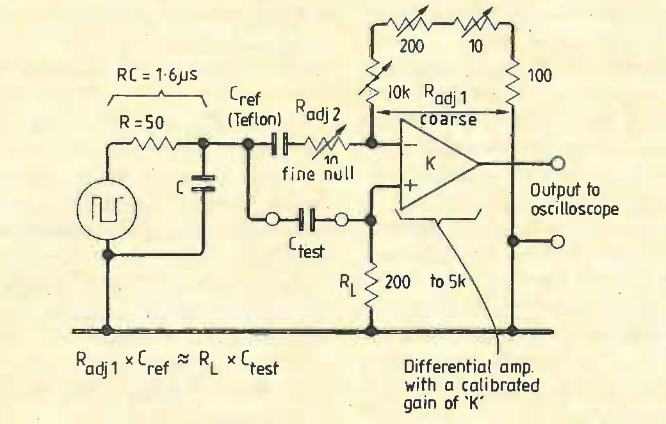
I would like to accept the challenge offered by Mr Self (*WW*, October 1983) on the question of distortion in electrolytic capacitors.

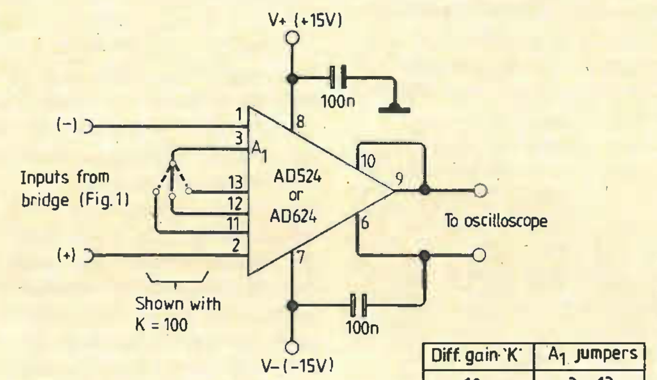
Both tantalum electrolytic and ceramic capacitors can be measured directly with a Sound Technology or equivalent distortion analyser.[1,2] The only important factor to consider is scaling the RC time constant (R being an external load resistor) to be near the measurement frequency within an order of magnitude. If one considers warp-generated frequencies below 10 Hz, many designs can be compromised by poorly chosen time constants and component selection.

Another test method uses an asymmetrical pulse of 1 to 20ms in length driving two identical RC time constants, except that one 'C' is an electrolytic and the other is a film such as polypropylene. When the outputs of these two RC time constants are subtracted from each other using an instrumentation-type op-amp (in-amp) and the remainder viewed on an oscilloscope, one can find up to 7.5% of the original pulse height that is not nullable, even after adjusting for differences in capacitance, inductance, and series resistance between the two capacitors. This test may also be performed on a Sound Technology because it has an in-amp input.

Generally the remainder will lie between 0.1% and 4%, depending upon capacitor construction, dielectric, the presence of d.c. bias, pulse width, loading and other factors. This residual is not level dependent, so any reasonable pulse amplitude between 0.5 and 10 volts can be used. Alternatively, one can use pink noise or music as a source.

Use of an Analog Devices AD524 instrumentation op-amp in a ×100 gain configuration allows one to use an oscilloscope directly without need for further amplification. The remainder is primarily due to dielectric absorption[3] although other sources of error are probable. With the AD524, differences between capacitor types and brands can be measured to less than 0.001%, allowing various film caps such as polyester and polycarbonate to be compared with polystyrene and polypropylene.





Diff. gain 'K'	A1 jumpers
10	3—13
100	3—12
1000	3—11

I hope that these test procedures will help debunk the myth that capacitors behave close to the ideal model that many engineers have chosen to accept without question.

John Curl
Berkeley
California
USA

(Letter received in April, 1984 — Ed).

References

1. J. Curl, "Omitted Factors in Audio Design," 1978 IEEE International Conference on Acoustics, Speech, and Signal Processing, April, 1978, p.66.

2. J. Curl, "Omitted Factors in Audio Design," *Audio*, September, 1979, pp. 20-24.

3. W.G. Jung and R. Marsh, "Picking Capacitors," *Audio*, February, 1980, pp. 52-62.

I would like to thank Mr Self for the details provided for the Sound Technology unit he uses for distortion tests, and for the well-reasoned letter in April *WW*. For the sake of clarity, it is probably not worthwhile arguing about connector quality — you either believe in 'good' connectors or you don't. In this regard, I notice that the telephone supplied me appears to be full of gold flashed contacts and recent electronic watt-hour reference standards used in the calibration of electricity meters use silver bearing solder connections everywhere rather than any mechanical contacts. The latter was explained to me as necessary in order to obtain repeatable performance characteristics at the level of ± 0.04% uncertainty from true. (Sangamo Type A-6 and A-7, which also features rather wonderful wire crusher thumbwheels for connection to the external world.)

As a last point, I should mention that I built a *WW* project some three years ago — the Linsley-Hood head amplifier. Being a single-ended design, it certainly needs coupling capacitors and I used the usual inexpensive Matsushita electroytics at first. This is a very good head amp. and its characteristics suggested that a parts upgrade might produce superb results. A year of searching around and cajoling manufacturers led to the procurements of some top quality Sprague 673D electrolytics, all of which I bypassed with Sprague polypropylenes in a second unit. Since the circuits are identical, it is a laugh to compare the two pre-amps. They measure the same and sound completely different to even the most casual observer, and no, the inexpensive unit is not better. Nor is it even close. So here is a case where a difference exists even between electrolytic capacitors, as common sense would expect at a 20 to 1 price differential. If it is not a distortion difference of some kind, then what is it? Since the best capacitor is no capacitor at all, I look forward to my next winter's project, which is to build Mr Linsley-Hood's designs from January 1985 *WW*. I fully expect the results will be marvellous.

In the meantime, Mr Self should not feel so threatened by what he regards somehow as attacks on his integrity. He would occasion less argumentative discussion by not appearing so pedantic in print, which is what caused me to respond to the original article and led to the current letter-writing saga. However, seeing that this epic has stimulated someone of Mr Curl's stature to examine the subject in detail, then all of us will have been well served.

W.M.B. Armstrong
Armdale
N.S. Canada

BEEB CUTS

Your article in the September issue of *Wireless World* on BBC plans to save money was interesting but not, I submit, entirely relevant to your readers.

I understand that the bulk of the cuts to be made in BBC

Central Services will fall on the engineering department, and in particular on the Studio Capital Projects Department. In common I am sure with many others, I have had many passages of arms with this department, cursing them for being over-cautious and swearing at them for over-specifying! Nevertheless I believe that they do an essential job in maintaining that technical excellence on which a large part of the BBC's international reputation rests, and it is difficult to see how the Director of Engineering is effectively to carry out his responsibilities for technical standards under such conditions.

A viable option would surely be to 'privatize' the Designs, Architectural and Capital Projects Divisions, possibly under the auspices of BBC Enterprises, and encourage them to undertake paid outside work — studio design, both architectural and technical, technical assessment, etc. — as well as making, on a properly accountable basis, equipment recommendations to the user groups within the BBC itself. One of the most frequently asked questions to an exporter is "Do the BBC use it?", and it would seem a waste not to capitalize on this reputation. Surely, manufacturers and importers would be prepared to pay for assessments which could lead to an "approved for use within the BBC" label?

Undoubtedly, as in any large organization, there are economies to be made in operation and improvements in productivity. The present proposals however are more reminiscent of "throwing the baby out with the bath-water".

P.W. Granet
Managing Director
Granet Communications Ltd.

VALVE DISC PREAMPLIFIER

With reference to recent discussion (e.g.Lewis, Feedback, August 1985) your correspondents may like to pursue a reference in "High Quality Sound Reproduction" by James Moir (Chapman & Hall 1958). In this classic textbook, he describes in Chapter 3 the experiments performed to measure the sensitivity of the ear to phase distortion, and states that with a 400Hz square wave reproduced firstly unaltered and secondly with all components above 400Hz reversed in phase but still with their amplitudes unaltered, "the change from one signal to another could not be detected by any member of a test group of 100 subjects, even when the waveform change was simultaneously presented on a cathode-ray tube and a reproducing system of the highest standard was employed"

The original work by Lane was reported in *Bell Syst. Tech.J.* in July 1930, and was completely confirmed by Moir in 1955 on up to date equipment, and reported in *Wireless World* in April 1956.

While not wishing to infer another explanation, I feel it is necessary not to fall into the trap of assuming a theory, especially when original published work exists.

It may be that work designed to measure group delays and non-linear phase characteristics in the recording/reproducing chain would throw some interesting light on this problem. Moir does point to Steinberg's work on phase distortion on telephone quality reported in the same volume as Lane's work, implying a different effect on sound quality between linear and non-linear filters.

P.W. Small
Cambridge Automation
Haverhill
Suffolk

LOGIC SYMBOLS

With all the recent letters regarding the shape of gates and flip-flops, I am surprised that no one has commented on the use of mixed logic notation in circuit diagrams. Leaving aside the debate on the shape, I have used four different systems in my brief career: using mixed logic can decrease the complexity and turn a circuit diagram into a logic diagram.

The de Morgan translation of gates is carried out automatically as mixed logic is used and the circuits' logic becomes easily understandable as it is reduced to its basic And, Or and Not components. Thus the diagram's main function is to communicate the logic flow of signals between gates and not the interconnection route of wire or p.c.b. tracks.

One disadvantage is that a Nand gate, for example, could adopt an Or shape but any good circuit diagram should contain device type and p.c.b. reference number.

So come on, *Wireless World*, set an example and lead the way, adopt mixed logic convention and, at the risk of more readers' letters, the new rectangular shapes!

A.G.H. Sibley
Abingdon
Oxfordshire

The proof of the pudding is in the eating. Have you tried to quickly sketch out a new circuit using them? Life is too short. They only convey useful information after all the numbers and letters are filled in. This is not necessary with the old curvy pointy symbols with knobs on, or with say a latch or monostable since the map is the message. (Apologies to the late great McLuhan.) Long may the wiggly resistor reign over the boring box!

The old symbols are practical for real use. A circuit can be recognised at a glance (if reasonably laid out), and only when exact diagnosis is required does one need the pin numbers.

The new ones are only good for plotting on cheap v.d.us and dot matrix printers with limited graphics programs, they are not usually easy to read because all information is presented at the same level and the reader suffers rapid brain fatigue.

On another tack, I thoroughly applaud your "Every word a pearl?" in the August issue. Most people use too many words and kill the meaning with cleverness (I know, I do it too!). Then again too many people seem to take a manufacturers application note, maybe two paras and a circuit, dress it up with a box and lights, and then publish with two pages of waffle. So please keep up the supply of genuine pearls!

R.F. Stevens
Ickenham
Middlesex

WIRELESS?

Mr John Beud (Letters, September) has an ally here. Although I cannot claim his length of experience, I have derived much pleasure and great fascination from wireless for some thirty years, starting as a youthful enthusiast of eleven or twelve.

It seems to me that the subject of your masthead has now divided itself naturally into two separate areas, and I would add a strong plea for those of us who still remember 'real' wireless not to be forgotten. I have long had a growing suspicion that the move towards totally semiconductor electronics has involved a certain general and self deception. I do not for a moment deny that many hitherto inconceivable wonders are now possible, and I regularly use several of them, but I believe that there has been a certain discharging of babies along with the bathwater, and that we have lost much in terms of simplicity, efficiency and plain old-fashioned quality.

Mr Beud selected communications receivers for comment. Apart from totally agreeing with his comments, I find it interesting that the same issue reviewed a number of contemporary receivers. I could afford none of these, except possibly the little Sony, and in fact I have its predecessor, the ICF2001, which I find a disappointment. When I recall spending £2 in 1955 on a ninety-ninth-hand Hallicrafters S38 my disappointment smoulders into frustration. This little set, modest even in its day, would let me work just about every part of the globe — and all on 50 feet of aerial between the apple trees. I still occasionally produce a small valve receiver for some latest plot, and they never disappoint me in their results. Looking at the prices of those receivers reviewed as being useful to the enthusiastic amateur, I am finally convinced that a small company producing good simple a.m./f.m./s.s.b. valve superhets to sell at a realistic price would soon flourish. Any offers of help to launch it?

In other areas too, we neglect thermionics to our own loss. I recently rediscovered the space-charge electrometer valve, and was delighted to find how very good it is compared with the f.e.t. and how much more environmentally tolerant it can be.

Pat Hawker (Communications Commentary, Sept.) mentions growing enthusiasm for old style transmitters. Mr Beud and I are shouting the praises of old-style receivers. Perhaps we should all start the Campaign for Real Wireless. Certainly some editorial fodder for the more traditional souls would be welcome. Best of all, it might do much to remove the 'black box' attitude prevalent among many of today's younger constructors, and encourage a genuine and intelligent interest in the fundamentals of wireless, as opposed to semiconductor theory. Sealing wax and string are out of fashion now, but it is salutory to remind ourselves of the many great discoveries and discoverers associated with this approach, where the apparatus rather than the understanding was improvised.

Jeremy Ahern
Ystradgynlais
Powys

The letter from John D. Beud in the September issue highlighted the difficulty not only of obtaining some quality valved communications receivers of yesteryear but also the problem encountered in obtaining relevant technical information. An example of my own experience may be of interest to readers.

When I wished to obtain a manual for the US military R388/URR receiver of 1952 vintage I wrote to two specialist suppliers. The first, who advertises in the amateur press, quoted a figure of £9.95. However, it was stated that delivery could be as long as a month and if the item could not be located a search fee of £1 would be deducted from the refund. My second inquiry resulted in a quote of £3 for the official manual plus 70p postage and it was supplied within a matter of days.

Technical information for the BRT 400 is available for £3.25 plus postage as above from A.J. Brooks, 5 Farrant House, Winstanley Rd, London SW11 2EJ.

I am searching for anyone who can supply parts for the apparently defunct Ferrograph series of recorders. If any information is to hand there may well be others who are in the same position as myself and who would welcome the publication of a supplier's name and address.

Hilary Humphries
Newmarket
Suffolk

Parts for Ferrograph equipment can be obtained from Audio Video Marketing, Units 20/21, Royal Industrial Estate, Jarrow, Tyne and Wear. NE32 3HR — Ed.

RELATIVITY — and NOSTALGIA

Since I have been mentioned by name, I think I should respond as best I can to the question about relativity, but the letter from George Lewin stirs some ancient memories. While still at school I was given a stack of back numbers of *Wireless World* (long ago disposed of), so I should be interested to know when it first appeared. Professor Townsend was a great man in his day, which was probably 1915 when his book on Electricity in Gases was published, but I do not think he would ever have been interested in relativity: he disliked thermionics and vacuum techniques and goodness knows what he would have made of out present solid-state technolgy. The lecher wire oscillator was run at 900 volts because, so it was said, someone thought 1000 volts would be dangerous!

Various formulae of relativity theory have been confirmed experimentally. The increased inertial mass of a particle moving at a velocity comparable with the velocity of light is sufficiently apparent from work with particle accelerators and the interchange of mass and energy from nuclear reactions. The 'curvature of space' in the presence of matter, which is predicted by general relativity, is said to be confirmed with an accuracy of 0.3% by bouncing a radar signal off a planet as it is about to pass behind the sun. There has been the experiment of sending an atomic clock round the world from West to East in a high flying jet aircraft while a similar atomic clock was flown round from East to West. The two showed a small difference in time after the experiment, a difference which agreed approximately with that predicted by relativity. Einstein's general theory of relativity, as well as some other post-Newtonian theories of mechanics, postulates the existence of gravitational waves which several laboratories are looking for but none is believed to have found as yet. (There is, however, indirect evidence from astronomical observations, namely that the loss of orbital energy from a certain binary star could be accounted for by energy carried away in gravitational waves). That is all I know about relativity, so may I now pass the buck to Dr L. Essen, formerly of NPL, who has taken much more interest in relativity than I have.

D.A. Bell
Walkington
Beverley

ENERGY TRANSFER

Since Ivor Catt has questioned the normal view of electric current, I would like to mention a problem which has troubled me since my student days, relating to the Hall effect in p-type semiconductors.

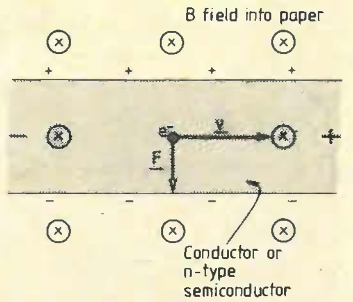
A charge Q moving through a magnetic field B experiences a Force $F = BQ\,v\sin\zeta$ where is the velocity of the charge and is the angle between the velocity and the field, with the direction of *F* given by Fleming's left-hand rule.

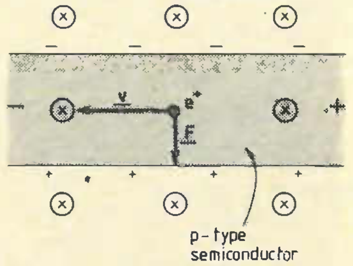
It follows that when a negatively charged electron is moving along a wire through a perpendicular magnetic field, it will be forced to one side of the wire as shown in Fig. 1, where a current-carrying wire acquires a Hall voltage. Once this voltage is established, the electrostatic force balances the magnetic force. This works equally well in the case of n-type semiconductors. However, in the case of p-type semiconductors the measured Hall voltage is reversed. This is said to be because the majority charge carriers are positive "holes" moving in the opposite direction, as shown in Fig.2. My problem is that no positive charges actually move; it simply appears that they do, in the same way that a "free seat" appears to move backwards along a doctor's waiting-room queue, as patients (electrons) move one place forward when the space (hole) is immediately in front of them. In fact, the patients are moving forward and nothing is moving backwards. A force cannot push against nothing.

Even if one believes that a force can act upon a massless "hole" (which Newton would find difficult), whenever the hole moves one step one way, an electron would automatically be moving the other way at the same speed, therefore presumably experiencing the same force, the two effects cancelling and the nett Hall voltage being zero.

My interpretation of the established theory doesn't agree with experiment.

R. Petzeratt
Brighton





Following the debate in *WW* concerning the nature of electric current, Ivor Catt has shown that the establishment explanation of electric current, consisting of moving electronic charges, is anomalous. However, it may be that the reluctance of many readers to accept these anomalies is due to this explanation being so closely associated with the model of the atom with which we have all grown up. If the established theory of electric current is indeed inextricably linked to this model of the atom, so that if one fails the other collapses, it might be useful to look back again at the roots of this view of the atom.

Following Dalton's atomic theory of 1803, the atom had been regarded as the smallest possible particle of matter. However there was a disagreeably large number of types of atoms (elements) on the Periodic Table, and it seemed sensible to look for something more fundamental. Simple atomic structures were devised, starting with the "plum pudding" atom, and later the "nuclear" atom of Ernest Rutherford in 1904, according to which all atoms were built of a nucleus containing protons and electrons surrounded by a system of orbiting electrons. The attractiveness of this atomic model was largely due to its overwhelming simplicity. It replaced more than ninety "starting points" with just two. The theory won over the establishment, so that later, despite modifications of structure by Nils Bohr and others, the two particles remained.

Armed with this model, physicists soon investigated the atom further, and found that various loose ends didn't quite tie up. In order to save the theory, just as Thomas Kuhn describes in "Structure of Scientific Revolutions", extra *ad hoc* hypotheses were added to the original theory. Physicists made their names by discovering new fundamental particles, behaving as scientists in the Kuhnian "Normal science" mode, each particle being just right to plug its particular gap. Today, on top of the original two, we have collected a veritable zoo, including neutrons, photons, positrons, neutrinos, pions, muons, nuons, and other strange particles which refuse to behave as they ought, plus all their anti-particles, not to mention the speculative gravitons and tachyons, giving us a total of well over thirty.

If Rutherford had originally proposed this many fundamental paticles with such peculiar properties, however well it performed, it would have been rejected as absurd, and physicists would have sought a better answer. More recently, dissatisfied physicists have made somewhat abortive attempts to build these "fundamental" particles from even more fundamental "quarks", but seldom has anyone seriously questioned whether Rutherford's basic idea could have been wrong.

Oliver Fish
Hove
Sussex

One notices how many contributors to Mr. Catt's enquiries into the existence, or otherwise, of electric 'current', have been folk steeped in line-transmission knowledge. And who as such have been able to clearly distinguish between R pure and simple, and the R+jx aspect of practival transmission system.

The question which has been lodged in the writer's mind, ever since Mr Catt lauched his views, is "what is the behaviour of a long line when subject to low-temperature super-conduction conditions"? always supposing any source of an applied e.m.p. is sans either 'R' or 'R+Jx'. One imagines the velocity of propagation would be equal to that of free space, but what of phase ange considerations?

First go to Mr Catt please.
Ouida Dogg
Hurstpierpoint
Hassocks
West Sussex

LIGHT, DISTANCE AND TIME

While I hate to add to your magazine's no doubt lengthy correspondence on special relativity, Alex Jones' letter (Sept. 1985) calls for a reply.

Whilst I wholeheartedly agree with Mr Jones' sentiments concerning some of the basic errors present in "standard" relativistic theory, and feel he should be congratulated on correctly dealing with most of them, there are a few points that he omitted, notably the flaw in Einstein's second postulate.

Not only is it impossible to satisfactorily explain why or by what mechanism the velocity of light should choose to remain constant in all frames of reference, but a cursory examination shows that Einstein, apart from showing an understandable topological naivete seems to have forgotten what a velocity actually is.

The velocity of light in a given direction, as opposed to its speed, has never been measured and it is probably a basic law that it never can be, certainly not by the there-and-back experiments performed at the end of the last century to determine the existance of the aether. These measurements could only give an average of two opposed velocities that would be a constant whatever the relative motion of the aether (which can be used to equate energy with length, yields new equations of motion for the regions where the abbreviated $E=0.5mv^2$ is no longer accurate enough, and allows for the expansion of space by radiated energy).

The other fatal flaw is (as Mr Jones nearly says) in Einstein's use of Cartesian geometry to formulate his equations. Using a polar system more suited to coping with observations made from a given point and discarding his incorrect use of the Lorentz transformation (which relies on a fixed velocity of light), the result is a simpler equation for the time-dilation effect, which has it that clocks moving towards the observer run fast, clocks moving away run more slowly, and that those that are "stationary" or moving at constant distance from the observer stay in sync. — exactly the same results that you would obtain using temporal perspective, The Doppler-Fizeau effect or plain common sense to calculate the "apparent", and "non-relativistic" time-shift on moving objects.

E. Baird
Isleworth
Middlesex

CAUSALITY

Although somewhat belated (February 1985 issue of *EWW*) this is an acceptance of a challenge made in that issue. ". . . if there are readers of this journal who can see a way around the strongly held view that "the necessary connection" exists only in the human mind. (News Commentary, p.6.) This issue concerned the existence or non-existence of necessary connections between physical events in nature such as a force-e.m.f. and a current flowing in a wire. The present view of Hume-Ayer etc. is that there is no such a link between separate events and that only a constant conjunction of such discrete events is observed.

A concrete example of a necessary connection between an e.m.f. and a resultant current flow illustrates this. The physical necessity lies in two forms in such a case: (1) that of the physical link between an e.m.f. and the current flow; and (2) most of all in the form of mathematical laws governing the whole casual chain of physical events. In the first form modern quantum theory shows that a physically real, detectable photon of radiation links the external electromagnetic field to the flow of a current, usually as a flow of free electrons (this is debatable as to the nature of current). This secures the physical bond between cause, external e.m.f., and effect, current flow in the wire. But a Human could reply here that there is just a finer cause-effect relationship here, i.e. e.m.f. -Photon-electron motion. And this is where the reply of (2) in terms of mathematical laws is crucial.

It is a historical fact that the extreme empiricism of Hume-Ayer etc. is limited both in its reliance on common experience and especially on the logic of ordinary language. And here is where that school makes its gravest error re scientific law. It assumes with Aristotle that laws are of the form, 'If A, then B' or equivalently 'All A's are B,' the generalizations of logic. But as Galileo pointed out and Newton repeated, nature follows and laws of mathematics and not the sterile tautologies of philosophers. In the language of mathematics as applied to nature one finds that necessity not found in mere tautologies, and which binds events into a net of necessary relations. It is only when the philosophers of tautology go to work on the notion of natural necessity with their *a priori* logical model that nature gets bifurcated into an irrational constant conjunction of events, on the one hand, and a series of empty tautologies, on the other hand. This is the fatal divorce that makes so much of modern philosophy of science into an empty scepticism or a hopeless relativism of language systems.

G. Glondeau
Canmet, E.M.R.
Ottawa, Ontario
Canada

Letters
Letters for publication are always welcome, but the shorter and pithier, the better. I try not to edit original letters, but sometimes they are far too long, and therefore cut, and the writers upset. Please keep your letters short.

by J.F.C. Hastings

Satellite receiver design

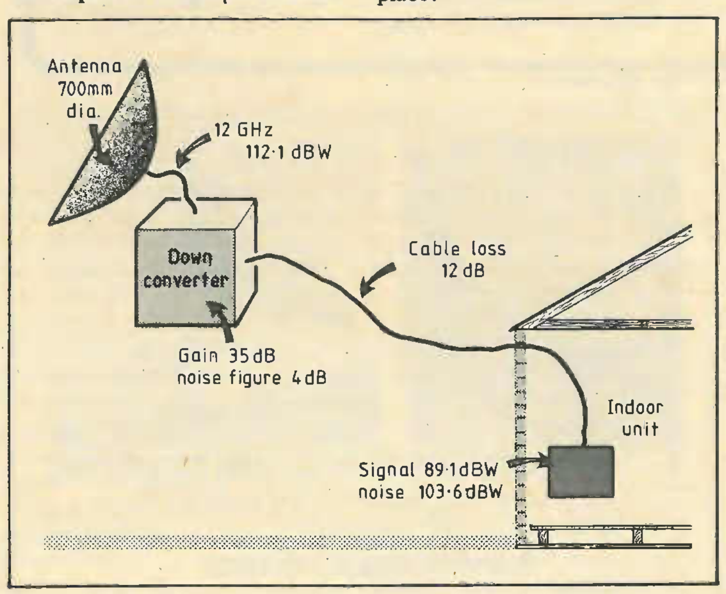
Through direct satellite tv broadcasts by Britain may still be some way off manufacturers are readying receiver designs.

Under the World Administrative Radio Conference plan of 1977, forty channels are assigned to the 800MHz-wide band extending from 11.7 to 12.5GHz. Each country taking part is provided with a service area tailored as far as possible to suit the country concerned and the plan has been so arranged that the channels allocated to any one country (usually five) all fall within one half of the band. This means that the tuning range of the receiver need only cover 400MHz, although in some cases the full 800MHz might be desirable because reception of transmissions intended for other areas might be required.

The satellites occupy a number of positions in the equatorial plane, but the transmissions intended for any one country all come from a satellite at one position. The receiver can therefore operate from a fixed antenna without need for tracking.

John Hastings is a senior engineeer with Thorn EMI Ferguson's advance study group.

Fig.1. These figures relate to the expected signal level at the edge of the services area. The level of −89.1dBW corresponds to 303μV at 75Ω.



Receiving system

Although other types are possible, it is likely that the antenna will take the form of a parabolic reflector and waveguide feed.

The first part of the receiver will be bolted directly onto the antenna, avoiding the inconvenience of a long waveguide into the building. This part will consist of a down-converter changing the signal to a frequency in the range 1 to 2GHz. It may then be fed via inexpensive coaxial cable to the remainder of the receiver, usually known as the indoor unit.

The present state of the art dictates that the oscillator in the first frequency changer is fixed, so that the signal fed down to the indoor unit must occupy a band at least 400MHz wide. Station selection will be accomplished in the indoor unit, where a further frequency conversion takes place.

Antenna sighting

The boresight of the antenna must point directly towards the satellite and a line of sight to it must exist. Because the satellite is placed in the plane of the equator, the elevation angle becomes lower for positions farther north on the earth's surface. Both elevation and azimuth angles depend on the angular position of the satellite. The Table shows elevation and azimuth angles for 0°W and 51.5°N (roughly corresponding to London). The UK satellite position is 31°W giving an elevation of 24.35°. For locations farther north this reduces, and a typical figure for Northern England is 22°.

The antenna does not have to be on the roof as is often assumed. Despite the low angle, it will be possible to mount it on a south-facing wall in many cases, provided that the diameter does not exceed the 0.9 metre maximum envisaged for domestic installations.

It may also be possible to mount it on the ground, although precautions would have to be taken to avoid damage by children or others. Even a small dent would seriously affect the performance: the contour must be maintained to a small fraction of the wavelength (25 mm).

Noise performance requirement

First of all, it is necessary to consider the carrier-to-noise ratio required by a discriminator. For a normal type of limiter and discriminator combination without threshold extention, this is about 10dB for a satisfactory standard of performance. To allow for impairment due to errors, and atmospheric conditions, it is more usual to assume 14dB in practice.

Considering a matched source and load, the noise power in the load is kTB, where k is Boltzmann's constant, T is the absolute temperature (normally 290K), and B is the bandwidth. This is valid where the load generates no noise of its own. In a practical case T is taken as an inflated figure calculated from the antenna temperature and noise figure of the down converter as follows:

$$T = T_a + (F - 1)T_0$$

where T_a is the antenna temperature, F is the noise figure and T_0 is the reference temperature of 290K. A practical antenna temperature is 160°K and a typical noise figure is 4dB or 2.5 times, giving a T value of 595°K. Translating this and the other units into decibels relative to the units concerned gives

temperature	27.7dBK
Boltzmann's const	−228.6dB
27MHz bandwidth	74.3dBHz
	−126.6dBW

Signal power

It is clear that the signal power must be −112.6dBW, i.e. 14dB stronger. According to the WARC plan, a minimum power flux density of −103dB relative to 1W per square metre (usually written as −103dBW/m²) should be provided in the service area. Assuming a suitable size of parabolic reflector for home use is 70cm, and an efficiency of 50%, the signal power may be calculated as follows:

Power flux density	−103dBW/m²
area 0.385m²	−4.1dBm²
efficiency	−3 dB
errors	−2 dB
signal	−112.1dBW

This is 0.5dB greater than the figure calculated above, but as discussed later, the carrier-to-noise ratio is further degraded by noise from the indoor unit.

Figure 1 shows the levels according to the calculations made so far. An overall gain of 35dB is assumed for the down converter, provided in part by gain at the first level. The cable loss of 12dB corresponds to about 20 metres of normal 5mm diameter coaxial cable.

In spite of the gain of the down converter, the signal level is only −77.1dBW, making the system susceptible to interfering signals.

Choice of first i.f.

The danger of interference means that the choice of 1st intermediate frequency is important. It is essential to avoid frequencies occupied by terrestrial tv transmitters, which means that it must be placed above 860MHz. On the other hand, if the frequencies chosen are too high the design of the indoor unit may be unnecessarily difficult. This places the upper limit at about 2GHz bearing in mind the need for a relatively inexpensive indoor unit.

A band of 950 to 1350MHz has been proposed, and this should be satisfactory except at sites near to powerful radar transmitters operating in this band. Here, a higher frequency may be necessary and 1410 to 1810MHz has been proposed.

Indoor unit

Shown in skeleton form in Fig.2, the indoor unit consists of a wideband amplifier at first level by a high-pass filter to prevent interference from strong terrestrial signals. This is followed by a tuned band-pass filter, mixer, second i.f. amplifier, a surface-wave filter giving the required 27MHz bandwidth, a further i.f. amplifier, limiter and demodulator.

The technique of placing surface-wave filters between two amplifiers avoids the use of a single high-gain block with attendant stability problems, as the loss of the filter is around 25dB.

Noise performance

The noise contribution from the indoor unit should be a very small part of the total. If this is achieved, the overall noise performance will be virtually the same as that of the down converter. If the noise power generated by the indoor unit is one tenth of that arriving at the end of the cable, the effect on the overall carrier-to-noise ratio will be only 10 log (1/1.1) = −0.4dB, which is considered to be an acceptably low figure. The noise arriving from the down converter is −103.6dBW. The noise generated by the indoor unit must be one tenth of this or 10dBdown, i.e. −113.6dBW.

The noise power from an amplifier alone is $P_n = kTB(F/1)$ where F is the arithmetic noise figure of the system, so with P_n = −113dBW or $10^{-11.36}$,

$$F = \frac{10^{-11.36}}{kTB} + 1$$

$$= 41.4 \text{ or } 16.2\text{dB},$$

which is not difficult to obtain. As the effect on the overall c/n ratio would be extremely small, there seems to be little point in striving for lower noise figures than this.

Choice of second i.f.

The second i.f will normally be in the range between one and several hundred MHz and must be chosen with care. If too low a frequency is chosen, there will be second channel interference problems. If too high, istability problems may arise, as well as difficulties with the design of the demodulator. To avoid interference between neighbouring receivers, it is advisable to ensure that the second oscillator never coincides with a wanted signal at first i.f. level.

The WARC plan has been so devised that the wanted signals in any particular area are separated by an even multiple of the channel spacing of 19.18MHz. The condition mentioned above can therefore be achieved by choosing a second i.f. which corresponds to an odd multiple and the solution assumed in the diagram is seven times the channel spacing or 134.26MHz.

As bandwidth is 27MHz, the band covered will extend from 120.76 to 147MHz. There is a danger of interference due to direct breakthrough at second i.f. from terrestrial services, including the 2-metre amateur band. For this reason, it will be necessary to thoroughly screen the indoor unit and to provide an efficient high-pass filter at the input.

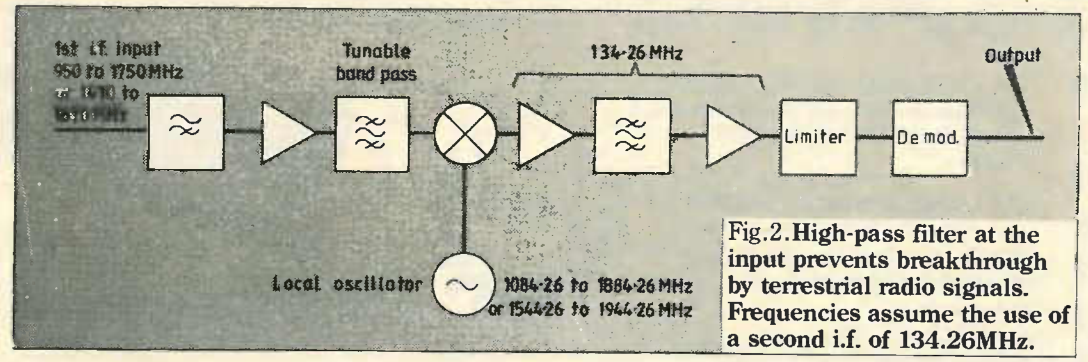


Fig.2. High-pass filter at the input prevents breakthrough by terrestrial radio signals. Frequencies assume the use of a second i.f. of 134.26MHz.

Table 1. Reception angles at longitude 0°, latitude 51.5°N. For more notherly locations the angles will be lower.

Satellite position	37°W	31°W	19°W	0°	10°
Elevation	21.8°	24.3°	28.5°	31°	30.3°
Azimuth	43.9°W	37.5°W	23.7°W	0°	12.7°E

Automatic frequency control

The range of signal levels at which the receiver will have to work is not very large and will in most cases not exceed 16dB. It is quite possible to design limiters to cope with this variation without undesirable effects, so that a.g.c. will not be necessary. However, it is felt that some kind of indication will be helpful as a tuning aid and for antenna alignment.

But a.f.c will almost certainly be a necessity. Remember that the down converter will be subjected to wide temperature variations at frequencies in the region of 10GHz: drift figures up to ± 5MHz may therefore be expected. Where the drift is low, ± 1MHz for example, it may be possible to accommodate the variation be simply widening the pass band of the i.f. filter. Otherwise a.f.c. must be provided, but this is not easy in an f.m. tv system because there is no constant relationship between the frequency at which maximum energy occurs and the centre of the pass band.

The answer lies in the use of a gated system which samples the signal when it is at a known constant level. In MAC systems this may be done by sampling during the sync data word which is transmitted with reversed 0 s and 1 s on consecutive lines. Intergrating these gives a level corresponding to the centre of the pass band. Of course, the sync. word must first be identified and the receiver synchronized, but this should be possible even with considerable mis-tuning.

Signal output

The output signal from the demodulator will in many cases have to undergo further decoding and processing depending on the system used. In the case of a MAC system a decoder will be necessary for both the vision and digital data signals. The display unit should ideally have a YUV input. A PAL-encoded output may be required if, for example, a video recording is to be made on an existing recorder.

Background reading

Freeman, K.G., Jackson, R.N., Mothersole, P.L., & Robinson, S.J. Some aspects of direct television reception from satellites, *Proc.IEE* vol.117 no.3, March 1970, pp.515-520.

Rainger, P., and Phillips, G.J. Direct broadcasting by satellite for the United Kingdom *BBC Engineering* no.115 September 1980 pp.3-14. See also *Wireless World* October, November 1980.

Lucas, K., and Windram, M. Standards for broadcasting satellite services, *IBA Technical Review* no. 18 pp. 12-27.

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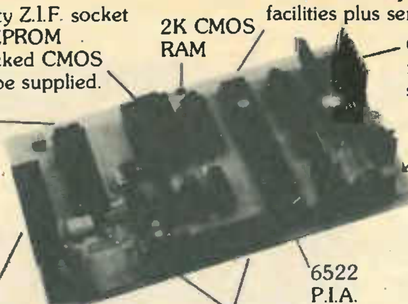

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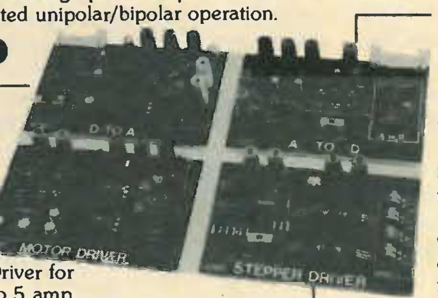

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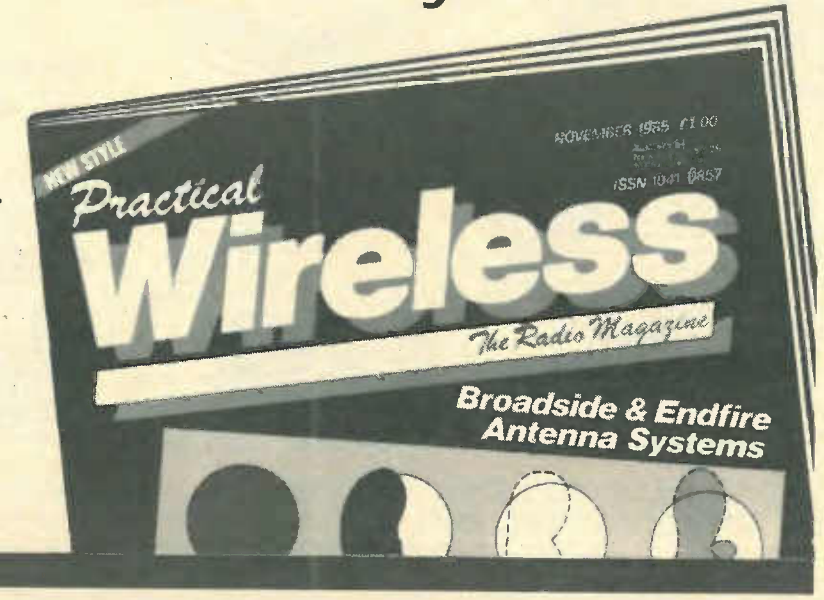

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CIRCLE 101 FOR FURTHER DETAILS.

Compact disc players — 2

The ear's acuity puts demands on audio converter accuracy that eclipse those of almost every other application

by J.R. Watkinson

There are two major ways of obtaining an analogue signal from binary data. One is to control binary weighted currents and sum them, the other is to use data to control the length of time a fixed current flows into an integrator.

Both methods, contrasted in Fig. 1, appear simple, but in these forms are of no use for audio because of practical limitations. In (c) the binary input is about to have a major overflow, and all of the low-order currents are flowing. In (d) the binary input has increased by one, and the most significant current only flows. This current must equal the sum of all the others plus one least significant bit to an accuracy of rather better than one l.s.b. In this simple four bit example, the necessary m.s.b. accuracy is better than one part in 16 (2^4), but for a 16-bit system this becomes one part in 65,536 or about 0.0015%. This degree of accuracy is very hard to achieve in the face of component ageing and temperature change.

The integrator-type converter in this four bit example (e) requires a clock for the counter which allows it to count up to maximum in one sample period. This will be more than 2^4 times the sampling rate. However, in a 16-bit device, the clock rate must be 2^{16} times the sampling rate, which for CD this would be 2.9 GHz! Clearly some refinements are necessary to allow these convertors to be used in digital audio.

Dynamic element matching

A method of producing highly accurate currents is dynamic element matching. Fig. 2(a) shows a current source feeding a pair of resistors of nominally equal value. The two will not be exactly the same due to manufacturing tolerances and drift and thus divide the input current approximately between themselves. A pair of changeover switches places each resistor in series with each output. The average current in each output will be identical provided that the duty cycle of the switches is exactly 50%. This is readily achieved with a divide-by-two circuit.

Current averaging is by a pair of capacitors which do not need to be of close tolerance or even of equal value. By cascading these divide-by-two stages, a binary weighted series of currents can be obtained, as in Fig. 2 (b). In practice, a reduction in the number of stages can be obtained by using a more complex switching arrangement[1]. This generates currents of 1:1:2 ratio by dividing the input current into four paths and feeding two of them to one output, shown in Fig. 2 (c).

A major advantage of dynamic element matching is that no calibration is required, making it attractive for mass production. This Philips invention was first used in the TDA1540, a 14-bit device with ½ l.s.b. linearity, and subsequently in 16-bit devices.

Dual integrators

The integrator approach is preferred by Sony, and the solution adopted is to have two current sources operating simultaneously, with a ratio of precisely 256:1. Clearly if the larger current flows for one clock period, the effect will be the same as if the smaller current source operated for 256 clock periods. Thus the least-significant eight bits of the input sample control the larger control. The clock frequency now only needs to be in excess of 2^8 times the sampling rate, or about 11MHz. As the output is a ramp, the clock must run faster than this to leave time during the sample period for the analogue vol-

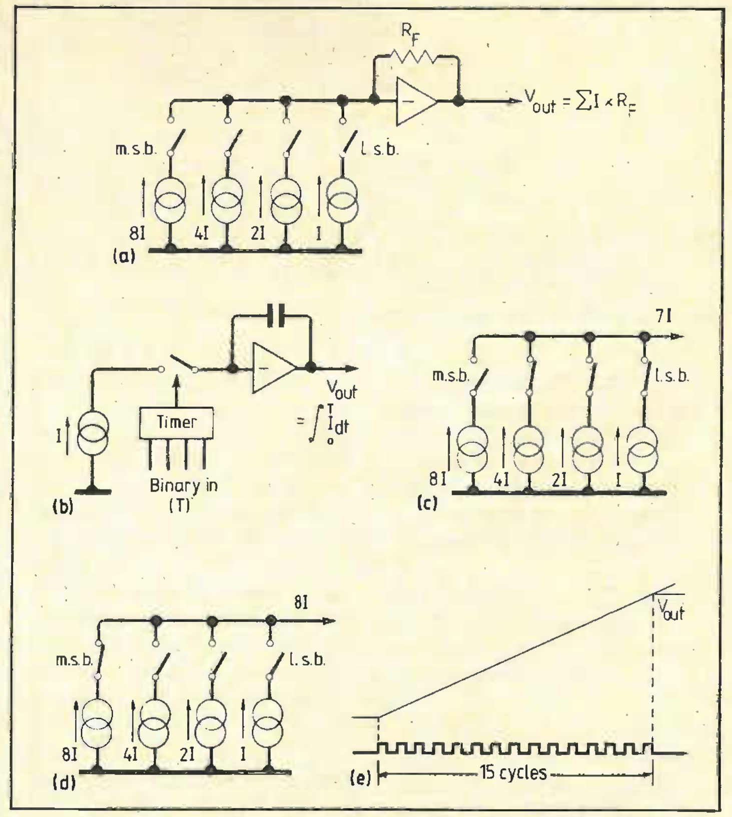


Fig. 1. Two main methods of obtaining analogue signal from binary data are the weighted current converter (a), and the timed integrator (b). In (c) the binary input is 0111 while in (d) it has increased by one bit, so a minimum accuracy is 1 in 16 for this four-bit converter, and would need to be 1 in 65,536 for a 16-bit converter. In the integrator technique (e), 15 clock cycles are counted for 1111 input and for a 16-bit device the clock rate would need to be 2^{16} times sampling rate!

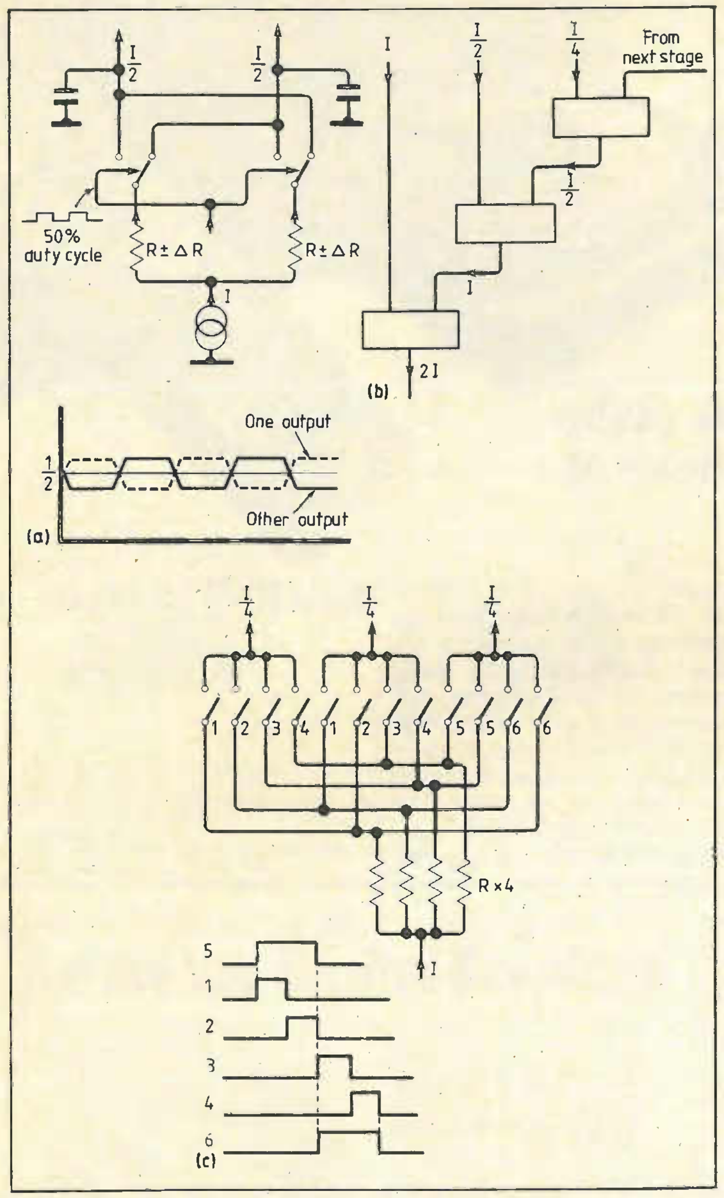


Fig. 2(a). Current division can be more accurate than the tolerance of resistors when this switching arrangement is used. Accuracy then depends on the duty cycle of switching.

Fig. 2(b). Cascading the current dividers of (a) produces a binary weighted series of currents.

Fig. 2(c). More complex dynamic matching systems. Four drive signals (1,2,3,4) of 25% duty cycle close switches of corresponding number. Two signals (5,6) of 50% duty cycle, resulting in two current shares going to right hand output. Division is thus into 1:1:2.

tage at the top of the ramp to be transferred to the circuits that follow.

The critical features of this approach are that the current ratio must be precise or the device will not be monotonic, and the capacitor must have low dielectric leakage to prevent non-linearity. It is only the ratio of currents which must be correct, the absolute accuracy of an audio converter is quite unimportant compared to the linearity requirement.

Fig. 3 shows a simplified diagram of the Sony CX-20017 with the two current sources. This device will operate at twice the sampling rate of CD. In the CDP-101, it is driven at a clock rate of 35MHz, and alternately converts samples for both left and right channels. This results in a saving of components and a time displacement between channels of 1/(2x44100) = 11.3µs, the equivalent of one loudspeaker being displaced by 3.5mm, assuming a typical value for the speed of sound. People who habitually listen with their heads in a vice can detect this and the unit has attracted some unjustified criticism. In fact, it is just possible to tell the difference between the presence and absence of the delay but almost impossible to say which is which.

The only problem with any foundation occurs if the two outputs are converted to mono by analogue addition; this results in h.f. roll-off. With this exception, other factors have a much greater bearing on subjective sound quality than the use of multiplexed d.a.cs.

Reconstruction

The output of a converter cannot be used directly; filtering is necessary. The converter output produces a spectrum shown in Fig.4, the result of amplitude modulating an infinite pulse spectrum (sampling frequency and harmonics) with a baseband audio spectrum. Although the sidebands above 20Hz are inaudible, the slightest non-linearity in subsequent stages would result in intermodulation distortion, to say nothing of possible dissipation problems in amplifiers. The reconstruction filter has a sharp roll off above 20kHz. A perfect low-pass filter has an impulse response that is a sinx/x wave shape, and if the filter repsonse is one half the sampling frequency, one impulse will have a value of zero at the position of the next. The various impulses add together to recreate the original waveform, Fig. 5. In practice an analogue filter cannot be made to have such an ideal impulse response, and the phase linearity of such filters will be less than perfect and certainly audible [2].

The reconstruction process only aperates correctly on genuine impulses of negligible duration. Where a zero-order hold (staircase) signal is supplied from a d.a.c. this is the equivalent of impulses whose width is equal to the sample period. A low-pass filtering effect takes place, and the amplitude response will be a sinx/x curve falling to zero at the sampling rate. This gives a loss of about 4dB at the Nyquist limit.

The effect can be reduced by resampling, which narrows the impulses from the d.a.c. This approach is highly compatible with the integrator type of converter, because the resampling switch simply passes the peak voltage of the the ramp after the current sources have turned off. Fig. 6 shows an example of such a system.

Oversampling

One approach to improving the phase linearity of converters full out is to use oversampling, which means using a sampling rate greatly in excess of that required by Nyquist. This results in a spectrum shown in Fig. 7. As there is now a large separation between baseband and sidebands, the reconstruction filter need only have a gentle roll-off and phase linearity will be improved.

Over sampling by factors of two and four is used in CD players. It is necessary to provide an increased sample rate using samples from the disc as input. The samples lying inbetween must be computed. The method is a digital simulation of the process of analogue reconstruction. The difference is that in the digital domain the impulse response can be made arbitrarily close to the theoretically perfect. The continuous analogue signal is the sum of sinx/x waves due to each of several adjacent samples, as Fig. 5 shows. Because a sinx/x wave stretches to infinity in both directions, its extremities must be neglected. By calculating the value of the wave versus distance, a point will be reached where the error caused by neglecting a distant impulse is less than system noise. This corresponds to taking account of some 12 samples either side of the point of interest.

Figure 8 shows how an intermediate sample is calculated in a ×2 oversampling system. The impulses immediately left and right are multiplied by 0.64 and those next farthest away are multiplied by −0.21, and so on, and the products added to obtain the intermediate value. The next intermediate sample will be obtained by moving all input samples one place relative to the coefficients and one old sample will be lost on the right, and a new input sample will arrive on the left. This movement of data across the multipliers as if in a shift register gives rise to the term 'transversal filter', also known as a finite impulse response filter.

The process can be extended for ×4 oversampling, Fig.8 (b). There are now three intermediate values to compute between input samples, thus three sets of coefficients will be needed. In practice the output sample which coincides with the input sample is passed on unchanged by using a set of coefficients where one is unity and the others are zero. These four sets of coefficients will be presented to the filter in turn while the input data are held, then the data will shift one place and the process repeats. In this way the output sampling rate will become four times the input rate. Following multiplication in the filter, the sample wordlength will have increased greatly beyond 16 bits, and will be rounded off in some way. The required wordlength is not immediately obvious.

An example of information transfer where four-bit codes are transmitted at a rate F is shown at Fig. 9 (a). A four-bit code contains 2^4 possibilities, so the information rate is 16F. The same information rate is obtained in Cb), where half as much information is transmitted twice as often. As each code now only needs an information content of eight, only three bits are now needed. By transmitting four times as fast, only two bits are needed, (c).

Transferring this result to the CD system, oversampling by two allows the use 15-bit data, and oversampling by a factor of 4

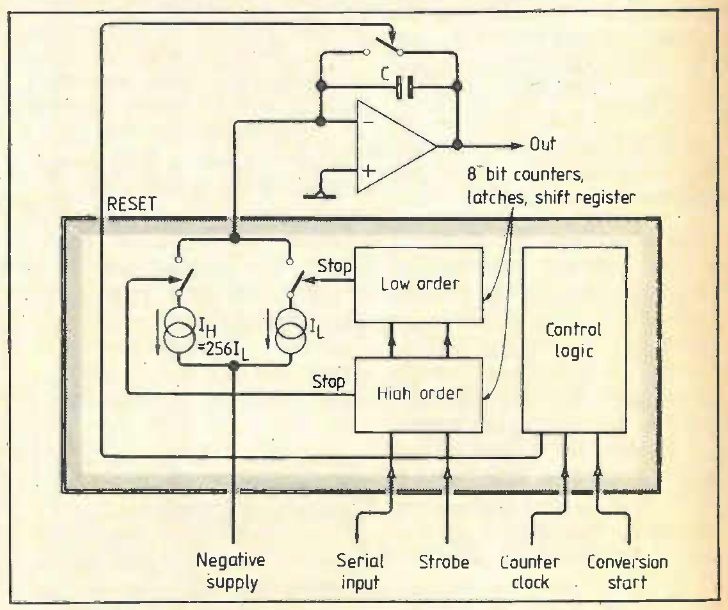


Fig. 3. Simpified diagram of sony CX-20017 having the high and low order current sources and associated timing circuits. The necessary integrator is external. Output needs to be resampled at peak of ramp (see Fig. 6).

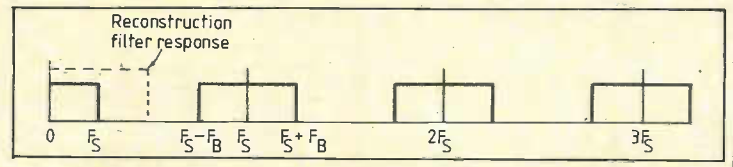


Fig. 4. The baseband signal (0 - F_B) appears symmetrically about the sampling frequency (F_s) and its harmonics. The resconstruction filter has to reject everything except the baseband.

Fig. 5. Each impulse entering a low-pass filter sinx/x wave. These add to produce a continuous signal.

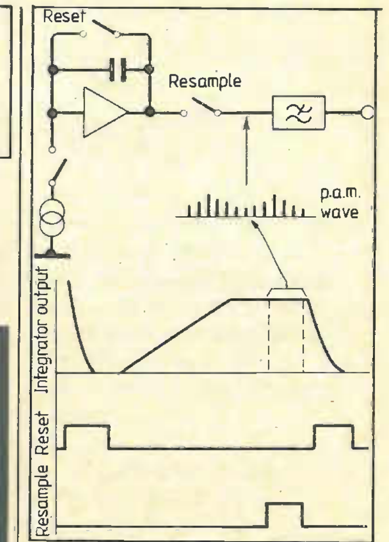
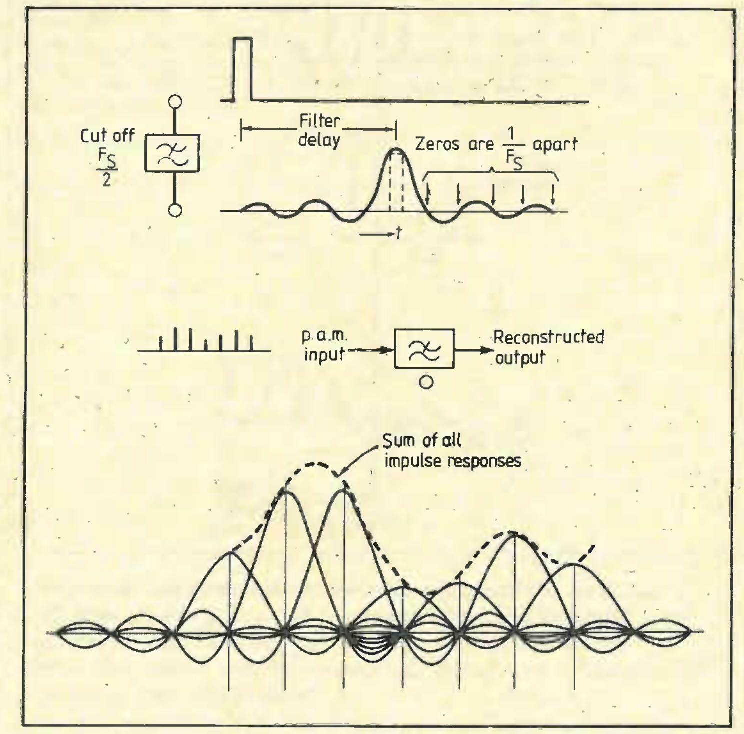


Fig. 6. In an integrator, the output level is only stable when the ramp finishes. An analogue switch is necessary to isolate the ramp from subsequent circuits. The switch can also be used to produce pulse amplitude modulated signal which has a flatter frequency response than a zero-order hold (staircase) signal.



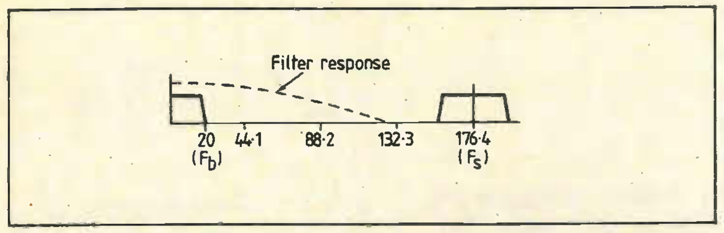


Fig. 7. **In this ×4 oversampling system, the large separation between baseband and sidebands allows a gentle roll-off reconstruction filter to be used.**

allows the use of 14-bit data, provided that the reduction in wordlength is done in an optimum fashion. This is not implicit in the definition of oversampling, and an additional mechanism is necessary to obtain these results.

Simple truncation of a sample stream is the same as if the original audio had been quantized into fewer levels. For every bit lost, a given level of quantizing distortion will be reached at a level 6.02dB higher. Simple truncation, then, will not allow us to obtain the results predicted by information theory.

The round off mechanism used with oversampling spreads the harmonic distortion due to truncation over the entire oversampling spectrum, thus distortion power within the baseband is only a fraction of the total. The frac-

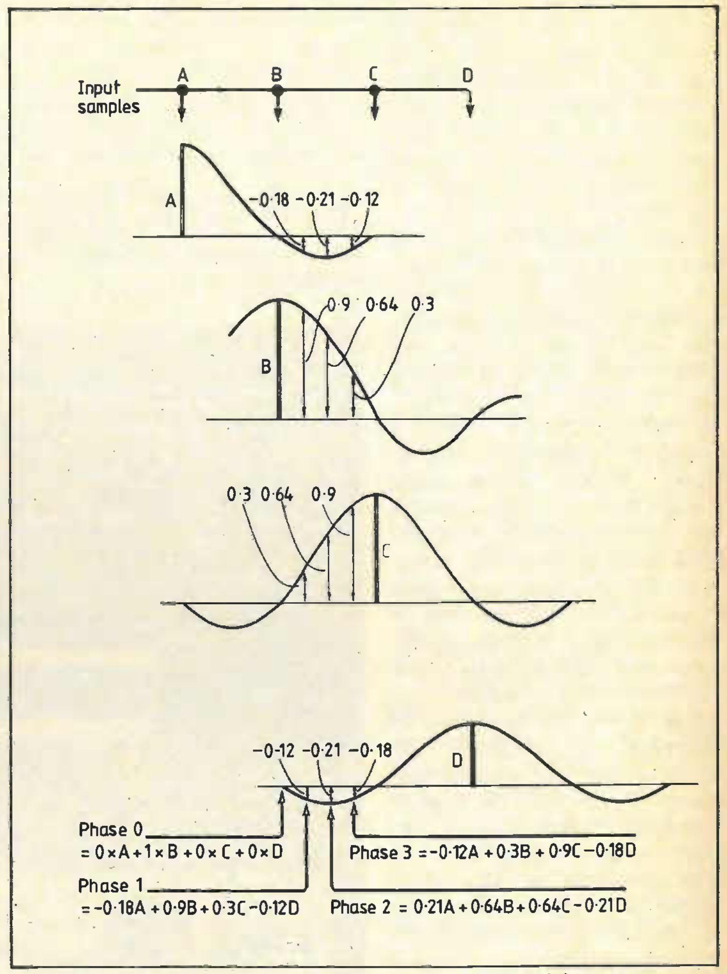


Fig. 8(b). **In ×4 over-sampling, for each set of input samples, four phases of coefficients are necessary, each of which produces one of the oversampled values.**

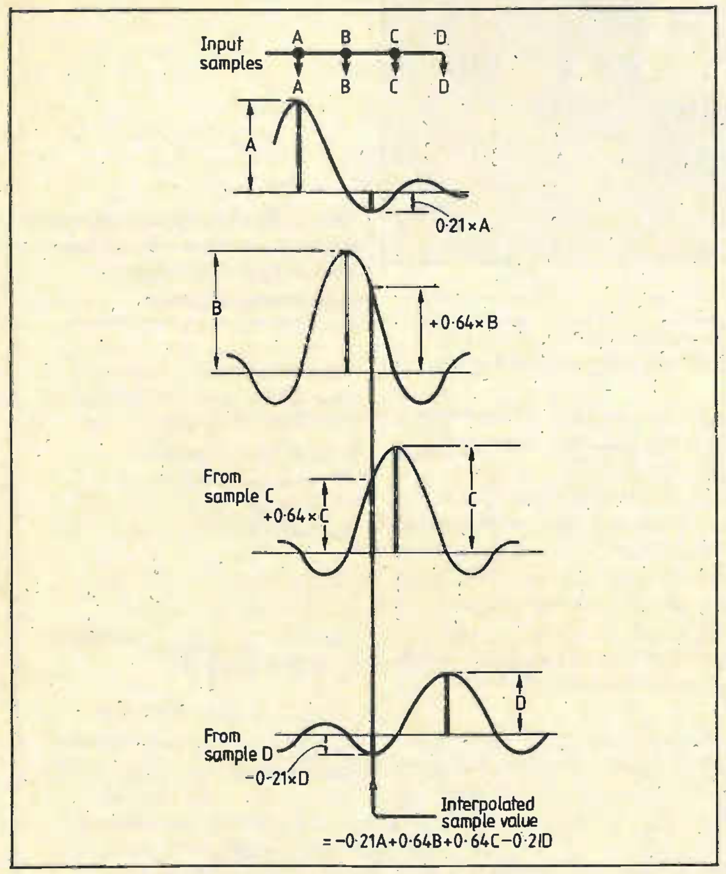


Fig. 8(a). **To compute an intermediate smaple, the input samples are imagines to be sinx/x impulses, and the contributors from each at the point of interest can be calculated. In practice rather more samples either side need to be taken into account.**

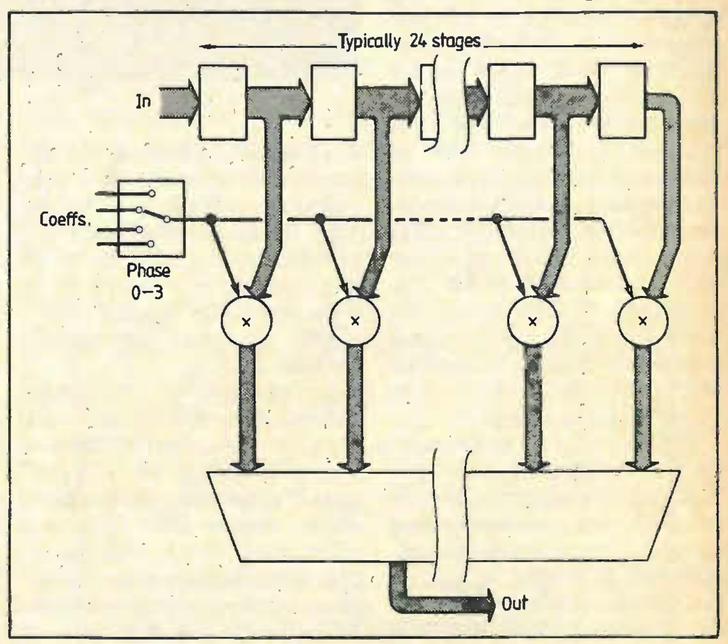


Fig. 8(c). **Practical implementation of digital filter. Shift register at the top provides access to several samples simultaneously. Multipliers produce contributions from each sample according to the coefficients. In ×4 oversampling, there will be four coefficient phases and four output values before data at top shifts one place. Lateral data shift gives rise to name of transversal filter.**

tion is in fact the reciprocal of the oversampling factor. For example, ×4 oversampling allows two bits to be neglected, which potentially raises the level of harmonics by 12dB; the round-off system spreads these harmonics over a spectrum four times as great, thus the distortion within the baseband is reduced by a factor of four, or 12dB.

The process of rounding up or down according to the value of the bits to be lost is well known, but in an extension of this technique the error caused by the previous roundoff is carried over to the current roundoff so that the average error of the two can be made small. As the sampling rate is much higher than normal, this averaging process does indeed take place, because equal and opposite errors at F_s = 176 kHz produce a signal at 88 kHz, which will not pass the filter or be audible. As shown in Fig.10, the accumulated error is obtained by using the bits that were neglected in truncation and adding them to the next sample.

An example is given of a ×4 oversampling system where two bits are to be lost. With a steady input, the system will produce 01110111.... If this one-bit signal is filtered, it will result in a dc level equal to the duty cycle of $\frac{3}{4}$, which is precisely the level which would have been obtained by converting the input code. Thus the resolution of the output is unchanged even though two bits have been lost.

The process is often referred to as noise shaping, but this is a misnomer, since failing to perform these steps results in harmonic distortion.

The oversampling system used by Philips[3] takes advantage of the aperture effect by using zero-order hold on the d.a.c. which oversamples at ×4. The small h.f. loss in the baseband is compensated in the digital filter, whose impulse response is that of a perfect filter which rises slightly up to the cut-off frequency. The amplitude response is shown in Fig. 11; ripples in the stopband are due to using filter coefficients which are quantized to finite accuracy.

The final stage of reconstruction is to use an analogue third-order Bessel filter. The overall phase linearity of such a system is much better that that of a conventional steep-cut filter, and contributes to subjectively improved sound quality. As the necessary hardware can be conveniently integrated, it is expected that a number of manufacturers will adopt the system.

The digital recorders used for mastering Compact Dics are described in the next part of the series.

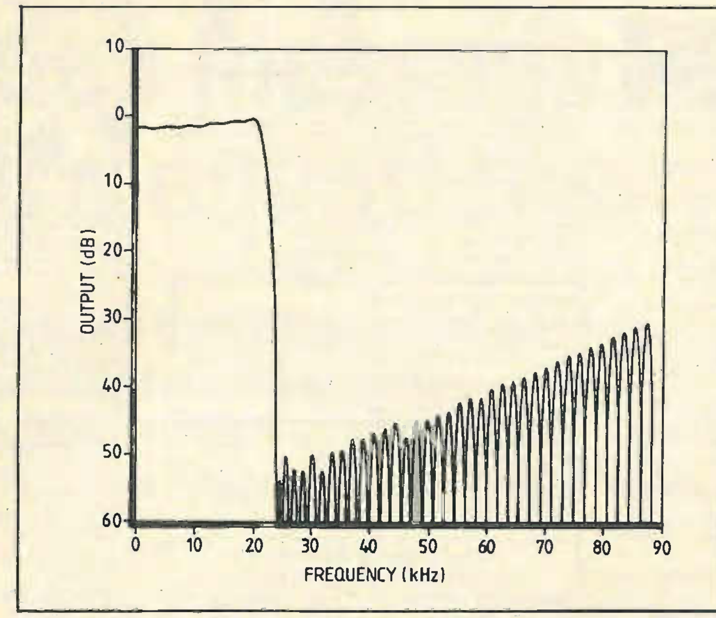


Fig. 11. **Amplitude response of digital filter in Philips oversampling system. The small rise to 20kHz offsets the sinx/x aperture effect of zero-order hold d.a.c. Ripple in the stop band is due to truncation of coefficients. (Diagram courtesy of Philips Technical Review).**

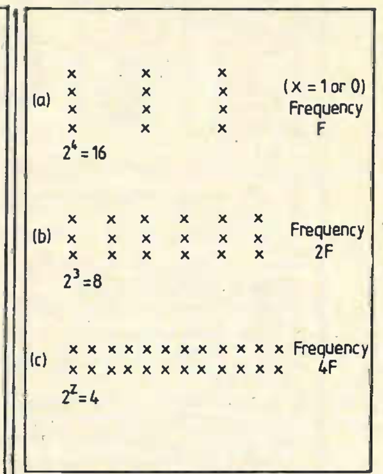


Fig. 9. **Information rate can be held constant when frequency doubles by removing one bit from each word. In all cases here it is 16F. Bit rate of (c) is double that of (a). Data storage in oversampled form is inefficient.**

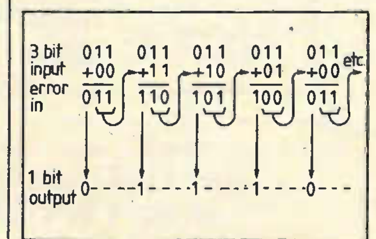


Fig. 10. **By adding the error by truncation to the next value, the resolution of the lost bits is maintained in the duty cycle of the output. Here, truncation of 011 by two bits, would give continuous zeros, but the system repeats 0111,0111, which after filtering will produce a level of three quarters of a bit.**

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2. Meyer. Time correction of anti-aliasing filters used in digital audio systems. *JAES* March 1984.
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The hidden message in Maxwell's equations

by Ivor Catt

Did Maxwell lodge with his bank the answer to his mathematical bluff, Maxwell's Equations, with instructons to open and publish a century later? And did the bank lose the envelope?

Historically, the theory of electrodynamics grew out of the theory of static fields, electric and magnetic. These static fields resulted from steady electric currents and static electric charge. Maxwell wrestled with the paradox of the capacitor[1,2], and this led him to reassert Faraday's idea of "the propagation of transverse [electro] magnetic [waves][3]." So the concepts of electric charge and electric current preceded the concept of a transverse electromagnetic wave[4], and it is generally agreed (but not by me) that the t.em. wave follows from the prior postulation of electric charge and current[1,2].

A strong case can be made for the view that the t.em. wave is a more fundamental Primitive, or starting point, for electromagnetic theory than electric charge and electric current.

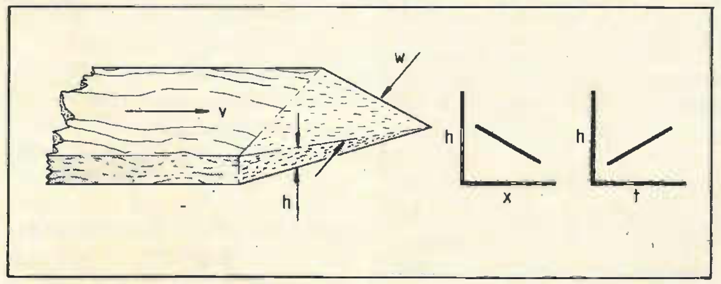
- When light and heat reach us from the sun, it is by the mechanism of a t.em. wave, not electric charge and current.
- Kip[5] says that the energy dissipated in a resistor entered it *sideways*, and was transported into the resistor by the t.em. wave.
- In 1898 J.A. Fleming[6] wrote that 'although we are accustomed to speak of the current as flowing in the wire, . . ., (it) is, to a very large extent, a process going on in the space or material outside the wire.'
- In *Wireless World*, May 1985, page 18, in a reply to G. Berzins, I showed that the t.em. wave, not the electric current, must be the mechanism by which energy is transferred.

The last two argements are even more powerful and fundamental.

- We all adhere to the underlying primitive 'conservation of energy'. Now energy is transported by the t.em. wave, not by electric charge and electric current.
- We all adhere to the underlying relativistic primitive, 'no instantaneous action at a distance'. While electric *charge* could be argued to be located at only one point in space-time, this is not true of an electric current, some of which is necessarily located at the same time at points which in the language of Minkowski are 'elsewhere' to itself.

Catt's equations of motion for a tapering wooden plank

Consider a plank of wood tapering to a point at the front, travelling at velocity v. The aspect ratio of the wood's cross section is z. Height and width at any point are denoted by h and w. Within the tapering section, the ratio of height to width remains z.



The velocity of the plank is the factor which relates the change of height with forward distance to the change of height at a point with time, so from first pinciples, we can write

$$\frac{\partial h}{\partial x} = -\frac{1}{v}\frac{\partial h}{\partial t} \text{ *(refs 7,8).} \qquad 1$$

Since we have stated that at any point, h/w = z, we can substitute for h in equation 1:

$$\frac{\partial h}{\partial x} = -\frac{z}{v}\frac{\partial w}{\partial t}. \qquad 2$$

Again from first principles, we can write

$$\frac{\partial w}{\partial x} = -\frac{1}{v}\frac{\partial w}{\partial t}. \text{ *} \qquad 3$$

In the same way as we substituted for h in equation 1 to get (2), now substitute for w, to get

$$\frac{\partial w}{\partial x} = -\frac{1}{vz}\frac{\partial h}{\partial t}. \qquad 4$$

Equations 2 and 4 we define as Catt's Equations of Motion for a wooden plank. Note that they hold true for any type of taper, and even for a straight portion of the plank, when both sides of the equations are equal to zero. The only imposed limitation is that h remain proportional to w.

Catt's equations of motion for a thick warm plank

We postulate that a thick plank of wood travels forward with velocity v. At every point within the plank, we postulate that the temperature T is proportional to the density of the wood ρ, so that $T/\rho = z$. (To picture this, think of spontaneous combustion.)

Catt's equations 2 and 4 now become

$$\frac{\partial T}{\partial x} = -\frac{z}{v}\frac{\partial \rho}{\partial t} \qquad 5$$

$$\frac{\partial \rho}{\partial x} = -\frac{1}{vz}\frac{\partial T}{\partial t}. \qquad 6$$

These equations remain valid for two thick short planks moving forward side by side.

Maxwell's equations compared with two thick short planks

Let us first review two of the many extant versions of Maxwell's Equations for a vacuum.

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t} \qquad 7$$

$$\frac{\partial H}{\partial x} = -\frac{\partial D}{\partial t}. \qquad 8$$

The version above has been obscured by the introduction of alternative symbols B and D to denote magnetic and electric fields. Our purpose is more easily served if we use another of the many versions that litter the text books (ref. 2):

$$\frac{\partial E}{\partial x} = -\mu_0\frac{\partial H}{\partial t} \qquad 9$$

$$\frac{\partial H}{\partial x} = -\epsilon_0\frac{\partial E}{\partial t}. \qquad 10$$

Our problem is that whereas the equations for planks have con-

* For explanation of the minus sign, see ref.9.

stants v for velocity and z for ratio, Maxwell's Equations have the obscure symbols μ_o and ϵ_o. However, this problem becomes trivial because it is known from experiment that

— the velocity of light or a t.em wave is $c = 1/\sqrt{\mu_o \epsilon_o}$

— the ratio between E and H at any point, described by the symbol Z_o, has been found by experiment to be equal to the constant $\sqrt{(\mu_o/\epsilon_o)}$.

By algebra, we find that $\mu_o = Z_o/c$ and $\epsilon_o = 1/cZ_o$ (ref.10). We can now see that equations 9 and 10 are in fact 5 and 6, Catt's equations for two thick short planks, and contain virtually no information about the nature of electromagnetism.

The hidden message in Maxwell's equations

In general, Maxwell's Equations tell us only the obvious truisms about any body or material moving through space. It is the obscurantism of the fancy maths in which they are dressed that has for the last century caused scholars to think that they contain significant information about the nature of electromagnetism (but see refs 7 and 9). Most versions are far more messy and obscurantified than the two comparatively clean versions (7) through (10) listed above. Other versions tend to contain a mixture of integrals, divs, curls, and much more, leading to a head-spinning brew, see for instance refs 1,13. (For the Inscrutable Ultimate, see panel for Chen-To Tai.)

Two questions arise:

— do Maxwell's Equations contain any information *at all* about the nature of electromagnetism?

— why do academics and practitioners generally believe that Maxwell's Equations are useful?

The answer to one of these turns out to be much the same as the answer to the other.

Returning to equation 1, this is only valid if the constant in the equation equals the velocity of propagation v. When we then mix together h and w to produce the hybrid equations 2 and 4, they only remain true if h and w are always in fixed proportion z. So we find that Maxwell's Equations 9 and 10 are only true if at every point in space E is proportional to H, and also if the velocity of electromagnetism has the fixed value c. So the only information about electromagnetism contained in the apparently sophisticated equations 9 and 10 is about the two ruling constants in electromagnetism: the fixed velocity c, and that E,H at every point are in fixed proportion Z_o. The remaining content of Maxwell's Equations is hogwash.

We have to conclude, with respect, that what Maxwell and his sycophants do not say about a tapering, disappearing plank of wood isn't worth saying.

Now move on to the second question, "Why do academics and practitioners generally believe that Maxwell's Equations are useful?" The answer to this question, deriving from the previous discussion, is extraordinary. We have already seen that Z_o and c are the only items of information buried in Maxwell's Equations. We resolve the paradox by pointing out that

> Z_o is not available as a concept to the whole of the fraternity called 'modern physics'.

The only way they can use such a necessary constant in their work is by taking on board with it all the meaningless rubbish in Maxwell's Equations which shrouds this valuable nugget.

In September 1984, in a paper delivered to a learned conference[11] and in that month's issue of *Wireless World*, I wrote: "It is noteworthy that Einstein himself and also the whole post-Einstein community who call themselves 'modern physics' never mention the impedance of free space $\sqrt{\mu_o/\epsilon_o}$, although it is one of the key primitives on which digital electronic engineering is based. The reader is encouraged to look for reference to it in the literature of 'modern physics'." Since then, no one has pointed out any case where it is mentioned in the literature. It follows that

> The only purpose served by Maxwell's Equations is as a package to deliver the constant Z_o to the theorist and to the practitioner.*

If they lacked another source for it, could also be accessed via Maxwell's Equations, but I think that to some extent c is available via other routes, although university lecturers remain muddled and vague about the velocity of a t.em. wave. Curiously, they are much more sure that the velocity of light equals the constant c.

Did Maxwell lodge with his bank manager the answer to his mathematical bluff, Maxwell's Equations†, with instructions to open and publish a century later? Did his bank lose the envelope? Should we say to Maxwell now, as he sits laughing, or perhaps smarting, on Cloud Nine, "Now pull the other leg?" No. I am sure that Maxwell was sincere, and did not knowingly shroud the very heart and soul of science, Electromagnetism, in confusion and nonsense for over a century.

* A bit like burning down your house to get roast pig.

† The meticulous student might like to follow up the assertion by H. J. Josephs that Heaviside, not Maxwell, wrote Maxwell's Equations. Is it true that Maxwell's writings do not contain Maxwell's Equations? This issue does not effect the discussion. Certainly my hero Heaviside fell hook, line and sinker for Maxwell's Equations. Nobody's perfect. According to Dr D.S. Walton, "The physical substance is in Maxwell's writings, but the formal expression that we are familiar with is due to Heaviside".

Appendix

It is worth repeating here from ref. 7 that the following two source equations, from which Maxwell's Equations are derived, have never been mentioned in the literature:

$$\frac{\partial E}{\partial x} = -Z_o \epsilon_o \frac{\partial E}{\partial t}$$

$$\frac{\partial H}{\partial x} = -\frac{\mu_o}{Z_o}\frac{\partial H}{\partial t}.$$

These are similar to equations 9 and 10. The alternative form is

$$\frac{\partial E}{\partial x} = -Z_o \frac{\partial D}{\partial t}$$

$$\frac{\partial H}{\partial x} = -\frac{1}{Z_o}\frac{\partial B}{\partial t}.$$

These are similar to equations 7,8. The cross-linkage of electric and magnetic fields E and H in Maxwell's Equations only obscures the issue. There is no interaction between E and H. (Similarly the *width* of a brick does not interact with its *length*.) They are co-existent, co-substantial, co-eternal (refs 12,14).

References

1. Carter, G.W., The Electromagnetic Field in its Engineering Aspects, Longman, 1954, p.313.
2. Kip, A.F., Fundamentals of Electricity and Magnetism, McGraw-Hill, 1962, p.312.
3. *ibid*, p.314. Kip quotes Maxwell as saying that Faraday proposed transverse waves.
4. Catt, I., et al., History of displacement current, *Wireless World*, March 1979, p.67.
Catt, I., The Heaviside signal, *Wireless World*, July 1979, p.72.
5. ref.2, p.327.
6. Fleming, J.A., Magnets and Electric Currents, 1898, p.80, quoted in *Wireless World*, Dec. 1980, p.79.
7. Catt, I., Maxwell's equations revisited, *Wireless World*, March 1980, p.77.
8. Catt, I., Electromagnetic Theory, C.A.M. Publishing, 1979, pp30,97.
9. *ibid*, pp.112, 281, 313.
10. ref. 8, p.237.
11. Catt, I., The Fundamentals of Electromagnetic Energy Transfer, International Conference on Electromagnetic Compatibility, Surrey University, IERE Pub. 60, Sept. 1984, p.57.
12. ref. 4, 2nd item also Oct. 1984.
13. Plonsey, R. and Collin, R.E., Principles and Applications of Electromagnetic Fields, McGraw-Hill, 1961, pp.301,311. Also Chen-To Tai (see panel).
14. Catt, I., Letter *Wireless World*, Feb. 1984, p.51.

Historical background reading

What did Maxwell do? What did he say that he did? Today, what do scientists believe that he did?

Did Maxwell postulate 'The Extra Current', now called Displacement Current, to resolve an anomaly which arose from the capacitor in a closed circuit? Or did he later falsely claim it as his reason? Or is it merely the false reason given in the history books? It is possible to argue that for my purpose these distinctions are unimportant, because if unknown, they do not influence the contemporary scene. (All the same, I believe that the true history of science is very important.)

Generally, I attemp to bypass these niceties, in order to create an uncluttered discussion of the technical flaws in today's science. By contrast, historians, lacking proficiency in electromagnetical theory, assume that today's situation is sound, and the only problem is that there are errors in our knowledge as to how we reached it.

This difference — that I am concerned with flaws in the contemporary body scientific and less concerned with historical detail — creates an uneasy relationship between the historians and me. As a result, I both do and do not want to point the reader to historical analysis of Maxwell exemplified by the following:

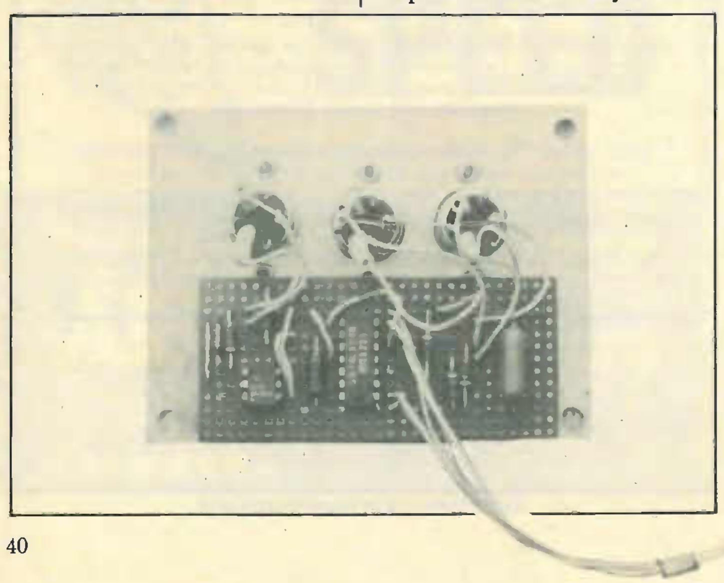
Chalmers, A.F., Maxwell and the displacement current, *Physics Education*, vol.10 1975, p.45
Gee, B., Models as a pedagogical tool: can we learn from Maxwell? *Physics Education*, vol.13, 1978, p.287.
Tai, Chen-To, On the Presentation of Maxwell's Theory, *Proc.IEEE*, vol.60, no.8, Aug.1972, p.936.

by D.J. Greaves B.A.

Polyphonic keyboard part 3

Midi interface details are included in this third article on a versatile keyboard instrument using two processors.

Midi interface back panel. The 6-pin dil i.c. is a medium-speed opto-isolator for receiving data at 31.25 kilobaud from a 5mA current loop. A 74LS04 i.c. buffers received data driving the 'through' socket and serial data from the 8088 processor for the 'out' socket.



Software for the 8088 microprocessor was written in assembly language and programmed into a 2764 8Kbyte eprom. There are two devices in the processor memory map, this eprom with addresses between E000 and FFFF and a 2Kbyte cmos ram with battery backup using addresses from zero to 7FF.

As mentioned last month, the processor accesses the whole of the rest of the instrument in an address space of 16 parallel ports. Names and functions of used ports are given opposite.

From the user's point of view, there are two main aspects to controlling Digipoly. First is operation of the front panel controls for setting up the instrument's sound and performance characteristics, and second is the response of the keys when pressed, i.e. music.

Communication between these aspects relies on a set of global variables in the 8088 memory map known as voxcons. These voxcons are stored in a 32byte array containing all information about the current sound of the instrument. Operating the front panel controls changes some of the voxcons in specific ways and playing the instrument uses them to create sounds.

Part of the random-access memory forms a library of sixteen sets of voxcons which are retained by means of battery backup while the main power is switched off. Save and recall functions issued from the front panel copy the current voxcons to a position in the library and back respectively. Two other similar variables, for fine and coarse pitch settings, are not saved in the library. It is important that these too are saved when the main supply is switched off.

When power is applied, the 8088 is given a power-on reseet which causess it to start execution at address FFF0, which is in the eprom. First it initializes variables in its own memory map and then sends the table of squares to the t.t.l. processor. The volume registers are all zeroed and all voxcons are set to default values giving a simple reed organ type sound, i.e. a triangle wave, abrupt envelope and all other features off.

The software then enters the main polling loop which, in outline, performs the following:

- scan keyboard, turning on or off notes that have changed since the last scan.
- send values to the d-to-a converter influence register.
- advance each envelope register phase
- inspect the Midi bus queue for commands
- scan front panel controls
- read control knob if enabled

When there is no work to be done, the polling loop takes just under 1ms. Advancing of envelope phases only takes place every fifth time around the loop, i.e. once in about 4ms.

Midi bus

Midi, short for musical instrument digital interface, is a standard interface used on nearly all modern keyboard instruments. It can be used for controlling sound generation sections of one musical instrument from the keyboard of another. Drum computers and sequencers can also be interconnected using the bus and there are Midi adaptors which allow instruments to be controlled by computer.

Three 180° five-pin DIN sockets are fitted to the instrument - 'Midi-in', 'Midi-out' and 'Midi-through'. Data is transmitted on pins four (positives) and five using a 10mA current loop to drive opto-isolators at the receiving end. Cables used are shielded twisted pairs with the shield connected to pin two at both ends; this pin is only earthed at the transmitting end. The connector chasis is not connected and pins one and three are unused.

Data is transmitted serially at 31.25 kilobaud. One start bit of zero is sent then eight data bits with the least-significant bit first followed by a stop bit of one.

Midi commands are normally three bytes long. First is the command byte with its most significant bit is set on. Represented in the least-significant four bits of this byte is a channel number, n. Subsequent bytes specify parameters and have values between zero and 127.

The bus is logically divided into sixteen channels, referred to as one to sixteen, but of course the bit pattern of the n field in the command byte has values from zero to fifteen. Channel numbers that a particular instrument uses and responds to are set from the front panel of the instrument and Digipoly is no exception. Using diferent channel numbers allows several instruments to chained together using the Midi 'through' sockets and independently controlled from a single computer or sequencer.

In some commands, the second byte is 'kk' which corresponds directly to a key on the instrument keyboard. Byte kk is zero for lowest C and 3C for top C. If a number greater than 3C (60 denary) is received then the instrument will play that note as though the keyboard were continued to the right, provided that this is still within the instrument's pitch range. The actual highest value will depend on how the keyboard is currently transposed.

One restriction on Digipoly is that the Midi 'out' socket cannot be used at the same instant as the 'in' socket. This is because data is serialized and deserialized in software and not using a uart (universal asynchronous receiver and transmitter) i.c. The only problem that this causes is that the useful loop test involving connecting the 'out' and 'in' sockets of the same instrument will not work.

Midi output

If transmit-on mode is selected on the front panel (Tx on), then information from the keyboard is not interpreted by Digipoly but is transmitted on the Midi 'out' socket. The channel number must also be selected from the front panel. Commands that may be transmitted are (9n, kk 40) which notifies any device on channel n that key kk has just been pressed on the keyboard, (8n kk 40) which notifies any device on the channel that key kk has just been released,(Bn 0p vv) used to adjust sound-generating parameters of other instruments and (91 04) sent as a continuous stream of double bytes on the Midi 'out' socket.

In the third command, adjust parameter, the parameter to be modified, p, is a value ranging from zero and 15 selected on the front panel. On selection of this

Names and functions of parallel ports used on the 8088 microprocessor.

BUTTONS, port 3,contains a bit-mapped image of front-panel control buttons.

LEDS, port 4, has various bit patterns written to it to control front-panel indicator leds.

BUT1, port 6, is a bit-mapped image of general-purpose buttons 1-8.

BUT2, port 7, is a bit-mapped image of buttons 9-16. All of these buttons are push-to-make and produce a zero bit when pressed.

CONTDAC, Port 8, when written to latches an eight-bit control word for the auxiliary d-to-a converter. This converter determines various analogue parameters. The same latch is used for scanning the clavier keyboard.

STATUS, Port 9, is a read-only port with bit flags as follows.
Bit seven, reflecting output of the oscillator is used for arpeggio (TBASE), and is available to clock a sequencer which could be added as a software extension.
Bit 6 is one if voltage from the rotary control potentiometer on the front panel is higher than that of the control d-to-a converter. In conjunction with

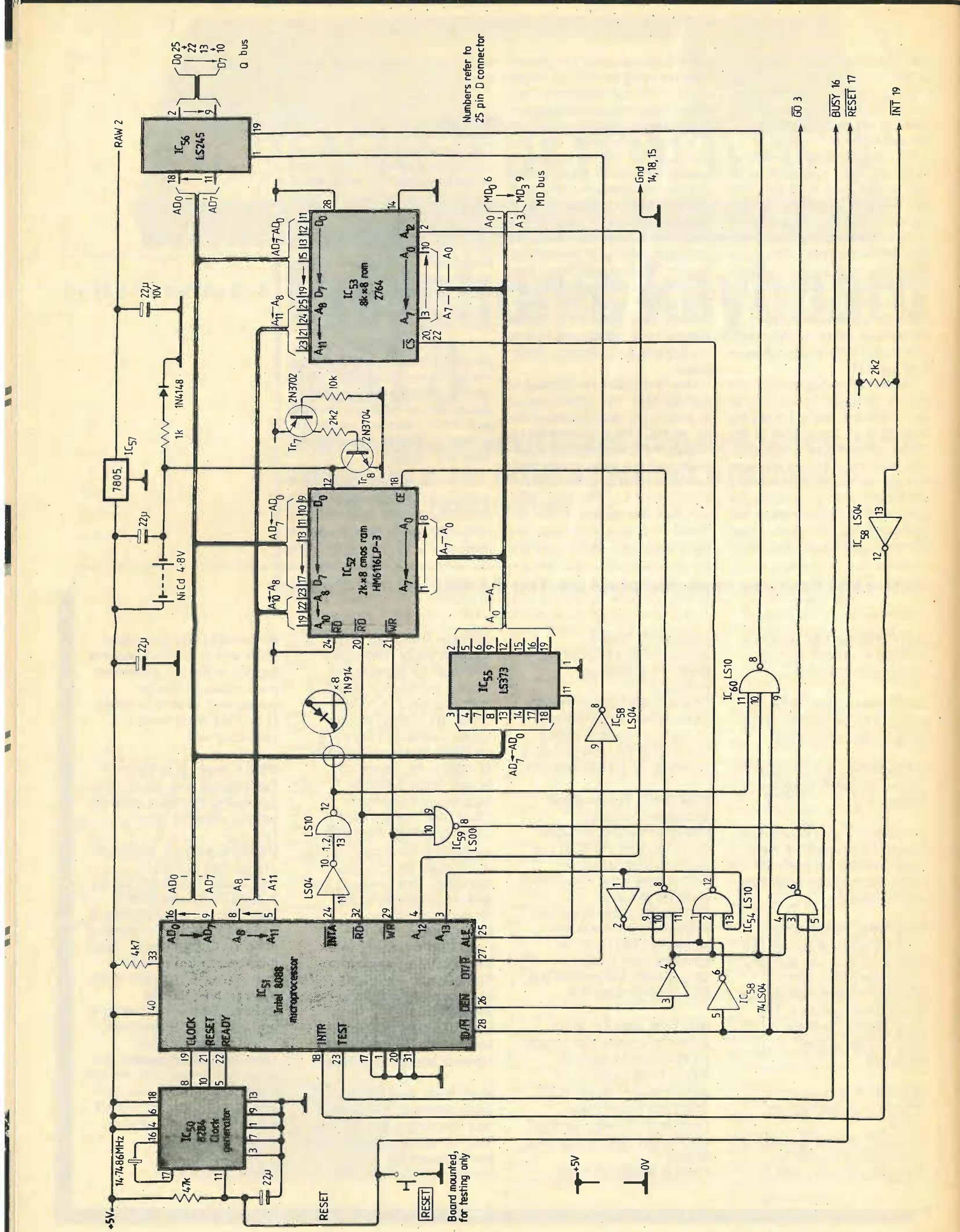
CONTDAC, this bit allows analogue-to-digital conversion under software control so that the 8080 can read the knob position.
Bit 2 is zero if the sustain foot switch is pressed.
Bit 1 is one if the clavier key indexed by the value last written to CONTDAC is currently held down.
Bit 0 reflects the state of the Midi in serial-data line.

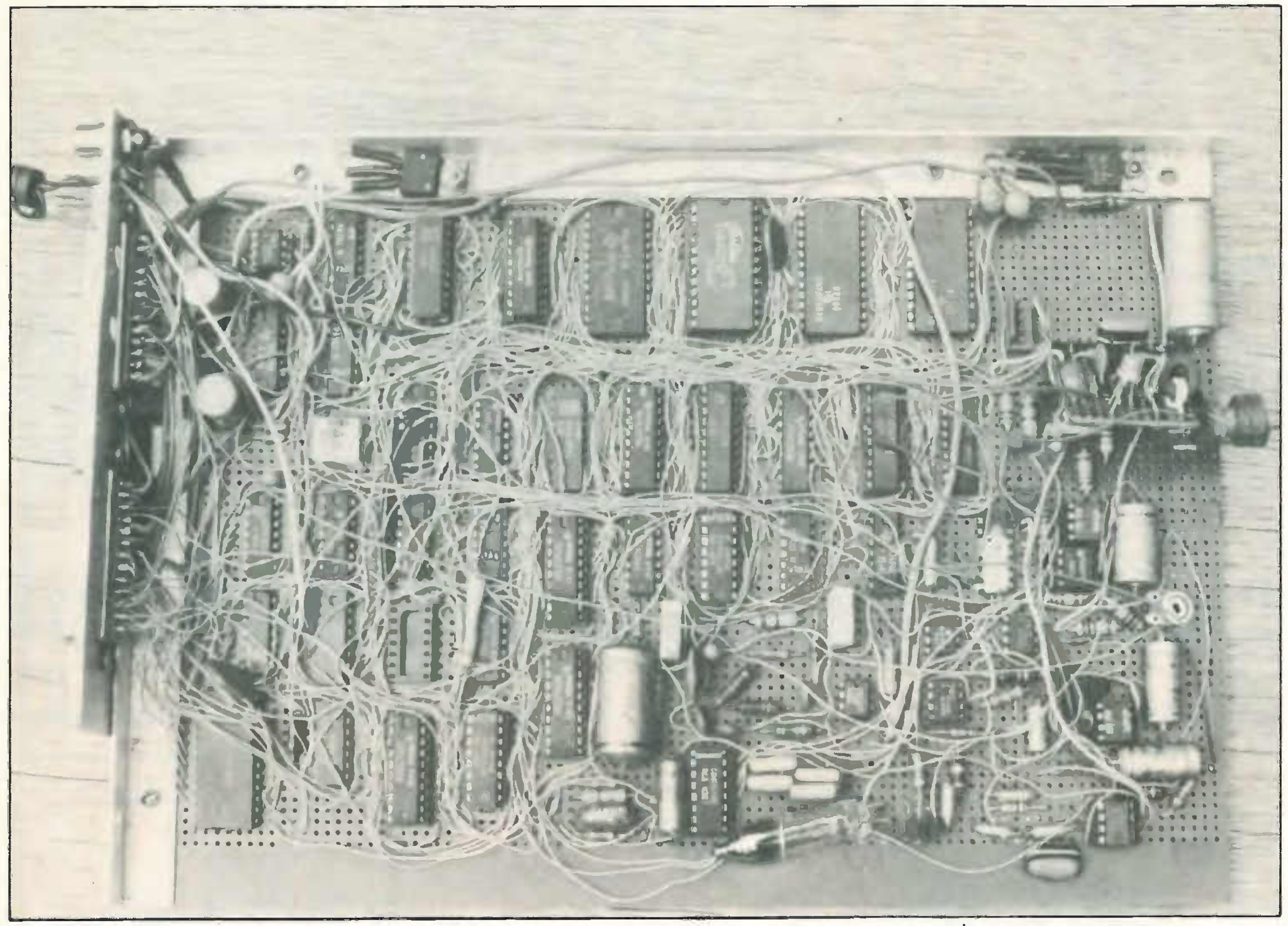
INFLUTE, port 11, when written to causes the voltage on the control converter output to be stored on a sample-and-hold capacitor. There are five of these capacitors. Writing numbers zero to four has the following effects.
Code 000 sets the track oscillator frequency. The track oscillator produces a sinewave for tremolo and vibrato and can be varied from about 0.2 to 10Hz.
Code 001, vibrato depth, varies coupling of the track oscillator to the master clock to change the degree of vibrato in the sound by frequency modulation.
Code 010, tremolo depth, varies coupling of the track oscillator to the multiply input of the main audio d-to-a converter. This changes the amount of tremolo in the sound by amplitude modulation.
Code 011, fine pitch, varies the steady frequency of the master clock to the t.t.l. processor and so pitches the whole instrument.
Code 100 sets the TBASE oscillator frequency over a range of about 0.2 to 10Hz.

HOSTREG, port 12, has its most significant bit inverted and connected directly to the Midi out socket at the back of the keyboard for communication with other instruments and computers. Other bits in this port address regions of the t.t.l. processor main memory. Values correspond directly to values of m in the microcode instruction set.

INDEX, port 13, is similar to the previous one, except that it provides the offset address within a memory region.

DATATX, port 14, is used for writing data to the t.t.l. processor. Values are set up in HOSTREG and INDEX first, then the required data is written to this port for passing on to the t.t.l. processor when it next executes a HOST instruction. Completion of the last operation can be detected by the 8088 using a handshake on its test input. The 8088 has a WAIT instruction which causes the processor to wait until the test input goes low; it is normally advisable to execute a WAIT instruction before updating ports 12 to 14.





Digipoly's main board. The t.t.l. processor is in the upper left area. Microcode prom, op-code latch, op-code decoder, 100ns register memory and the two a.l.us are in the top row of i.cs. Analogue circuits to the lower right include the output low-pass filter, vibrato and tremolo (note the glass-encapsulated themistor) sections and the d-to-a converter influence sample and hold circuits. To the right is a small perpendicular board holding the 10MHz master clock and at the left, a 14-pin keyboard socket and two 25-pin sockets for the 8088 board and front-panel controls.

Control-processing circuit (left) with battery-backed ram for storing user-defined voices when the power is removed. The 8088 microprocessor controls all instrument functions through 16 eight-bit parallel i/o ports.

parameter, the main control knob is enabled and any change in its setting causes the adjust parameter command to be retransmitted with a new value of vv. Value vv ranges from zero to 127. In the final command, used as a hardware diagnostic aid, the two byte transmission is repeated about once every 400µs.

Midi input

Any data received on the Midi 'in' socket will be retransmitted on the 'through' socket. If the data is one of the following commands, it will also be interpreted by Digipoly. Since the keyboard has no touch-sensitivity software, the third byte of these commands need not be present for correct operation. Normally, the command will be interpreted as soon as the first two bytes are received. Commands are (9n kk 40), note on command, which plays a Digipoly note exactly as if a key had been pressed, (8n kk 40) which has the same effect as releasing key kk on the keyboard, (Cn Op 00) for selecting a preset voice in the range 0-15, (Dn 7B 00) for turning all notes off and (FF) for repeating the power-on reset sequence.

While using the first command, the keyboard remains functional but pressing key kk will have no effect until the key is released, when it will silence the note. Normal polyphonic restrictions apply regarding the number of these commands that may be sent. The command for selecting a preset voice has the same effect as using the play button on Digipoly's front panel and the turn-all-notes-off command has the same effect as sending note-off commands to all current notes.

With respect to the Omni and Poly modes of the Midi standard, Digipoly always behaves as though Omni is off and Poly is on.

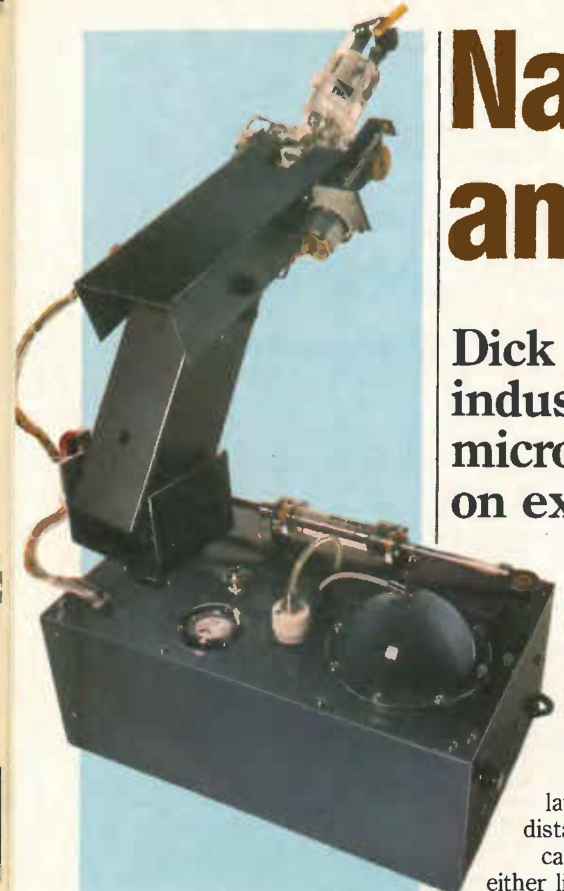
The t.t.l. and 8088 processor circuits are described next.

Software availability

Digipoly can be built for around £175 excluding case. Software is available in various forms from the author at 5 Grovely Way, Crampmoor, Romsey, Hampshire S05 9AX. A 50 page listing of the 8088 source program is £3 and a 40-track disc for the BBC microcomputer holding source, object and related files is £4 (single density). Programmed 2764 eproms containing the 8088 object code and a bipolar prom containing the t.t.l. processor code are £6.50 and £4 respectively. Please include £1 for UK postage and make cheques payable to D.J. Greaves. Brave readers can obtain a copy of the hexadecimal listing by sending a large stamped addressed envelope and a cheque for £1.35 to our editorial offices. Please make this cheque payable to Business Press International.

Naiad training robot — an introductory review

Dick Becker reviews the types of robot used in industry, to be followed by description of a micro robot designed to give low-cost hands on experience in robotics.



Designed by Dick Becker (his 10th robot design) and Peter Wells of Cybernetic Applications

Naiad robot trainer

Each of the various combinations of linear and rotary movement has its advantages and disadvantages when applied to industrial robots, as has the means of applying power — pneumatics, electric motors and hydraulics. Each of these is demonstrated by the Naiad, a desk-top robot designed specifically to provide experience in robotics, safely and cheaply. The hydraulics system uses tap water to ensure clean operation and perspex is widely used to enable students to see the working parts. The series of articles describes the electronic control system as well as the mechanics and explains its operation by microcomputer.

There is no such thing as a universal robot configuration There is a wide variety of means of achieving the required result, that is, to accurately manipulate a tool or gripper at a distance. The movements can be accomplished by either linear or rotary-acting mechanisms or a combination of them. The number of joints or actuators vary and there are many ways of delivering energy to the joints or actuators.

Despite the large number of possible ways of building a robot, industry has generally settled for four configurations which, with some variants, are illustrated in this article. At the working end of the arm the tool or gripper may be directly fitted, but frequently this is preceded by a multi-axis wrist, not shown in the diagrams.

Figure 1 represents a rectangular or cartesian coordinate robot which has three linear axes, each a degree of freedom, and consist of a rotary joint or linear actuator. Each of the axes of the rectangular coordinate robot has a linear action, the power coming from hydraulic or pneumatic cylinders or alternatively by lead-screw driven by servo or stepper motor.

The tool position is readily transferable to world coordinates and straight line movement of the tool (particularly along its axes) is quite easy to achieve. Constant speed of the axes will automatically give straight line motion until one axis has reached its intended coordinate. If the speeds are proportional to the distance to be moved, then each axis will stop at the final point resulting in a straight line for the whole of the path. The working envelope, which is the volume of space in which the end of the arm is capable of reaching, is rectangular in all three dimensions. The ability of rectangular coordinate robots to work simply in straight lines makes them very suitable for welding regular shaped workpieces and for assembly work, particularly where there is a matrix of positions such as on a printed circuit board.

A variant of the rectangular robot is the gantry robot on which the z-axis becomes the final axis, Fig. 2. Being intended for working over a large area, the x, y-axes are supported at each end and slide on rails mounted above the work area.

Figure 3 is a cylindrical coordinate robot similar to the rectangular coordinate configuration except that the x-axis linear movement is replaced by a rotary axis. This gives the robot a much wider work envelope but at the price of increased complexity in determining the tool position in world coordinates and the control of the axes for straight line motion. The working envelope is usually a partial cylinder as wiring or pipe-work generally prevents a full 360° of rotation.

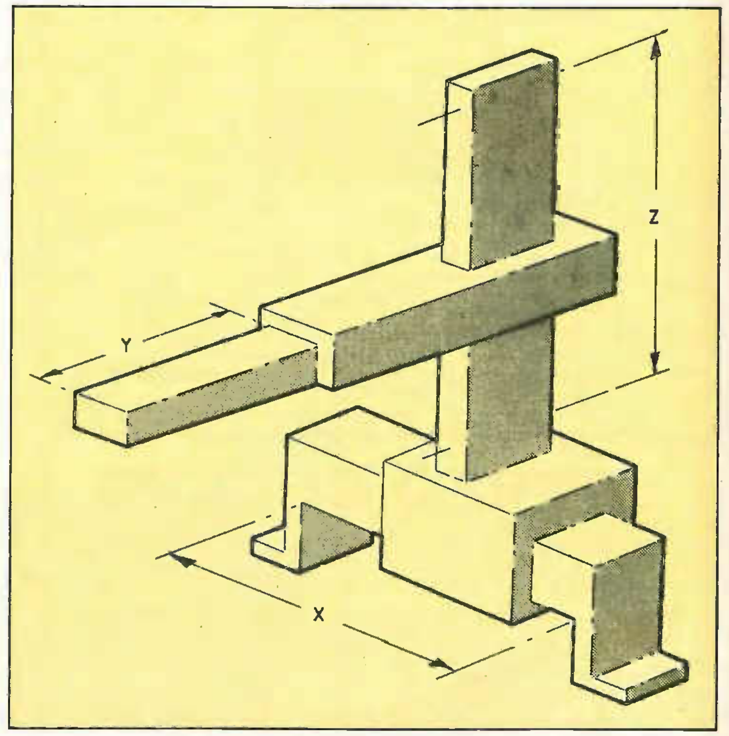


Fig. 1. **Three sliding members are tightly confined to their respective freedoms-of-movement x, y and z. This gives an operating envolope which is a solid rectangle. The manipulator can be positioned at any distance between zero and y from the rectangle x*z. Applications include automated car assembly.**

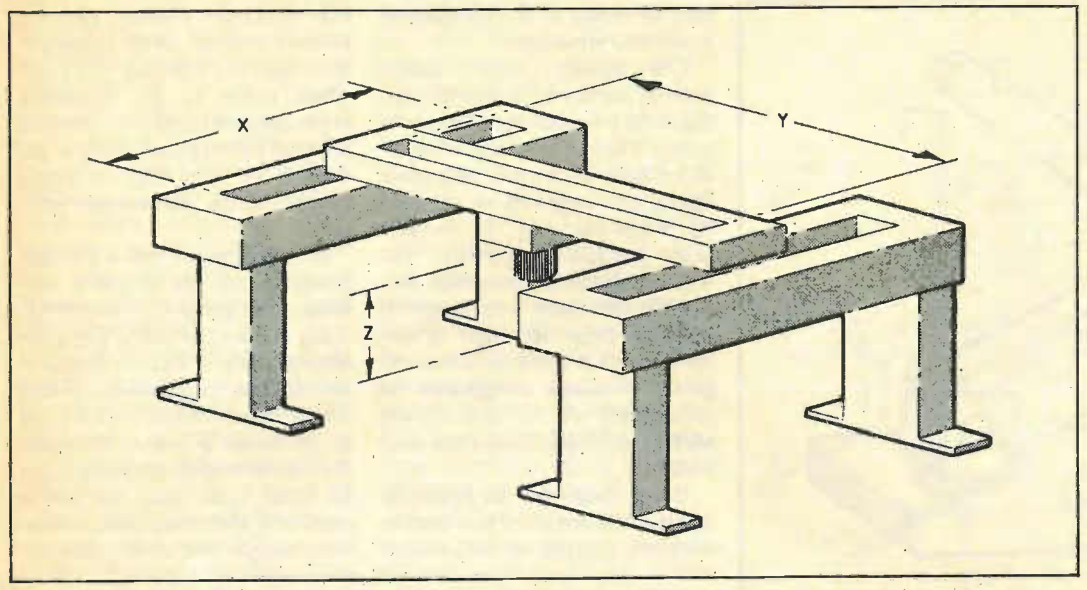
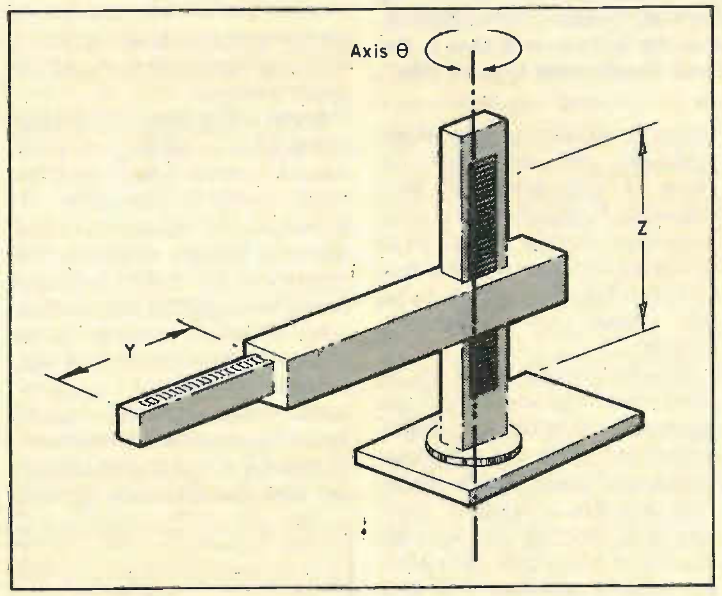


Fig. 2. **Further example of the solid rectangle configuration. Manipulator covers area xy with the manipulator height over work area variable between zero and z. Uses include machine tools, heavy plant assembly and transferring parts within workcells normally outside the reach of the more conventional robot.**

Fig. 3. **Cylindrical coordinate robot operates within a volume similar in shape to a horseshoe. Smaller radius is equal to fixed arm length, which increases by the dimension t to give larger radius. Dimension z governs height at which manipulator operates above base. Manipulator position is often specified in terms of R (radius of operation from vertical axis) and angle (theta-degree of rotation around vertical axis). z remains a linear coordinate defining operating height of manipulator.**



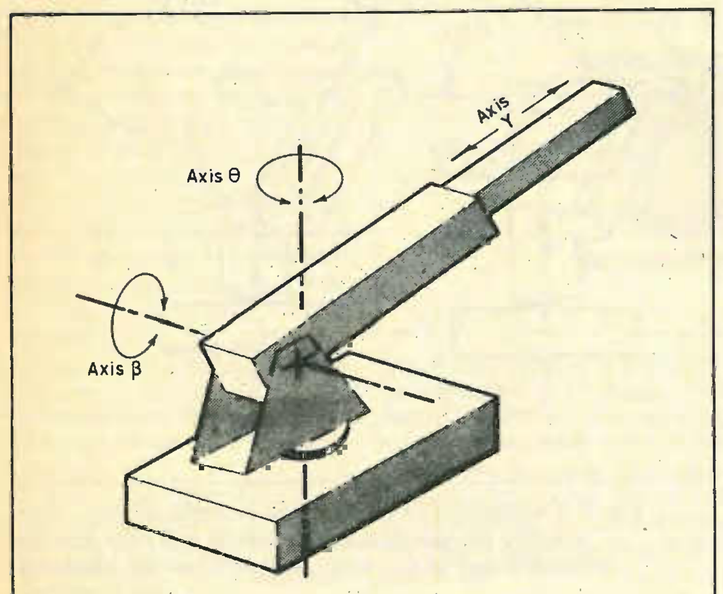


Fig. 4. **Versatile yet basic configuration is capable of operation at any point inside the volume described by two concentric hemispheres whose maximum radius of operation is the length of the fixed arm plus y. This configuration is particularly suitable for robots of heavy load carrying capability.**

Cylindrical coordinate robots are widely used for pick-and-place operations such as taking a finished component out of a press and placing it on a conveyor belt. If the belt is running parallel to the front of the press then the rotary axis will be moving through about 180°. A rectangular coordinate robot is unable to pick up a component in front of it and then transfer it to behind itself.

The turret or spherical coordinate robot is like the cylindrical robot but with the linear z-axis replaced by a rotary joint — see Fig. 4. This permits vertical movement without the necessity for a centre column taller than the movement required. When moving large loads there would be a huge tilting force on a tall column resulting in very heavy engineering being required. With the turret the gripper can be lifted well above the main body of the machine although it is unusual to have lifting capability of more than about 30° above horizontal. Their main application is the relocation of very heavy components such as engine castings and sacks of cement.

With their two rotary axes and one linear axis the working envelope of a turret robot is that of a partial spherical shell. Generally, a hydraulic system is necessary for providing the power to the axes of these robots.

The most versatile configuration is that of the articulated or jointed arm robot, Fig. 5. This has similar features to the human arm. Axis alpha corresponds to the human elbow, axis beta to the shoulder and axis theta to the waist. The versatility, however, results in a complicated relationship between axis angles and world coordinates, and it is often most practical to program such robots by teaching them on-site by leading the arm through the required positions using human eyesight as the means of establishing that the gripper or tool is at is correct location. Data corresponding to those axis coordinates which resulted in that final position is then stored.

The leading-through of the arm may be accomplished in a number of ways such as by switches on a control pendant, computer keyboard or by manipulation of a model of the robot, called a simulator. This last technique is parti-

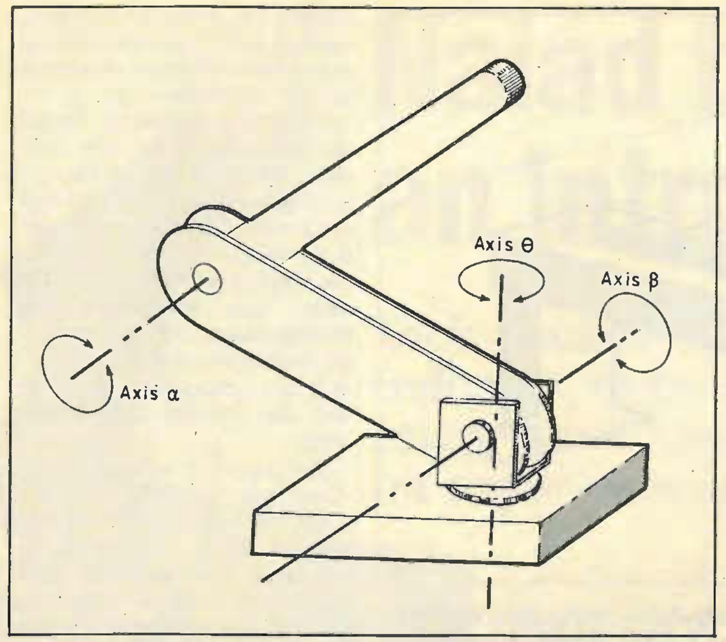


Fig. 5. **Articulated joints of this robot mean it 'reaches the parts other robots cannot reach', making it suitable for many and varied applications from automated welding stations to remote closed circuit tv inspection systems. Operating in a similar manner to the human arm this is the most versatile and widely used type of robot.**

cularly popular for programming a paint spraying operation. Another technique on-site programming is 'leading by the nose', a term derived from the farming community. Moving a bull to a different herd of cows would be a difficult task were it not for a ring in its nose. A short rope on the ring will enable two tons of 'beef-on-the-hoof' to be lead easily by the nose.

Some small robots can be moved around by hand, but on larger machines it is necessary for software to put the arm in a state of balance or else use touch sensors which when activated lead to the corresponding axis being incremented.

As a means of simplifying the control and off-line programming of articulated arm robots, there are some machines built with an additional member fitted to the lower arm, Fig. 6. One of the vertical members is powered as usual whilst the other is simply pivoted. The top section of the pantograph structure remains parallel to the base irrespective of shoulder movements, hence the forearm angle with respect to the workpiece changes only when required rather than as a side effect of rotation at the shoulder.

Articulated-arm robots come in many sizes ranging from capacities of hundreds of grams to hundreds of kilograms. The smaller machines are powered by servo or stepper motors whilst hydraulics are necessary for those of long reach and high capacity. Pneumatics have also been used, but the difficulties of achieving servo control of a system with a fluid as springy as air has made such machines unusual.

Another variant of the articulated robot is the scara, Fig. 7, an acronym for selective compliance articulated robot arm. This may sound impressive, but in reality they are like articulated arms turned on their side and with the multi-axis wrist replaced by a linear actuator operating vertically. There is also a rotary axis for turning the vertical axis. Selective compliance comes from the inherent 'give' in the rotary joints and occurs in any continuously operating servo system. A bang-bang servo system will not have the ideal type of compliance, where displacement of the joint depends on force, but will usually still have some 'give' from backlash sloppiness.

The compliance of a scara permits a component to be pushed into its correct place even if the arm position is not quite right, provided that the component and/or the housing is suitably tapered. As there are no vertically moving rotary joints there is no vertical compliance — hence 'selective' in the acronym. Vertical compliance, if present, could lead to tilting of the component leading to jamming.

Like gantry robots, scaras operate mostly on the horizontal plane with simple vertical movements and find most use for pick-and-place work and assembly operations where more versatility is not required. To simplify their application further, the wrist is usually mechanically coupled to the waist with a pair of belts to keep the angle of the wrist, with respect to the workpiece, constant irrespective of articulation of the arm except when specifically programmed to rotate.

Being used only for relatively small loads scaras are powered by servo or stepper motors except for the vertical axis where pneumatics are generally favoured for speed of action.

Robot categories are further sub-divided according to their control system which may be either servo or non-servo. A servo control system is one where a sensor measures the position of the driven axis and uses it to modify the drive to that axis. Position sensors used include potentiometers, linear variable differential transformers, resolvers and optical devices such as shaft encoders. The power to the axis is dependent upon the difference between the measured position and the desired position. It therefore follows that the axis will be at rest when there is no difference between measured and desired position and the rest position will depend on the data or signal which defines the desired position.

In a non-servo robot the rest positions are set by fixed end-stops. The axis is driven continuously and simply stalls when the stop is reached. This technique is widely used on pneumatic robots where the cylinders receive full air pressures at one of the ends. Whilst automatic end-stops can be fitted to an axis, the movements of the robot will remain very simple and such machines are generally confined to long-run pick-and-place operations. The stops have to be reset manually for each new program so it cannot be said that such machines are re-programmable.

According to the British Robot Association 'an industrial robot is a reprogrammable device that is designed to both manipulate and transport parts, tools, or specialized manufacturing implements through variable programmable motions for the performance of specific manufacturing tasks.' It follows that non-servo devices are not true robots, but just as the technician who repairs a washing machine is incorrectly referred to as an engineer, non-servo pick-and-place machines are unlikely to lose the title of robot. The Japanese do not discount such non-servo units as robots, so the title 'robot' is bound to appear in sales literature. Rather than become involved in a losing battle regarding titles, I think it better to use the non-ambiguous titles of 'servo-controlled robot' and 'non-servo robot'.

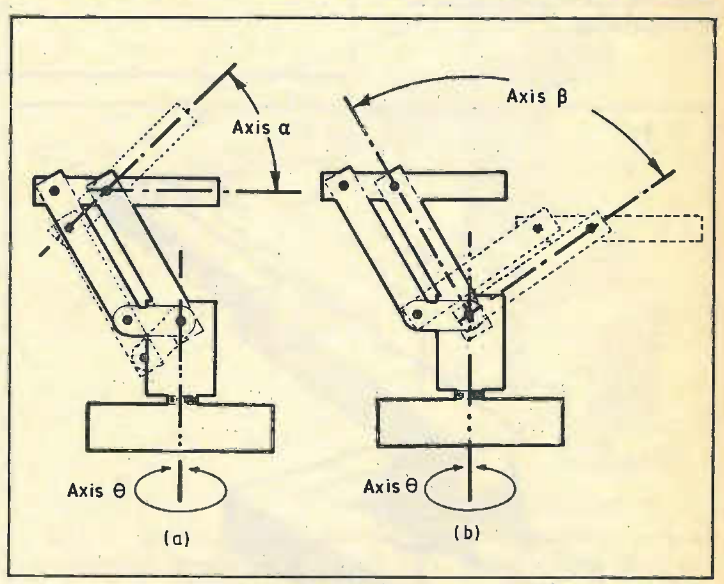


Fig. 6. **Pantograph coupling on an articulated arm robot ensures the manipulator or power tool may remain perpendicular to the work station when the shoulder axis is moved.**

Whilst the non-servo robot can operate rapidly by virtue of always being under full power and can operate accurately by virtue of the lack of drift, backlash or dead-band problems, as positions are determined by mechanical stops, their inability to change under computer control limits their application in computer integrated manufacture.

The energy source for non-servo robots is generally pneumatic, using air compressed to between six and eight bar (a bar is 14.5 lb/in^2 or 0.1MPa) applied via solenoid-operated valves to a cylinder from which energy transfer is via the piston. The force from the cylinder is proportional to the area of the piston (less the area of the piston rod on double-acting cylinders). Double-acting cylinders can be driven in either direction, whilst single-acting ones rely on springs or gravity to return the piston.

Hydraulic power could also be used for non-servo robots, but as they normally handle only small loads the high energy capability of a hydraulic system is not necessary.

Hydraulic systems are, however, used for powering the larger servo-controlled robots. With working pressures of up to 250bar huge forces will be generated in the cylinders which are of similar, but heavier, construction to those used for pneumatics. Hydraulic literally means 'using water' (Greek hydor = water) and the earliest hydraulic systems used water extensively. The new private telecommunications company Mercury is now installing fibre optic cables in a wide network of ducts under London through which until only a few years ago The London Hydraulic Company was supplying high pressure water for use in manufacturing industry and for raising hotel lifts.

Most hydraulic systems however now use mineral oil or water/oil emulsion which contains about 5% of oil. The problem with water is that it is not a very good lubricant, limiting the speed at which a piston can move without overheating of the piston seal at the point of contact with the cylinder wall.

A recent development in hydraulics called the rolling diaphragm (Fig. 8) has solved the problem of friction and hence renders pure water a suitable fluid for use in servo-controlled hydraulic systems. Hydraulics therfore becomes suitable for use in clean environments as required for food handling, radioactive isotope preparation and for laboratories where spillage of hydraulic oil would be unacceptable.

A conventional hydraulic seal consists of a ring of resilient material such as rubber, rubber impregnated fabric or p.t.f.e. This fits into a groove around the piston and has a diameter slightly larger than that of the cylinder. Inside the cylinder, the ring compresses and the resilience causes it to firmly fill the gap between the piston groove and the cylinder wall. It is this necessary resilience which leads to the force on the seal/cylinder contact point and hence the friction.

A rolling diaphragm is a top-hat-shaped rubber moulding reinforced by a fabric that will stretch widthways but not lengthways. The diaphragm is clamped to both the top of the piston and to part way down the length of the cylinder. There is a gap between the piston and the cylinder down which the diaphragm fits and when under pressure it clings to the walls of both the cylinder and the piston. When the piston moves, the diaphragm simply rolls on and off it without friction.

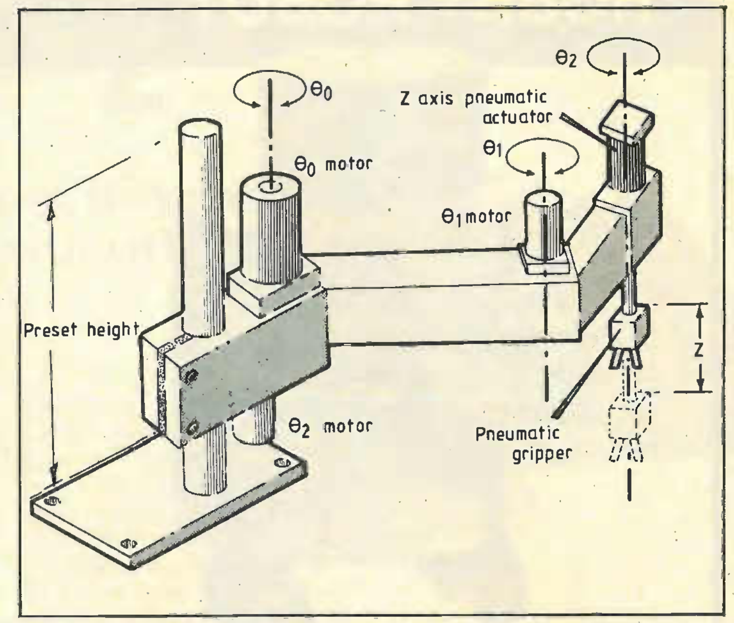


Fig. 7. **Scara robot is ideally suited to pick and place type of assembly work. It is capable of a high degree of accuracy and high speed of operation. Figure shows the true scara concept with the interesting feature that the wrist rotation (theta 2) is controlled by a motor fixed at the column clamp end. The wrist is then driven by toothed belts. This arrangement always keeps the workpiece in the gripper orientated in the same direction irrespective of positions of theta 1 and theta 2.**

The lack of static friction allows very small and slow piston travel without juddering or jumping, making very accurate servo control practical. An additional benefit of the rolling diaphragm is that it fully seals in the hydraulic fluid. With a conventional seal some leakage is inevitable sometimes referred to as self-lubricant.

A hydraulic system has the overhead cost of a high-pressure pump, accumulator (hydraulic pressure reservoir which acts like a capacitor), an oil cooler and expensive control valves. On small robots, where heavy load carrying is not sought, energy input to the axes via electric motors is adequate.

Both stepper and servo motors, which may be either d.c. or a.c., are useable for driving robots. Stepper motors have an even number of windings of which at any one time 50% have current passing through. The fixed magnetic flux holds the motor shaft stationary until a different combination of windings is switched in and the shaft moves to a different position. On sequentially switching between the windings the shaft will step through a constant angle for each switching transition.

Whilst stepper motors are widely used in machine tools, such as on the slide of a lathe where there is only moderate acceleration and deceleration, they are used much less than servo motors on articulated arm robots on which the rapid changes of position and loading can cause steps to be missed. Steps are missed when inertia or static loading prevents the motor shaft from reaching one stable position before the next transition occurs and, even with careful control of the rate of stepping it is still necessary to use a shaft encoder or resolver to confirm that steps of position of the shaft have actually occurred.

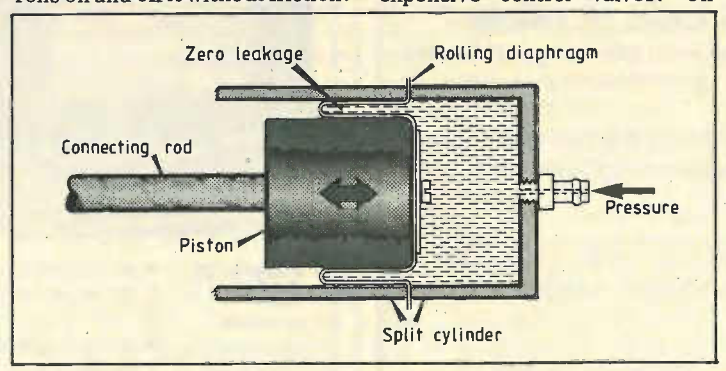


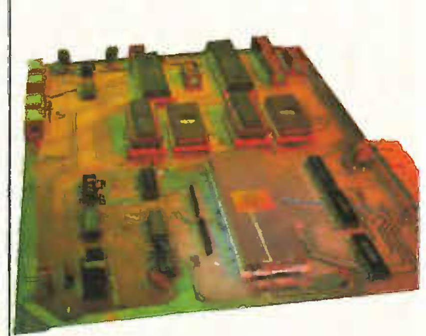
Fig. 8. **Diaphragm is clamped between two parts of cylinder and attached to the piston forming totally leakproof yet fully flexible chamber. As pressure is increased within the chamber, piston is pushed along the cylinder and diaphragm rolls along between the piston and cylinder wall. As well as being leakproof the system offers very low friction, and robot arms operated by this type of actuator have very smooth control — particularly important when small movements are called for.**

To be continued

68000 board — 2

by R.F. Coates

Bob Coates describes the circuit of Kaycomp — a 68000 microprocessor board with G64-bus option that can be built for £100.



Kaycomp is a low cost computer board using a Motorola 68000 microprocessor with 16-bit data bus. It is designed for use either as an evaluation/educational tool or as the processor board of a larger system, connecting to a wide range of readily available peripheral cards through its G64 bus. This second article describes the circuit.

Address decoding is performed by a three-to-eight-line decoder, IC_9 of Fig.1.(over) The three most-significant address lines A_{21-23} are decoded, splitting the 16M byte memory map into eight 2Mbyte blocks. Five outputs select eprom, ram, 68681 dual universal asynchronous receiver/transmitter (duart), 68230 peripheral interface/timer (p.i.t.) and the G64 bus.

None of these five devices actually requires a 2Mbyte address space; the duart only needs 32 bytes. As a result, each device is repeatedly addressed throughout its 2Mbyte block — addressing for the duart is repeated 65 000 times! This may seem a waste of addressing space but for a small system such as Kaycomp it allows adequate memory capacity while greatly simplifying address decoding. Figure two shows the memory map.

Eprom and ram outputs are further gated with the upper and lower data strobe signals, UDS and LDS, by IC_{10} for defining upper and lower-byte eproms and rams. The three enable inputs of IC_9 also qualify the output strobes.

Address strobe AS allows an output to be enabled only when a valid address appears on the address bus. To ensure that the outputs are only selected when the date bus carries valid data, the two data strobes are combined in IC_6 at pin eight.

Valid data is indicated by one or both of the data strobe signals being low, which occurs later in the cycle than AS. This is to satisfy timing requirements of the 68230 p.i.t. which needs valid data on the chip-select signal leading edge during a write cycle, rather than on the trailing edge transition as with other devices.

Finally, IC_9 pin six inhibits outputs during an interrupt acknowledge cycle during which the processor sets A_{4-23} high. Without the inhibit signal, in the case of user-vectored interrupts output seven would be selected to cause reading of the G64 bus at the same time as the interrupting device is placing its vector on the data bus.

Data acknowledge

To satisfy the requirements of asynchronous bus transfers, an acknowledge signal — DTACK — must be sent by the memory or peripheral back to the processor to inform it that the transfer is complete. If necessary, the processor inserts wait states in the cycle until it receives the acknowledgement.

Peripheral devices in the 68000 family have DTACK open-drain outputs which are directly connected to the processor DTACK input along with a pull-up resistor. Eproms and rams however do not have such an output so an equivalent signal must be created. On more expensive boards DTACK is normally simulated using either a multi-tap delay line or an active delaying device such as a shift register driven by the processor clock to produce a delayed chip-select signal for the DTACK input. There are often different circuits for each type of device and the delay is selectable so it may be set to the optimum required for each type of device on the board.

To keep things simple on Kaycomp, the chip select signals are applied directly to DTACK which means that no wait states are inserted and the memories must be fast enough to allow this. Eprom and ram select outputs of IC_9 are combined in IC_6 at pin eight and then inverted by the open-collector inverter IC_7 at pin eight, pulling DTACK low if either select output goes low.

Outputs one, three and six of IC_9 are not used. If the processor tries to access a vacant part of the memory map no DTACK signal will be generated and so the processor will insert wait states indefinitely. Resetting is necessary to recover the situation.

One output from IC_9 which does not result in DTACK being generated is the G64 bus select signal. This signal requires a synchronous bus transfer. To initiate this transfer, the processor input VPA (valid peripheral address) and not DTACK must be asserted. A ten clock-cycle synchronous transfer then takes place, no acknowledge being required. Output pin seven of IC_9 going low pulls the 68000 VPA input low through IC_8, pin eight.

Memories

In a 16bit system, byte-wide eproms and rams are used in pairs. Memory IC_2 is the lower-byte eprom, IC_3 the upper byte eprom, IC_4 the lower byte ram and IC_5 the upper byte ram.

Lower byte device data buses connect to the processor D_{0-7} lines and upper byte devices to the D_{8-15} lines. Address pins connect to the processor address outputs but as there is no A_0 output, A_1 goes to A_0 on the memories, A_2 to A_1 and so on. Pins 1, 26 and 27 of the eproms go to link one which is wired according to the size of eprom used. Similarly ram pins 23 and 26 go to link one and are also linked to suit the device in use.

Chip enable (CE) pins of each device are driven from the appropriate output of IC_{10}. Output enable (OE) pins connect to the read/write line, inverted at IC_7

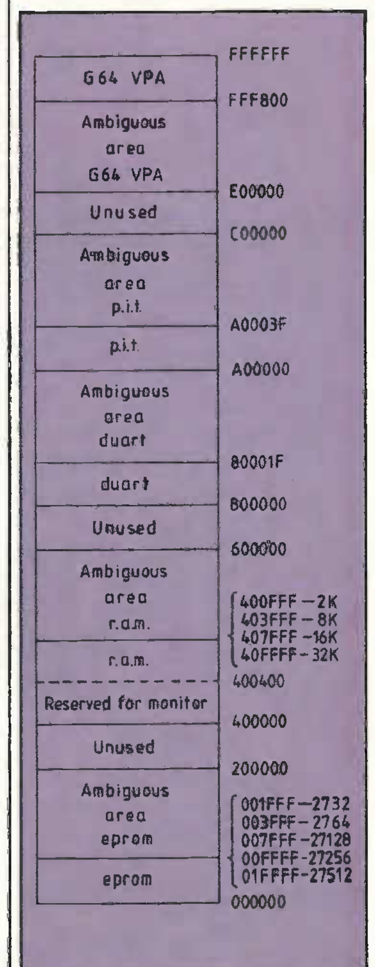


Fig. 2. **Kaycomp system memory map. Simple address decoding means a cheap system allowing sufficient memory for most computer-board applications.**

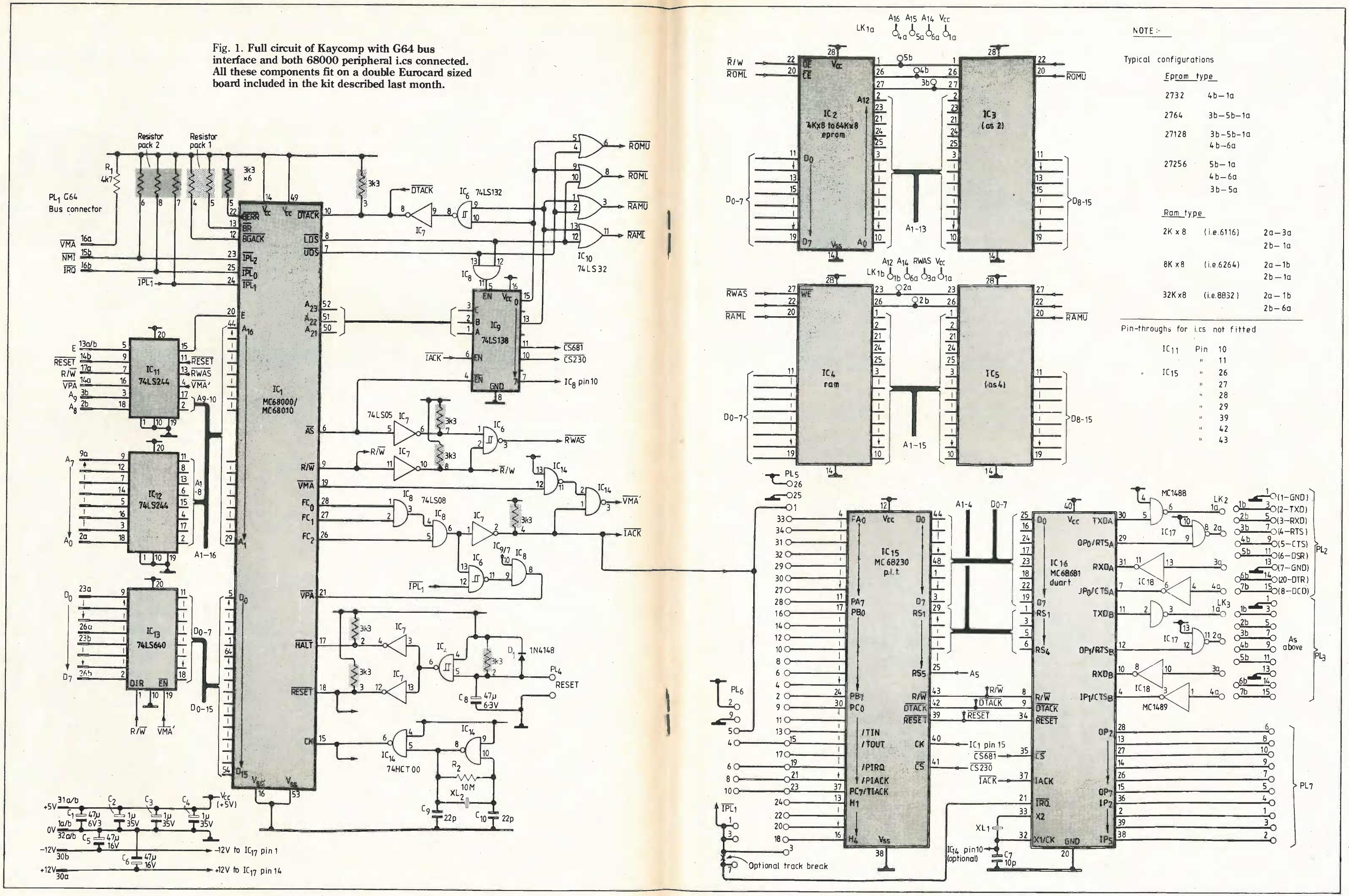


Fig. 1. Full circuit of Kaycomp with G64 bus interface and both 68000 peripheral i.cs connected. All these components fit on a double Eurocard sized board included in the kit described last month.

pin 10 so that the output buffers are disabled during write cycles. The read/write signal to the memories is the processor read/write output gated with the address strobe.

G64 bus interface

Circuits IC_{11-13} buffer on-board signals to the G64 bus, which can support a wide range of peripheral cards. The G64 bus specification allows a portion of the memory map (normally 1Kbyte) to be dedicated to peripheral cards, the reset of the memory map being available for memory.

Which area is being accessed by a particular bus cycle is indicated by either 'valid memory address' or 'valid peripheral address' being asserted low. These names are not to be confused with the 68000 pins of the same name. To avoid confusion I will call them G64-VMA and G64-VPA.

As Kaycomp is not designed to use the G64 bus for memory expansion, the G64-VMA line is pulled high by resistor R_1. The G64-VPA memory block is only 1Kbyte long so only address lines A_{0-9} are needed. Once again the lack of an A_0 line means that the G64 address lines are driven by the next higher 68000 address line and so the block becomes 2Kbyte in size.

Although G64 bus has 16 data bits, most peripheral cards only use eight bits and so IC_{13} buffers just D_{0-7} to the external bus. As a result, only odd addresses have any meaning when accessing the G64 bus. A byte read or write to an even address causes the processor to use D_{8-15} which are not connected. In the 2Kbyte block, we therefore have 1024 odd addresses on the G64 bus. This may sound a little complicated but it will become clearer later when programs for using the G64 bus are discussed.

The direction of transfer through IC_{13} is controlled by the read/write line and the buffers are enabled by the VMA' signal, which is also used as the G64-VPA signal after buffering by IC_{11}.

Signal VMA' is derived by logic associated with the processor FC_{0-2}, VMA and VPA pins. This section also generates the interrupt acknowledge, IACK, signal. If an address is generated by the processor which accesses the G64 bus, IC_9 pin 7 goes low. This takes IC_8 input pin 10 low, the output of which takes VPA low, initiating a synchronous bus cycle.

During this synchronous cycle, the processor takes VMA low for use as the G64-VPA signal for selecting the relevant G64-bus peripheral device. First though, VMA is qualified by IC_{14} outputs 11 and 3 which only allows VMA if IACK is high that, is, it is not an interrupt acknowledge cycle. This is because an 'auto-vectored' interrupt acknowledge cycle also asserts VMA. The reason for all this gating of signals will become clear later when interrupt handling is discussed.

As mentioned last month, there are two types of interrupt on the 68000, user vectored, where the interrupting device provides a vector number on the data bus, and auto-vectored which is similar to that on the 6800 in which a vector address is fetched from memory. Two interrupt pins, IPL_2 and IPL_0 are connected to G64 bus NMI and IRQ lines. The third, IPL_1, is connected to the duart IRQ output and may be optionally connected to the two interrupt outputs of the p.i.t., PIRQ and TIRQ.

When the processor recognises an interrupt on one of these lines, it starts an interrupt-acknowledge bus cycle. A function code of all ones appears on FC_{0-2} outputs which causes pin six of IC_8 to go high. This signal is inverted by open-collector buffer IC_7 at pin 2 to give a low level IACK during this cycle. When pin 6 of IC_8 goes high, if IPL_1 is also high indicating that this is not the source of interrupt, IC_6 pin 11 and IC_8 pin 8 go low to force VPA low. The same occurs when forcing a synchronous bus cycle.

If VPA is taken low during an interrupt acknowledge cycle, the processor interprets this as meaning a request for an auto-vectored interrupt and not a synchronous bus cycle. It responds by also taking VMA low, which is why VMA' is disabled if IACK is asserted, VMA and VPA serving dual purposes. Thus an interrupt on IPL_2 or IPL_0 (NMI or IRQ) generates an auto-vectored interrupt, but an interrupt on IPL_1 (a 68000 peripheral) does not cause VPA to go low and so generates a vectored interrupt. Why there are two types of interrupt is explained in a later article.

There are three other lines driven on the G64 bus, E which is the 6800 type synchronous clock used to time synchronous bus transfers, read/write and reset.

Halt/Reset

A full processor reset is applied to the 68000 when both halt and reset pins are taken low, either at power-up or when the two reset pins are shorted. At power-up or after opening the reset contacts, the level at IC_6 pin 5 rises to V_{cc} slowly due to charging of C_8 through a resistor. While pin five is below its input threshold voltage, output pin six is high and the two sections of IC_7 hold the halt and reset inputs low. As voltage across C_8 rises, IC_6 output pin 6 will go low, a Schmitt trigger gate here ensuring clean switching. Halt and reset inputs then go high at the same instant allowing the processor to start.

A two-pin printed circuit mounting plug is provided with the kit, which may be connected to a push-switch if required. If 'Kaycomp' is not mounted in a case, squeezing the two pins together provides a crude but effective switch.

Dual uart

The 68681 is a dual asynchronous receiver/transmitter providing two independent serial ports, a data rate oscillator and a number of general purpose i/o pins. Configuration of the serial interfaces and data rate setting is under software control.

Interfacing to the processor is quite simple as the 68681 is a 68000 family peripheral. It is an 8bit peripheral, so only D_{0-7} are used, along with the four lowest address lines connected to register select pins RS_{1-4}, thus the device occupies 32 bytes of memory space (16 registers at odd addresses).

Read/write, DTACK and RESET lines connect straight to the appropriate processor pins, CS connects to output four of IC_9 and IACK is driven from the interrupt acknowledge generating logic. Interrupt request output IRQ is taken to the processor IPL_1 input, thus the duart can generate a level two vectored interrupt.

According to manufacturer's specifications the duart internal data rate generator requires an external 3.6864MHz crystal, XL_1. However, not far away from this frequency is a cheap 3.5795MHz US colour-tv crystal. These have been found to work satisfactorily despite that the data rates are slightly off frequency.

When receiving a serial character the duart, with a clock frequency of 16 times the data rate, first detects the leading edge of a start bit, then counts eight clock periods to align itself in the middle of the start bit. Subsequently every 16 clock periods the duart reads the input level a number of times, up to nine (eight data bits plus one parity bit) according to the data format configuration.

Ideally, each bit is read at its middle point, but with a slow crystal the reading point gradually drifts later in the bit. This is alright provided that the drift doesn't accumulate to the point where it reads over the boundary into the next bit. With a worst-case configuration of eight data bits, one parity bit and one start bit, ten bits are read over 160 clock periods. The distance between the middle of a pulse and the start of the next is eight clock periods, so drift allowable before an error is 8 in 160, or 5%; the difference between the two crystal frequencies is only 2.9%.

This assumes a clean signal which should be the case unless long serial leads are used or the environment is electrically noisy. The kit printed circuit board accepts both colour tv and HC18/U crystals.

Crystal output at pin 32 may also be used to drive the processor clock if processing speed is not important. For this, XL_2, C_9, C_{10} and R_2 are omitted and a wire link used to connect IC_{16} pin 32 to IC_{14} pin 10. Gate IC_{14} does not now have to be an HCT version. An LS version will suffice.

On the peripheral side of the i.c. there are two each of serial outputs and inputs plus eight general purpose t.t.l. outputs and six general purpose t.t.l. inputs. Optionally two of the inputs, $IP_{0,1}$, may be used as RS232 CTS (clear to send) inputs and two of the outputs, $OP_{0,1}$, as RS232 RTS (ready to send) outputs. Outputs and inputs for each serial interface are buffered by an RS232 line driver IC_{17} and line receiver IC_{18} respectively.

There is one problem when using RS232 — every computer, terminal and modem manufacturer seems to have its own interpretation of the standard and one

continued on page 64

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The WS3000 range all have BT approval.

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... £195.00(b)
Adaptor for 2764/2564 .... £25.00

SPECIAL OFFER

2764-25 **£2.40 (d)**; 27128-25 **£3.20 (d)**; 6264LP-15 **£4.50 (d)**

ACORN IEEE INTERFACE £282 | INDUSTRIAL PROGRAMMER EP8000 £695 (a)

DISC DRIVES

TECHNOMATIC drives are fitted with high quality slimline mechanisms and are available with or without integral mains power supply. The dual drive power supplies are switch mode type and are generously rated. All drives with integral power supply are fitted with a mains indicator.
All drives are supplied with all the necessary cables, manual and a formatting disc. All drives are capable of operating in single or double density modes.

Single Drives:		With integral psu.	
1 × 100K 40T SS: TS100	£85(b)	PS100	£120(b)
1 × 400K 80/40T DS: TS400	£125(b)	PS400	£145(b)
Dual Drives: (with integral psu) Stacked Version:		Plinth Versions:	
PD200 2 × 100K 40T SS	£190(a)	PD200P	£215(a)
PD800 2 × 400K 80/40T DS	£265(a)	PD800P	£289(a)

3.5" Drives: TS35 1 × 400K 80T DS **£99(b)** TD35 2 × 400K 80T DS **£175(b)**

3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee Discs in packs of 10.

5¼" DISCS				3½" DISCS	
40 T SS DD	£13(c)	40 T DS DD	£18(c)	80 T SS DD	£30(d)
80 T SS DD	£22(c)	80 T DS DD	£24(c)	80 T DS DD	£38(d)

FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. **£14.50 (b)**

DRIVE ACCESSORIES

Single Disc Cable £6 (d)	Dual Disc Cable £8.50 (d)
10 Disc Library Case £1.80 (d)	30 Disc Storage Box £6 (c)
30/40 Disc Lockable Box £14 (c)	100 Disc Lockable Box £19 (c)

MONITORS

MICROVITEC 14in. & 20in RGB
1431 Std Res **£185 (a)**; 1431 Ap std Res PAL/Audio **£205 (a)**;
1451 Med Res **£240 (a)**; 1451AP Med Res **£280 (a)**; 1441 Hi Res **£389 (a)**;
Swivel Base for Plastic 14"Microvitecs **£20 (c)**
2030CS Std Res £380 (a); **2040CS Hi Res £685 (a)**
Plinth for 14in. Monitors **£8.50.**
Microvitec Monitors with TTL/Linear Inputs also available.
SANYO CD 3125 NB 14in. RGB Std Res **£159 (a)**
KAGA TAXAN 12in. RGB
Vision II Hi Res £225 (a); New Vision III plus **£330 (a); Supervision III** plus **£275 (a)**
Mitsubishi 14" RGB Med Res. LBME BBC Compatible **£299 (a)**
Green Screens: KAGA 12G **£99 (a)**; SANYO DM811 12CX **£95 (a)**;
Swivel Stand for Kaga Green **£21 (c)**
BBC Leads: KAGA RGB **£5** Microvitec **£3.50**; Monochrome **£3.50 (d)**

UVERASERS

UV1T Eraser with built-in timer and mains indicator. Built-in safety interlock to avoid accidental exposure to the harmful UV rays.
It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. **£59 + £2 p&p.**
UV1 as above but without the timer. **£47 + £2 p&p.**
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms. UV141 has a built in timer. Both offer full built in safety features UV140 **£69**, UV141 **£85**, p&p **£2.50.**

PRINTER BUFFER

The buffer offers a storage of 64K. Data from three computers can be loaded into the buffer which will continue accepting data until it is full. The buffer will automatically switch from one computer to next as soon as that computer has dumped all its data. The computer then is available for other uses. LED bar-graph indicates memory usage. Simple push button control provides. REPEAT, PAUSE and RESET functions. Integral power supply. **£199 (a).**

Serial Test Cable

Serial Cable switchable at both ends allowing pin positions to be re-routed or linked at either end — making it possible to produce almost any cable configuration on site.
Available as M/M or M/F **£24.75 (d)**

Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without rewiring the cable assay. Jumpers can be used and reused. **£22 (d)**

Serial Mini Test

Monitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines. Connects in Line. **£22.50 (d)**

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	—
St Hood	90	95	100	120
Screw	130	150	175	—
Lock				

TEXTOOL ZIF

SOCKETS 28-pin £9.00 | 24-pin £7.50 40-pin £12.00

EDGE CONNECTORS

	0.1"	0.156"
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12-way (vic 20)	—	350p
2 × 18-way	—	140p
2 × 23-way (ZX81)	175p	220p
2 × 25-way	225p	220p
2 × 28-way (Spectrum)	200p	—
2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22-way	190p	—
2 × 43-way	395p	—
1 × 77-way	400p	500p
2 × 50-way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612	Plug	Skt
2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B		400p
IDC Skt A + C		400p

For 2 × 32 way please specify spacing (A + B, A + C).

MISC CONNS

21 pin Scart Connector 200p
8 pin Video Connector 200p

AMPHENOL CONNECTORS

36 way plug Centronics (solder 500p (IDC) 475p
36 way skt Centronics (solder) 550p (IDC) 500p
24 way plug IEEE (solder) 475p (IDC) 475p
24 way skt IEEE (solder) 500p (IDC) 500p
PCB Mtg Skt Ang Pin
24 way 700p 36 way 750p

GENDER CHANGERS

25 way D type

Male to Male	£10
Male to Female	£10
Female to Female	£10

RS 232 JUMPERS

(25 way D)

24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female Female	£10.00
24" Male Male	£9.50
24" Male Female	£9.50

DIL SWITCHES

4-way 90p 6-way 105p
8-way 120p 10-way 150p

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

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

ATTENTION

All prices in this double page advertisement are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows: (a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TECHNOLINE VIEWDATA SYSTEM. TEL: 01-450 9764
Using 'Prestel' type protocols. For information and orders — 24 hour service, 7 days a week

74 SERIES

7400 0.30
7401 0.30
7402 0.30
7403 0.30
7404 0.36
7405 0.30
7406 0.40
7407 0.40
7408 0.30
7409 0.30
7410 0.30
7411 0.30
7412 0.30
7413 0.50
7414 0.70
7416 0.36
7417 0.40
7420 0.30
7421 0.60
7422 0.36
7423 0.36
7425 0.40
7426 0.40
7427 0.32
7428 0.43
7430 0.30
7432 0.36
7433 0.30
7437 0.30
7438 0.40
7439 0.40
7440 0.40
7441 0.90
7442A 0.70
7443A 1.00
7444 1.10
7445 1.00
7446A 1.00
7447A 1.00
7448 1.00
7450 0.36
7451 0.35
7453 0.38
7454 0.38
7460 0.55
7470 0.50
7472 0.45
7473 0.45
7474 0.50
7475 0.60
7476 0.45
7480 0.65
7481 1.80
7483A 1.05
7484A 1.25
7485 1.10
7486 0.42
7489 2.10
7490A 0.55
7491 0.70
7492A 0.70
7493A 0.55
7494 1.10
7495A 0.60
7496 0.80
7497 2.10
74100 1.90
74107 0.50
74109 0.75
74110 0.75
74111 0.55
74116 1.70
74118 1.10
74119 1.70
74120 1.00
74121 0.55
74122 0.70
74123 0.80
74125 0.65
74126 0.55
74128 0.55
74132 0.75
74136 0.70
74141 0.90
74142 2.50
74143 1.30
74144 2.70
74145 1.10
74147 1.70
74148 1.40
74150 1.75
74151A 0.70
74153 0.80
74154 1.40
74155 0.80
74156 0.90
74157 0.80
74159 1.75
74160 1.10
74161 0.80
74162 1.10
74163 1.10
74164 1.20
74165 1.10
74166 1.40
74167 4.00
74170 2.00
74172 4.20
74173 1.40
74174 1.10
74175 1.05
74176 1.00
74178 1.50
74179 1.50
74180 1.00
74181 3.40
74182 1.40
74184 1.80
74185A 1.80
74190 1.30
74191 1.30
74192 1.10
74193 1.15
74194 1.10
74195 0.80
74196 1.30
74197 1.10
74198 2.20
74199 2.20
74221 1.10
74251 1.00
74259 1.50
74265 0.80
74273 2.00
74276 1.40
74278 1.70
74279 0.90
74283 1.05
74742 3.20
74290 0.90
74293 0.90
74298 1.80
74351 2.00
74365A 0.80
74366A 0.80
74367A 0.80
74376 1.60
74390 1.10
74393 1.20
74490 1.40

74LS SERIES

74LS00 0.24
74LS01 0.24
74LS02 0.24
74LS03 0.24
74LS04 0.24
74LS05 0.24
74LS08 0.24
74LS09 0.24
74LS10 0.24
74LS11 0.24
74LS13 0.34
74LS14 0.50
74LS15 0.24
74LS20 0.24
74LS21 0.24
74LS22 0.24
74LS24 0.50
74LS26 0.26
74LS27 0.24
74LS28 0.24
74LS30 0.24
74LS32 0.24
74LS32 0.24
74LS33 0.24
74LS37 0.24
74LS38 0.24
74LS40 0.24
74LS42 0.50
74LS43 1.50
74LS48 0.90
74LS49 1.00
74LS51 0.24
74LS54 0.24
74LS55 0.24
74LS73A 0.30
74LS74A 0.35
74LS75 0.45
74LS76A 0.36
74LS78 0.42
74LS83A 0.70
74LS85 0.75
74LS86 0.35
74LS90 0.48
74LS91 0.90
74LS92 0.35
74LS93 0.54
74LS95B 0.75
74LS96 0.90
74LS107 0.40
74LS109 0.40
74LS112 0.45
74LS113 0.45
74LS114 0.45
74LS122 0.70
74LS123 0.80
74LS125 0.50
74LS126 0.50
74LS132 0.65
74LS133 0.55
74LS136 0.45
74LS138 0.55
74LS139 0.55
74LS145 0.95
74LS147 1.75
74LS148 1.40
74LS151 0.65
74LS152 2.00
74LS153 0.65
74LS154 1.60
74LS155 0.65
74LS156 0.65
74LS157 0.50
74LS158 0.65
74LS160A 0.65
74LS161A 0.75
74LS162A 0.75
74LS163A 0.75
74LS164 0.75
74LS165A 1.10
74LS166A 1.50
74LS168 1.30
74LS169 1.00
74LS170 1.40
74LS173A 1.00
74LS174 0.75
74LS175 0.75
74LS181 2.00
74LS183 1.90
74LS190 0.75
74LS191 0.75
74LS192 0.60
74LS194A 0.75
74LS195A 0.75
74LS196 0.80
74LS197 0.80
74LS221 0.90
74LS240 0.80
74LS241 0.80
74LS242 0.90
74LS243 0.90
74LS244 0.80
74LS245 1.10
74LS247 1.10
74LS248 1.10
74LS249 1.10
74LS251 0.75
74LS253 0.75
74LS256 0.90
74LS2457A 0.70
74LS258A 0.70
74LS259 1.20
74LS260 0.75
74LS266 0.60
74LS273 1.25
74LS279 0.70
74LS280 1.90
74LS283 0.80
74LS290 0.80
74LS292 9.00
74LS293 0.80
74LS295 1.40
74LS297 9.00
74LS298 1.00
74LS299 2.20
74LS321 3.70
74LS322A 3.90
74LS323 3.00
74LS324 3.20
74LS348 2.00
74LS352 1.20
74LS353 1.20
74LS356 2.10
74LS363 1.80
74LS364 1.80
74LS365 0.50
74LS366 0.50
74LS367 0.52
74LS368 0.50
74LS373 0.90
74LS374 0.90
74LS375 0.75
74LS377 1.30
74LS378 0.95
74LS379 1.30
74LS381 4.50
74LS385 3.25
74LS390 0.60
74LS393 1.00
74LS395A 1.00
74LS399 1.40
74LS445 1.80
74LS465 1.20
74LS467 1.20
74LS490 1.50
74LS540 1.00
74LS541 1.00
74LS608 7.00
74LS610 19.00
74LS612 19.00
74LS624 3.50
74LS626 2.25
74LS628 2.25
74LS629 1.25
74LS640 2.00
74LS640-1 3.00
74LS641 1.50
74LS642 2.50
74LS642-1 3.00
74LS643 2.50
74LS643-1 3.00
74LS644 3.50
74LS645 2.00
74LS645-1 4.00
74LS668 0.90
74LS669 0.90
74LS670 1.70
74LS682 2.50
74LS683 3.00
74LS684 3.50
74LS687 3.50
74LS688 3.50
74LS783 21.00

74S SERIES

74S00 0.50
74S02 0.50
74S04 0.50
74S05 0.50
74S08 0.50
74S10 0.50
74S11 0.75
74S20 0.50
74S22 0.50
74S30 0.50
74S32 0.60
74S37 0.60
74S38 0.60
74S40 0.50
74S51 0.60
74S64 0.45
74S74 0.70
74S85 3.00
74S86 1.00
74S112 1.50
74S113 1.20
74S114 1.20
74S124 3.00
74S132 1.00
74S133 0.60
74S138 1.80
74S139 1.80
74S140 1.00
74S151 1.50
74S153 1.50
74S157 2.00
74S158 2.00
74S163 3.00
74S169 5.50
74S174 3.00
74S175 3.20
74S188 1.80
74S189 1.80
74S194 3.00
74S195 3.00
74S196 3.50
74S200 4.50
74S201 3.20
74S225 5.20
74S240 4.00
74S241 4.00
74S244 4.50
74S251 2.50
74S257 2.50
74S258 2.50
74S260 1.00
74S261 3.00
74S283 2.70
74S287 2.25
74S288 2.00
74S289 2.25
74S299 4.50
74S373 4.00
74S374 4.00
74S387 2.25

74C SERIES

74C00 0.70
74C04 0.50/4069
74C08 0.70
74C10 0.70
74C14 0.50/4016 4584
74C20 0.70
74C32 1.00
74C42 1.50
74C48 1.50
74C73 1.00
74C74 1.20
74C76 1.00
74C83 2.00
74C85 2.25
74C86 0.50
74C90 1.90
74C93 1.50
74C95 1.60
74C107 1.00
74C150 5.00
74C151 2.00
74C157 2.50
74C160 1.80
74C161 1.80
74C162 1.80
74C163 1.80
74C173 1.00
74C174 1.50
74C175 1.50
74C193 1.50
74C194 1.50
74C195 1.50
74C221 2.50
74C244 2.00
74C245 2.25
74C373 2.25
74C374 2.25
74C902 1.20
74C911 9.00
74C912 4.50
74C922 6.00
74C923 6.50
74C925 6.50
74C926 7.50

74ALS SERIES

74ALS00 0.45
74ALS02 0.45
74ALS04 0.50
74ALS08 0.50
74ALS10 0.45
74ALS20 0.45
74ALS32 0.45
74ALS74 0.70
74ALS138 1.50
74ALS139 1.50
74ALS244 4.00
74ALS245 4.75
74ALS573 2.60
74ALS574 4.50
74ALS580 2.60

4000 SERIES

4000 0.20
4001 0.24
4002 0.25
4006 0.70
4007 0.25
4008 0.60
4009 0,45
4010 0.60
4011 0.24
4012 0.25
4013 0.36
4014 0.60
4015 0.70
4016 0.36
4017 0.55
4018 0.60
4019 0.60
4020 0.80
4021 0.60
4022 0.70
4023 0.30
4024 0.48
4025 0.24
4026 0.90
4027 0.40
4028 0.60
4029 0.75
4030 0.35
4031 1.25
4032 1.00
4033 1.25
4034 2.50
4035 0.70
4036 2.50
4037 1.10
4038 1.00
4040 0.60
4041 0.55
4042 0.50
4043 0.60
4044 0.60
4045 1.00
4046 0.60
4047 0.60
4048 0.55
4049 0.36
4050 0.35
4051 0.65
4052 0.60
4053 0.60
4054 0.80
4055 0.80
4056 0.85
4060 0.70
4063 0.85
4066 0.40
4067 2.30
4068 0.25
4069 0.24
4070 0.24
4071 0.24
4072 0.24
4073 0.24
4075 0.24
4076 0.65
4077 0.25
4078 0.25
4081 0.24
4082 0.25
4085 0.60
4086 0.75
4089 1.20
4093 0.35
4094 0.90
4095 0.95
4096 0.90
4097 2.70
4098 0.75
4099 0.99
4501 0.36
4502 0.55
4503 0.36
4504 0.95
4505 3.60
4506 0.90
4507 0.35
4508 1.20
4510 0.55
4511 0.55
4512 0.55
4513 1.50
4514 1.10
4515 1.10
4516 0.55
4517 2.20
4518 0.48
4519 0.32
4520 0.60
4521 1.15
4522 0.80
4526 0.70
4527 0.80
4528 0.65
4529 1.00
4531 0.75
4532 0.65
4534 3.80
4536 2.50
4538 0.75
4539 0.75
4541 0.90
4543 0.70
4551 1.00
4553 2.40
4555 0.36
4556 0.50
4557 2.40
4560 1.40
4566 1.40
4568 2.40
4569 1.70
4572 0.45
4583 0.90
4584 0.48
4585 0.60
4724 1.50
14411 7.50
14412 7.50
14416 3.00
14419 2.60
14490 4.20
14495 4.50
145000 6.50
14599 2.00
22100 3.50
22101 7.00
22102 7.00
40014 0.48
40085 1.20
40097 0.36
40098 0.40
40100 1.50
40101 1.25
40102 1.30
40103 2.00
40104 1.20
40105 1.50
40106 0.48
40107 0.55
40108 3.20
40109 0.80
40110 2.25
40114 2.25
40147 2.80
40163 1.00
40173 1.20
40174 1.00
40175 1.00
40192 1.00
40193 1.00
40194 1.00
40244 1.50
40245 1.50
40257 1.80
40373 1.80
40374 1.80
80C95 0.75
80C97 0.75
80C98 0.75

LINEAR ICs

AD7581 12.00
ADC0808 11.90
AM7910DC 25.00
AN-1-5050 1.00
AY-3-1350 3.50
AY-3-8910 4.90
AY-3-8912 5.00
CA3019A 1.00
CA3020 3.50
CA3028A 1.10
CA3046 0.70
CA3059 3.25
CA3060 3.50
CA3080E 0.70
CA3085 1.50
CA3086 0.60
CA3089E 2.50
CA3090AQ 3.75
CA3130E 0.90
CA3130T 1.30
CA3140E 0.45
CA3140T 1.00
CA3146 2.25
CA3160E 1.50
CA3161E 2.00
CA3162E 6.00
CA3189E 2.70
CA3240E 1.50
CA3280G 3.00
D7002 6.00
DAC1408-8 3.00
DAC0800 3.00
DAC0808 3.00
DG308 3.00
HA1366 1.90
ICL7106 6.75
ICL7611 0.95
ICL7650 4.00
ICL7660 2.50
ICL8038 4.00
ICM7216B 22.00
ICM7217 7.50
ICM7555 0.90
ICM7556 1.40
LC7120 3.00
LC7130 3.00
LC7131 3.50
LC7137 3.50
LF347 1.20
LF351 0.60
LF353 0.90
LF355 0.90
LF356N 1.10
LF357 1.00
LF398 4.00
LM10CLH 4.50
LM301A 0.30
LM307 0.45
LM308CN 0.75
LM310 2.25
LM311 0.60
LM318 1.50
LM319 1.80
LM324 0.45
LM334Z 1.15
LM335Z 1.30
LM336 1.60
LM339 0.40
LM348 0.60
LM358P 0.50
LM377 3.00
LM380N-8 1.50
LM380N 1.50
LM381AN 1.70
LM383 3.25
LM384 2.20
LM386N-1 1.00
LM387 2.70
LM389 1.89
LM391 1.80
LM392N 1.10
LM393 0.85
LM394CH 4.00
LM709 0.35
LM710 0.48
LM711 1.00
LM723 0.60
LM725CN 3.00
LM733 0.65
LM741 0.22
LM7747 0.70
LM748 0.30
LM1011 4.80
LM1014 1.50
LM1801 3.00
LM1830 2.50
LM1871 3.00
LM1872 3.00
LM1886 6.00
LM1889 4.50
LM2917 3.00
LM3302 0.90
LM3900 0.80
LM3909 1.00
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15V 7815	0.50	7915	0.15
18V 7818	0.50	7918	0.50
24V 7824	0.50	7924	0.50

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CIRCLE 96 FOR FURTHER DETAILS.

Domestic microelectronic controller

by J.L. Gordon

Software for Intarlec: intelligent alarm and partial control of the electrical installation

Software for the unit described (September) is installed in a 2K eprom and initiated on reset of the microprocessor. A complete listing of a typical working program and program description is available for those with a particular interest. This text however considers the general arrangement of the loop-type program being used.

A flow diagram shows general construction of the software, but this may be modified to suit an individual requirement. The general construction of the program is that of a basic loop which provides the following functions:

SET-UP REGISTERS
↓
READ IN DATA
↓
TEST ALARM AND MODE OF OPERATION
↓
TEST LIGHT LEVEL
↓
TURN ON IF REQUIRED
↓
TURN OFF WHEN TIMEOUT
↓
PROCESS KEY INPUT IF ANY
↓
UPDATE TIMING REGISTERS AND PERIPHERAL TIMERS

The main loop will be executed about 800 times per second, depending on the precise nature of the software implemented. This provides for more than adequate interrogation frequencies. There are various other sub-routines that are required from time to time to supplement the main loop. In the main, these are pulled into the loop when needed and dropped from the loop when not required. This does alter the loop timing but as the routines are used infrequently it doesn't cause a major upset. The exception to this is the edit routine which does stay active and will upset the timing of events such as light-on times. Again, the editor is intended as a system diagnostic aid and will therefore hardly every be used.

Of these subroutines, the routine which scans the display and looks for key presses is called on each pass of the loop. 'Scan' puts the mode and last-contact-in information onto the display once every 240 routine calls, as decided by a constant in zero page, and produces a slight flicker on the display which is noticable if it is looked for closely. The 'scan' routine also calls a further routine which reads a key press from the keyboard and stores the active key number in a reserved location.

If a scan is to be performed then a display drive routine is available which can convert a number into the correct seven-segment alphanumeric form and send this serially to the display. Part of the routine may also be used to send any pattern to the display if required.

The edit routine may be pulled into the loop if the editor has been called. Location 'editon' is used to indicate when the editor is required. This routine is called in place of the scan routine and allows editing of zero-page registers and the rapid testing of the simulate light table. The editor will automatically cancel when its timer reaches zero, or it may be cancelled immediately by pressing key 6.

The editor routine was simply included to allow initial setting up of a system and as an aid to peripheral fault location. Many constants may require changes to suit a particular installation, these may be corrected using the editor before the final program is installed. Light timer constants etc. are values which may need modification. The key functions in edit mode are described in the users literature. Key 7 allows the table of data used for the simulate routine, to be tested rapidly.

A keyboard input may be performed to indicate to the program, the required mode of operation. A location called 'alamcn' (alarm number condition) contains zero if no alarm has been requested, a positive number when the night only mode is required and a negative number if there is no person in the house. If an alarm condition is detected in mode 3, the routine 'alac', which is responsible for sounding the alarm when the premises are empty. 'Alac' starts with a delay and retest of the alarm call to remove false calls. If the call proves valid, the house lights are flashed and a two tone internal sound is generated. This procedure continues whilst retesting the contacts, for about 30 seconds. If the call still proves valid, the outside alarm is activated along with the internal tone and the flashing lights. After several minutes, the alarm is cancelled and deactivated for a few seconds before retesting in mode 3.

Tests for simulate and silent entry are also made in mode 3. If the location 'simul' is not zero then the routine 'sim' is required. 'Sim' performs one operation when 'simtim' (simulate timer) reaches the next value held in the data table 'simtab'. The table of data starts at zero-page 80 hex and can continue to page one if required. The last item of data in 'simtab' must be 00 so that the routine is cancelled until the next evening. Data is used in blocks of 3 bytes as follows.

Byte 1 When to turn on the next light. This hex. number is compared with simtim + 1 which is a timer that starts at 00 and clocks up. Lower numbers should appear first in the table.

Byte 2 is a number from 1 to the number of lights controlled and indicates which light is to be turned on.

Byte 3 is a hex. number representing the length of time that the light is to remain on. This number is incremented to zero so FF hex is a short time (about 6 min.) and F0 hex is over 1 hour etc. Numbers to 01 hex. may be used. Lights are turned off by another part of the program.

When 'simtim' equals byte 1 then the 3 bytes are read and executed.

The subroutine 'enter' decodes presses on the front door bell for entry during mode 3. The caller gets a response through the internal sounder system, one of which is situated behind the front door. If the code used is correct, the alarm is deactivated for about 50 seconds, and the stairs and kitchen lights turned on. Silent entry can be achieved with time to turn off the alarm in the prescribed manner.

When the alarm is set in mode 2, mats outside bedroom doors are tested first, if they are activated before any other, the alarm will be deactivated for about five minutes. The stairs and kitchen lights are turned on during deactivation to allow movement about the house. After five minutes, and presumably when the house occupants are back in bed, the alarm will automatically restart and the lights will go out. If the time is too short the alarm must be cancelled and reset before retiring again. Any other contact in mode 2 will cause the internal alarm to sound and all lights under computer control to be turned on. A buffer against spurious noise setting the alarm off is provided, a wait of about one fifth of a second is performed before retest. If the retest is positive the alarm will sound. There are five lights under computer control in this arrangement of the system. The 8154 p.i.a. provides two addresses for each bit in the two ports as well as addresses for the whole port and data direction registers. This simplifies the setting, clearing and reading of peripheral data from within the program. To set or clear a bit, it is simply necessary to set up the required bit address on the address bus and the job is done. Reading individual bits is also possible from either of the set or clear addresses. The bit value is placed in the most significant bit position on the data bus so that it may be tested from the negative flag. Table 1 contains a list of the peripheral addresses and their label used in an assembly listing.

At the start of the main program the registers are cleared, tables and constants set, stack initiated and port directions set. Mode 3 is set and the alarm temporarily deactivated.

Pulses are sent to the auto reset circuit at the start of the main loop. The peripheral data is then read by the 'datagt' subroutine. This routine reads all the relevant port bits and deposits the data in registers in zero page. In this particular implementation the ultrasonic detector is averaged to reduce the possibility of false calls. Registers containing the frequency at which the detector is read and the average value to be reached which causes 'kitcon' (kitchen control byte) to become negative may be edited for optimum working. The constants mentioned are 'intmcn' for the frequency of reading, and 'mean' for the average value.

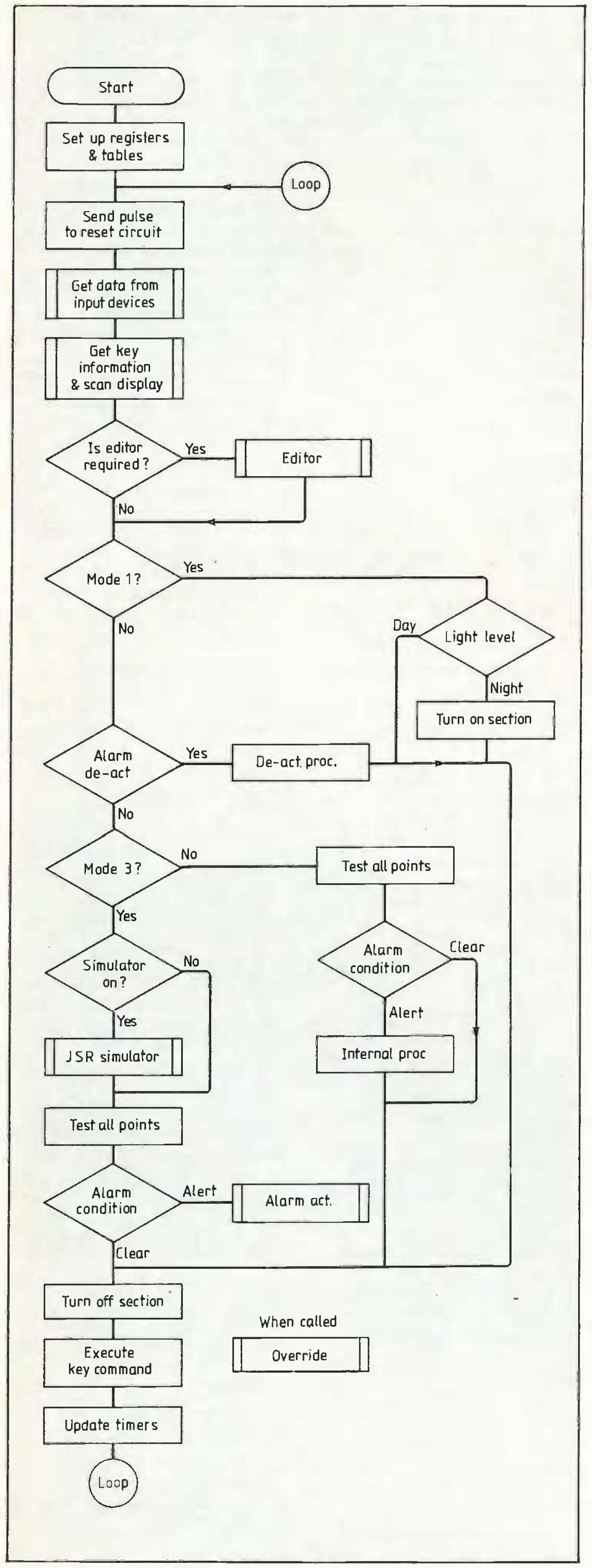
This routine also places the number of the contact last activated, into a register called 'lastin'. This register is used by the scan routine to display the last contact on one of the two displays. 'Astate' (alarm contact state) also contains the contact information in the form of an 8 or 16-bit word for use in the alarm test section.

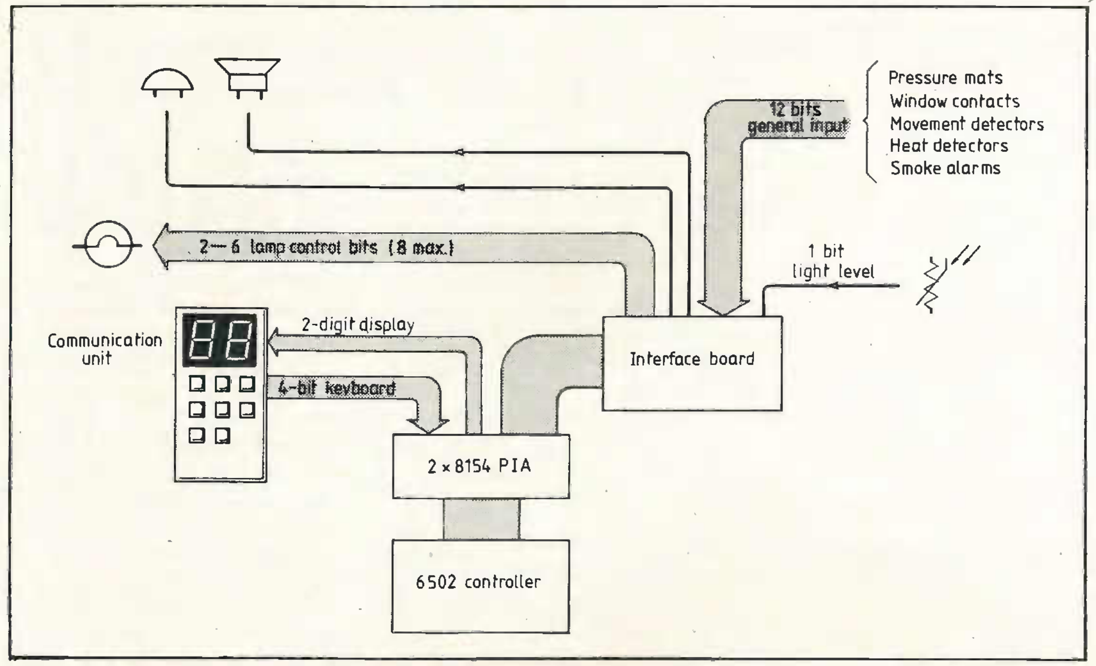
In the loop section performed

Table 1. Intarlec labels.

		Labels		
		Set	Clear	Registers
Port A	**Page 09**	Peripheral		Zero Page
Bit 0				LANMT
1				TOSMT
2				BOSMT
3	Input from			HALMT
4	contacts			ALMMT
5				FDOOR
6				BDOOR
7			KITSEN	KITCON
Port B	**Page 09**			
Bit 0	Landing light	LANLGT	LANLGO	Timers
1	Stairs light	STALGT	STALGO	lines
2	Hall light	HALLGT	HALLGO	20 to 60
3	Kitchen light	KITLGT	KITLGO	
4	Outside light	OUTLGT	OUTLGO	
5				
6				
7				
Port A	**Page OE**			
Bit 0	0			KEY
1	1 Keyboard			KEY 1
2	2			
3	Keyboard test			
4	Clock	CLKS	CLKC	
5	Data	DATS	DATC	
6	Light level		LISEN	LIGHT
7	Test pulse	PULSEN	PULSEO	
Port B	**Page OE**			
Bit 0	0			Timer
1	1 Alarm output			"ALMTM"
2	2			
3				
4		DOORBL		DBELL
5	Input from	BELCN	BELCON	
6	contacts			
7				

Inputs with no peripheral label are addressed through the port address





The central controller can service up to eight mains lights, 12 inputs from various sensors, a five-tone internal sounder and special connections such as light level and auto reset prevention. Six port bits are used for user interface, allowing a reasonable length connection cable to the controller.

in mode 1, the light level is checked: if it is dark, the turn-on section is performed which turns on each light and sets its timer if the appropriate contact register is set. If it is light, the turn-on section is skipped and the turn-off section is performed. This section turns the peripheral (light or alarm) off when a timer is zero.

The key command section executes the key command as contained in the register 'key', and Key will be executed for values between 1-8, but not it 'key' is zero. The key command section will also not operate if the alarm is set but has not been deactivated, this will reduce the possibility of an intruder cancelling the alarm.

Each key function is described in the users literature.

Key 8 calls the 'overid' (overide light) subroutine, which is responsible for turning on any light at keyboard request. 'Overid' uses the 'wait' sub-routine for time intervals between key presses. The routine lights 'NO' on the display, asking for the number of the light required. When the number is read 'OK' is sent to the display before the routine ends. Timing of lights turned on by 'overid' may be edited through a register 'overtm' (timer constant for light extensions).

The last routine in the main loop is the time update section, which increments program timers until they became zero. Timers are not incremented each time round the loop, the incrementing takes place when a register 'time3' becomes zero. Registers time1, 2 and 3 are used to set the main timing of the program, and in turn are set by zero page constants 'maint1' 'maint2' and 'main3' which can be edited if corrections are to be made. Three timers are used for flexibility, any increase in the constants will cause all timed events to be quicker, and a decrease will make them slower. Most of the timers that are incremented are two byte timers which gives an approximate value for byte two of 225 × 6 min. or about 1 day in the system described.

The only subroutine not discussed is 'wait', which is a delay routine used by many other parts of the program. It also sends pulses to the auto-reset circuit since it may be used for long delays. 'Wait' is 0.077 seconds long which makes it useful to call before verifying contact calls. This subroutine is not called when the loop is simply running free without any diversions.

Summary

The unit described represents a working system that has proven to be both reliable and pleasant in use. The final system has been working for over two year, but the unit has been working in test form for over 12 months before this. Automatic to get use to, but every aspect of the system is now taken for granted.

Many alterations to the system are clearly possible. The point mentioned in the introduction about contact masking under fault conditions was not however included. Nevertheless, registers may be included like 'oldst', to allow this option. It would simply be necessary to keep a record of the calling contact and time between calls to recognise the faulty position. This position could be masked from the alarm routine.

Other alterations are also possible, the addition of a real time clock and computer control of a socket outlet would make early morning alarm calls and hot water for tea possible. A control bit for a 999 caller could be activated by the routine 'alac' if required.

The low-cost control hardware should make units that are more sophisticated than this available to a large number of householders in the near future.

Testing the unit over long periods has shown that although design may include more elaborate peripheral control, simple interface techniques do prove reliable. Almost any type of contact which can be bought for an ordinary alarm system, may be used with this system. The point to remember is that the unit needs to know which area a person is in and not necessarily which door is open. Pressure mats are given a limited life but those used with the original system have now functioned correctly for over two years, and some for much longer than this. One exception was a pressure mat which was carelessly fitted under a carpet so as to be disturbed each time a door was opened, this was replaced after twelve months and alterations made to the door height.

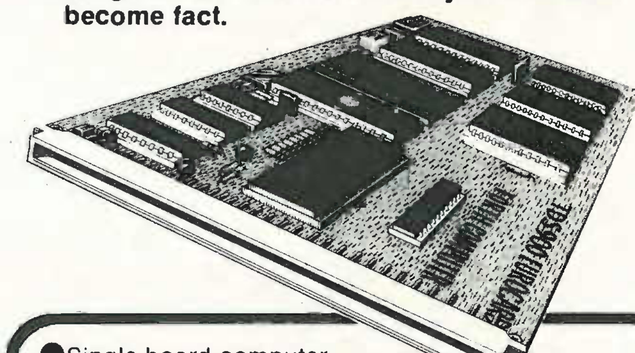
It it is now possible to buy passive infra-red movement detectors at reasonable cost. These have been included in later implementations of the system and have given long trouble-free operation. The ultrasonic unit used in the original system required software averaging to eliminate false calls. Although this averaging was successful, some of the original problems were later linked to the method of d.c. supply by long cable. The use of sensors which require a d.c. supply should be carefully considered although supply from the main unit need not be ruled out.

It would be tempting to include another level of signal processing at the main unit to remove noise. However this would add to the complexity and cost of the system. Noise reduction, which was previously firmly in the domain of the hardware designer, may be transferred to firmware once the source of the noise has been identified. Of course this does assume that the controller board itself is noise-free. Averaging input signals has proven to be an effective way to eliminate most noise from periferals, which may be particularly evident if screened cable is not used.

Finally, making low-voltage control connections to the mains must be done with the utmost care. If the unit is to remain in service over long periods thought must be given to the occurrence of infrequent events such as decorating, burst pipes etc. More expensive options for mains control do exist but the method described should prove cost effective providing mains isolation is assured.

Software

A program listing is available in response to a large stamped and addressed envelope sent to the editorial office and marked 'Intarlec'.



by F.O. Edeko

Why stereophonic images broaden

As an image moves away from stage centre its width increases for frequencies up to 300Hz, while above this frequency range the reverse starts to occur. A new theory indicates the cause of broadening and suggests how it can be avoided.

F.O. Edeko obtained an M.Sc. degree in Sound Electronics from Leningrad's Institute of Motion Picture Engineers in 1979. He joined the University of Benin, Nigeria, as a lecturer in 1980 and is presently researching in multichannel sound reproduction at Sheffield University, where he has recently submitted a thesis for the degree of Ph.D.

An ideal sound reproduction system is one which is capable of reconstructing the wavefront from a given sound scene in an exact form over a region in space occupied by the head of a listener. The use of two spatially separated loudspeakers imposes restrictions on the ability of stereophony to reconstruct the correct acoustic field so that a sharp image can be perceived. Such a system can provide a well-defined image for a centrally located listener mainly at low frequencies, depending on the geometrical displacement of the speakers relative to the listener[1].

It has been observed previously that images tend to broaden as they are displaced along the stage width[2]. The problem of correctly reproducing images has led to the development of many theories of localization[3] and several ways of improving stereophony have been proposed[4-7]. However, not much success has been achieved when one compares reproduced sound scenes with live performances.

This report provides a new approach to the assessment of stereophonic image broadening and it is hoped that this will lead to ways that could be employed in loudspeaker design, geared toward generating well-defined stereophonic images.

What causes image broadening?

The answer to this question can be found by considering stereophony as a wavefront reconstructed process. This approach of looking at sound reproduction is not limited in angle and encompasses the case of a general sound scene which could completely surround a listener.

The plane-wave component of the wavefront reconstructed by two spatially-located speakers around a listener's head provides the fundamental direction information of the apparent source producing that field.[1] Other components of this reconstructed field tend only to degrade the definition of localization, which is what gives rise to image broadening.

Thus the residual obtained by removing the plane-wave component of the wavefront from the reconstructed field reveals the contributions present due to other auxiliary sources in space. The main image is defined by the plane-wave component and the auxiliary sources create the impression of spreading of the main source. This is broadening.

The wavefront reconstructed by two speakers in Fig.1 along the x-axis can be expressed as

$$F(x) = \exp jk[\,R + \frac{x^2}{2R}\,]\{\,L\exp(jkx\sin\theta_o) + R\exp(-jkx\sin\theta_o)\,\},$$

where R and L are the amplitudes of right and left channels respectively and $k = 2\pi/\lambda$. Ignoring the common multiplicative term, as it carries no directional information, leaves

$$F(x) = 2L\cos(kx\sin\theta_o) + (R-L)\exp(-jkx\sin\theta_o). \quad (1)$$

The phase $\phi(x)$ of wavefront F(x) is of interest because it is this which determines image direction.

The wavefront F(x) contains a linear phase term as well as other harmonic components. The harmonic components cause image broadening. The ratio of the r.m.s. of the harmonic components to the magnitude of the plane-wave component provides an indication of how much the main image suffers degradation, which in essence is a measure of how the image will broaden.

To find this measure of image broadening, it is necessary to decompose the wavefront F(x) into its spatial components. For simplicity, consider the case of equally driven speakers, that is R=L. Under this condition equation 1 simplifies to

$$F'(x) = 2L\cos(kx\sin\theta_o). \quad (2)$$

To decompose F′(x) into its harmonic components, F′(x) can be defined as a repetitive function $F'(x) * III(x/2X_m)$ so that the Fourier series expansion can be applied, where * denotes convolution and $III(x/2X_m)$ is a comb function with period $2X_m$ equal to the head width[8].

Under this condition the head will still sense only F(x) alone because of the band-limited nature of the process.

For $-X_m \leq x \leq X_m$, the series expansion of F′(x) is

$$\frac{2L\sin A\pi}{A\pi} + \frac{4LA\sin A\pi}{\pi} \times \sum_{n=1}^{\infty} (-1)\,n-1\,\frac{\cos(nx\pi/X_m)}{n^2 - A^2} \quad (3)$$

where $A = (2X_m \sin\theta_o)/\lambda$. (Integer values of A lead to simple solutions). The constant term of this equation decreases as frequency increases. The harmonic components that are responsible for image broadening will increase in value as frequency rises.

For an on-axis image therefore, it is expected that an increase in frequency will bring about increased image spread and a loss of central image definition.

A measure of image broadening, termed the image width factor, can therefore be expressed as

$$\text{IWF} = \frac{\text{r.m.s. of harmonics}}{\text{r.m.s. of plane wave}}$$

In dealing with the image width factor for on-axis images it is sufficient to consider only the first and second harmonics of equation 3.

General approach for finding image width factor

The use of equation 3, to determine IWF is limited to on-axis images. To examine image broadening for any image position along the stage width it is necessary to develop another version of equation 3 for the case when R≠L. The derivation of such an expression is cumbersome and unnecessary.

A simple and convenient approach is by software. The computer simulation involves generating the wavefront F(x) over a region of $-X_m \leq x \leq X_m$. No assumption need be made in generating F(x). By least-square methods the best-fit phase slope is fitted into the phase of the wavefront F(x). The average of the amplitude of the generated wavefront for all sampled points along the x-axis and the fitted-phase data are then considered as the amplitude and phase of the plane wave component of F(x).

By the method of complex subtraction the plane-wave signal is removed from the generated field at each corresponding sampled point. The r.m.s. of the residual signal is then calculated as the square root of the sum of the squares of the real and imaginary parts of the residual signal for all sampled points. The r.m.s. of the plane-wave is found in a similar way. The generation of F(x) is implemented to allow for variations in input levels to the left and right loudspeakers. Using this approach the image width factor can be found for any image position determined by the interchannel intensity ratio at any given signal frequency.

Such a scheme has been implemented in software for a typical head widht of D = 14cm using the layout geometry in Fig.1. Results of computer simulations of measure of image-width variations with image positions are shown in Figs 2a, 3a and 4a. The image position for a given interchannel intensity ratio can be found by deducing the spatial direction of the fitted-phase front[1]. The image position is expressed as image linear displacement off-centre divided by the stage width. (The velocity of sound has assumed to be $343ms^{-1}$.)

Several interesting things are seen in these graphs. Results of computer simulations for different frequencies show that for frequencies up to 300Hz, the image width factor increases as image is displaced away from stage centre. The case of f = 250Hz is shown in Fig.2a. As frequency increases to about 500Hz, the image width undergoes a transition where the width factor is virtually constant. Further increases in frequency makes the image become less broad as it is displaced away from stage centre. This is in agreement with equation 3 which suggests

Fig.1 **Stereophonic system geometry (W = 2.3m, H = 2.0m)**

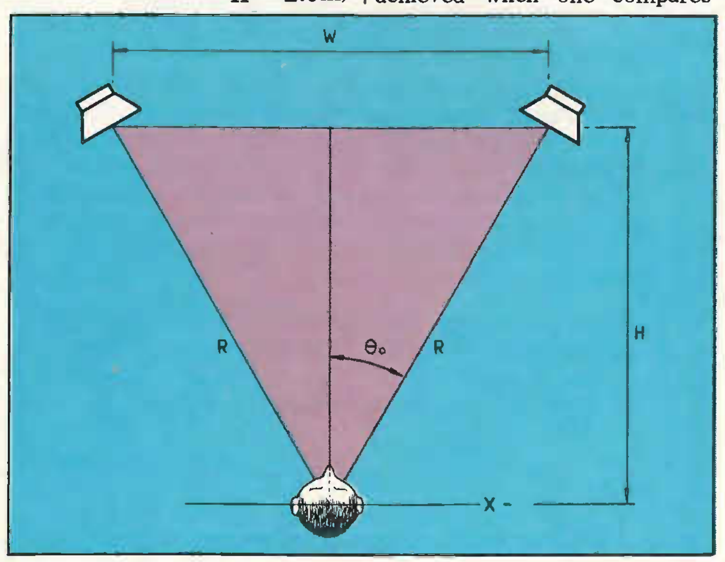


Fig. 2(a) **Computer simulation of image width factor variation with image position (f = 250Hz)**

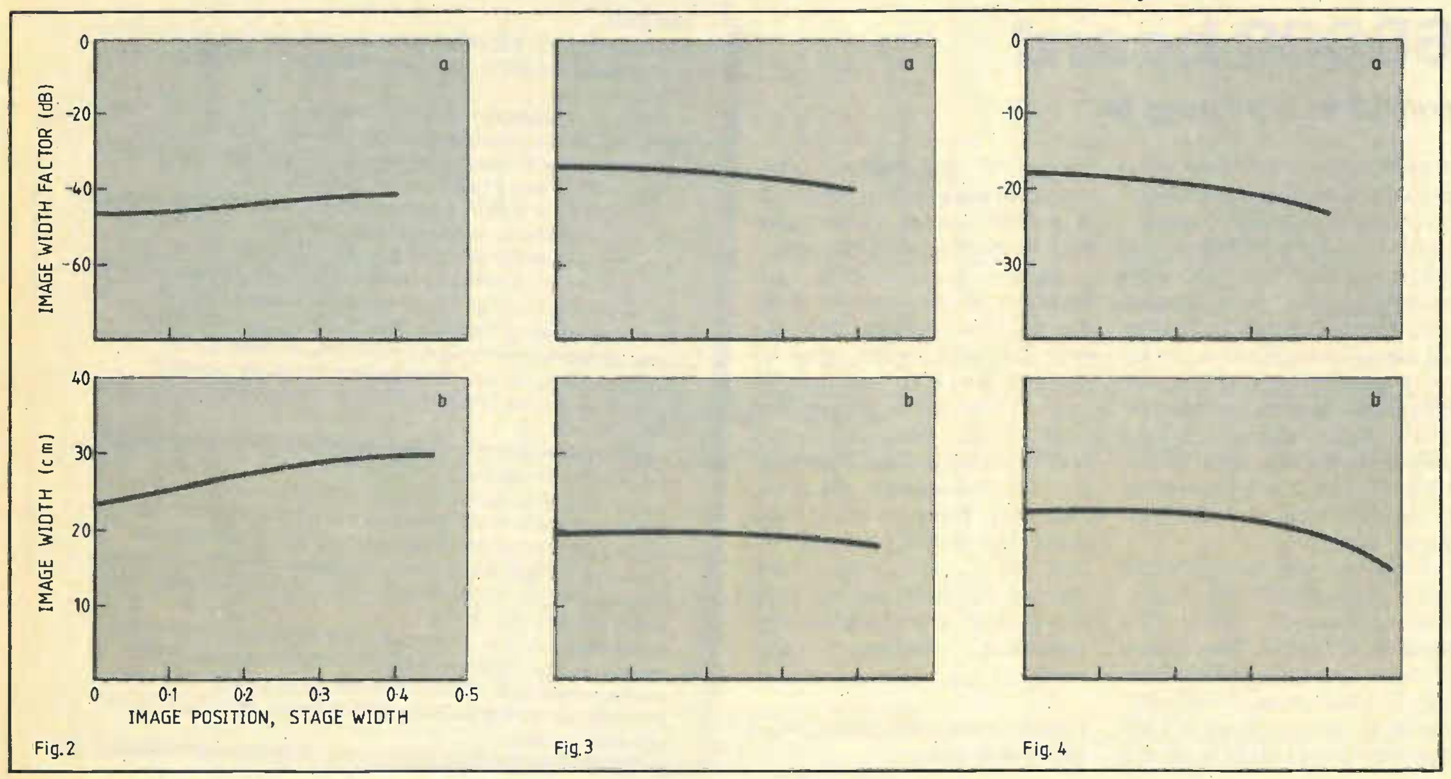
Fig. 2(b) **Practical results of image width variation with image position (1/3 octave pink noise, 250 Hz, 10 subjects)**

Fig. 3(a) **Computer simulation of image width factor variation with image position (f = 500 Hz)**

Fig. 3(b) **Practical results of image width variation with image position (1/3 octave pink noise, 500 Hz, 10 subjects)**

Fig. 4(a) **Computer simulation of image width factor variation with image position (f = 1250 Hz)**

Fig. 4(b) **Practical results of image width variation with image position (1/3 octave pink noise, 1250 Hz, 10 subjects)**



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broader on-axis images with increases in frequency.

Listening tests

Practical tests have been carried out to validate the theoretical predictions made above. The tests involved subjectively determining image width using the geometric arrangement in Fig.1. The tests were carried out in an anechoic chamber with reverberation time of less than 0.25 seconds for all frequencies down to 125Hz. The signal used was ⅓-octave band limited pink noise produced by a random noise generator in conjunction with a bandpass filter set (Bruel & Kjaer type 1402 and 1611). Each loudspeaker cabinet housed a single type 8P unit produced by Goodmans Loudspeakers Ltd. Ten subjects took part in the tests.

Each subject, occupying a central position, was asked to keep a fixed head position and looking directly toward the stage centre. The listener was then told to state the location of the image and its width using the dimensions on a bar placed along the stage width. The tests were carried out using 250, 500, 1250Hz, as centre frequencies of the ⅓-octave signal.

Average practical results of image width versus image position in terms of stage width as shown in Figs 2b, 3b and 4b.

Comparison between theoretical and practical results shows good agreement. The practical curve in Fig. 2b for the central frequency of 250Hz shows that image width increases as image is displaced away from stage centre. This is in good agreement with theoretical predictions in Fig. 2a. Fig. 3b, 500Hz, shows an almost constant image width. This compares very well with the theoretical results in Fig. 3a. At high frequencies, 1250Hz, Figs 4a and b, both practical and theoretical results show that image width decreases as the image moves away from stage centre.

How to overcome image broadening

Image broadening will always exist in a two-loudspeaker system. This is because the quality of the plane-wave signal deteriorates with increase in frequency. At low frequencies the broadening of the image may not be adversely perceived because the image width factor is considerably less than the −20dB level which corresponds to the minimum perceptible change in the effective source distribution[1]. However, at high frequencies the image width factor exceeds the −20dB level and image definitions will worsen and can now be obviously perceived.

To overcome image broadening it is necessary to increase the quality of the plane-wave component of the reconstructed field as frequently increases. The best way to achieve this is to use an array of speakers. The number of speakers in such an array will depend on how much of the high frequency band one needs to correctly reproduce.

An array of speakers is generally regarded as an excellent form of stereophonic sound reproduction[5]. However, the cost and inconvenience of having many speakers makes this approach uninviting. Quite a lot of methods of improving image quality have been proposed while retaining the convenient two speakers systems[4–6]. While these methods may help to improve the accuracy of localization and naturalness of stereophonic images, they do not solve the fundamental problem of image broadening. The use of video cassettes, which have the potential for storing many audio channels may help reduce the cost of having an array of speakers and thus facilitate the use of such a system which is the only real way of solving the problem of image broadening, or indeed of overcoming the general problem of fidelity and usable listening area in stereophonic sound reproduction.

68000 board

continued from page 54

manufacturer's computer won't couple directly to another's terminal without juggling of connections. Hence the proliferation of 'break-out' boxes to help when configuring new arrangements, with leds to show what's happening and patch-links to let you try every combination until it works! Rather than add another interpretation to the standard I have added link areas two and three to allow any signal to be connected to any pin on the interface connector as required.

Plugs two and three for the serial ports are 20-way insulation-displacement type plug headers. Pins have been chosen so that if the standard RS232 25-way D-type connector is used, say on an external panel of a box that Kaycomp is fitted in, then if insulation displacement type connectors are used at each end, a straight through ribbon cable may be used between the two.

On the circuit diagram, pin numbers shown against plugs two and three are those of the 20-way connector while those in brackets give corresponding 25-way D-type pin numbers and their function. Only pins 1 to 8 and 20 are used, 1 and 7 going to 0V, the remainder to link areas two and three. Finally, the remaining general purpose i/o pins (IP_{2-5} and OP_{2-7}) are brought straight out to plug seven, a 10-way insulation displacement connector plug header.

Construction is discussed in the next article.

Notes

Well-intentioned but over-zealous proof reading on behalf of our typesetters led to some anomalies in this article in the October issue.

In the first column on lines 31 and 39, 68000 should read 6800. The same misprint is found on page 53 in the first column on line 26 under the heading 'About the circuit', and in lines 42, 45 and 51 of the next column.

Initially in the article, it is erroneously stated that Kaycomp can have 128Kbyte ram and 64Kbyte eprom, but it is clear from the rest of the text that the correct specification is 128Kbyte rom and 64Kbyte ram. In the third column on page 53, the sentence beginning 'Normally, these three pins...' has a section missing from it. It should read 'Normally, these three pins are fed from an 8-to-3-line encoder but on Kaycomp they are fed directly from the three possible interrupt sources.' Finally, in Fig. 2, the bus has 19 address lines and not 16.

Price of the board with line-by-line assembler added to the monitor program is £109 inclusive.

Two hybrid static rams suitable for Kaycomp memory expansion were mentioned last month, the DMS8832 and the HMS62832. These are manufactured by Digital Memory Systems, PO Box 84, Walton-on-Thames and Hybrid Memory Products of Weymouth Road, West Chirton Industrial Estate, North Shields NE2 97TY.

Sockets suitable for top-side soldering are Augat 1800 series, Jermyn 18000 series and Robinson-Nugent ICE series. Augat 510-AG91D terminal strips, Augat 700 series terminal carriers and Jermyn 8500 series terminal carriers are also suitable.

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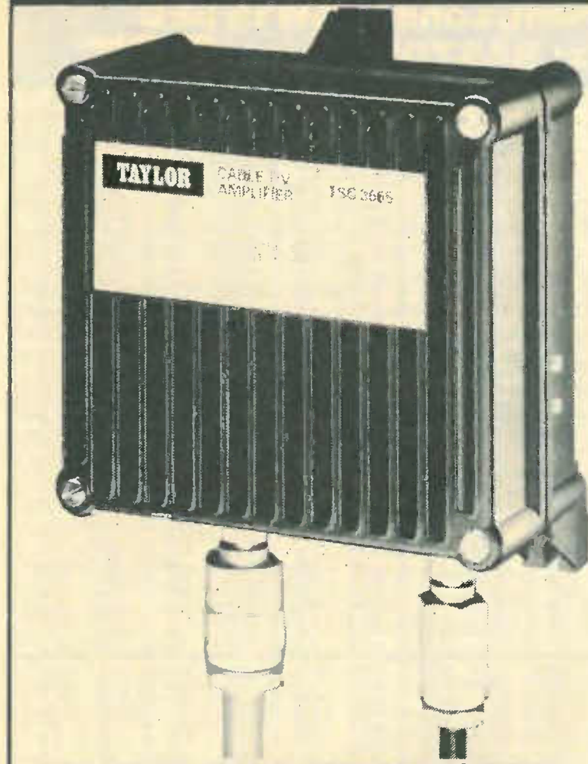

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TSC3060SM	40-300	10-30	60dB (1000mv)	+ or – .5dB	5dB	25-45V 7VA~
TSC3660	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	27-42V 18VA~
TSC3660SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	25-45V 13VA~
TSC3665	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	24-42V 24VA~
TSC3665SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	25-45V 18VA~

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EZV9	40-300	9dB	1dB	EZU9	470-860	9dB	1dB
EZV12	40-300	12dB	1dB	EZU12	470-860	12dB	1dB

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B	SCP10	Screw-on coaxial plug for 10mm Outside Diameter cable
C	SCP'	Screw-on coaxial plug for 5-9mm Outside Diameter cable
D	SAC	Screw-on right angled connector
E	SFC	Screw-on female line connector
F	SMC	Screw-on male line connector
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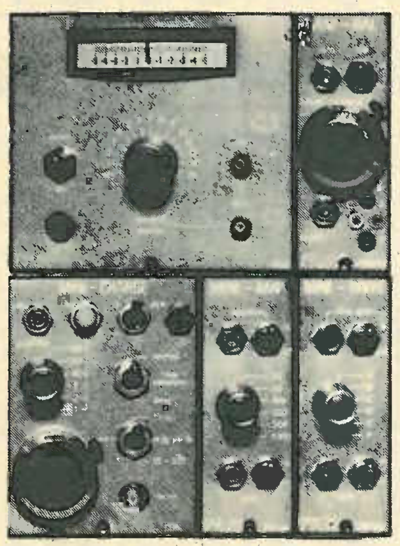

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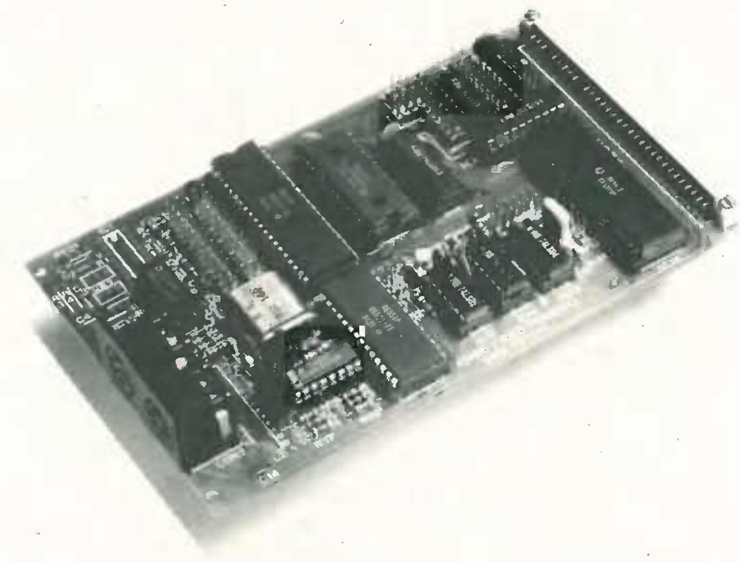

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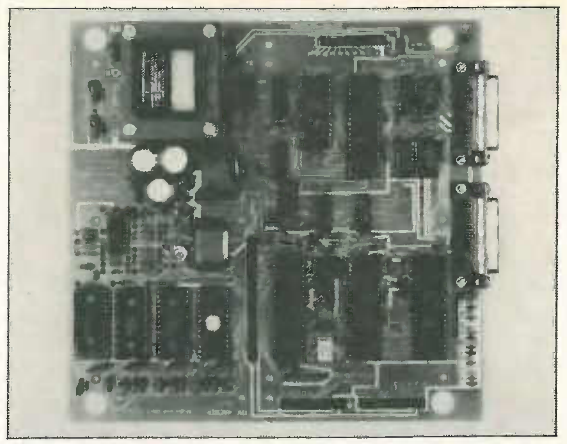
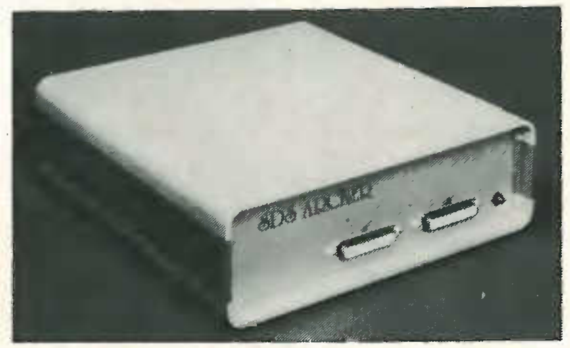
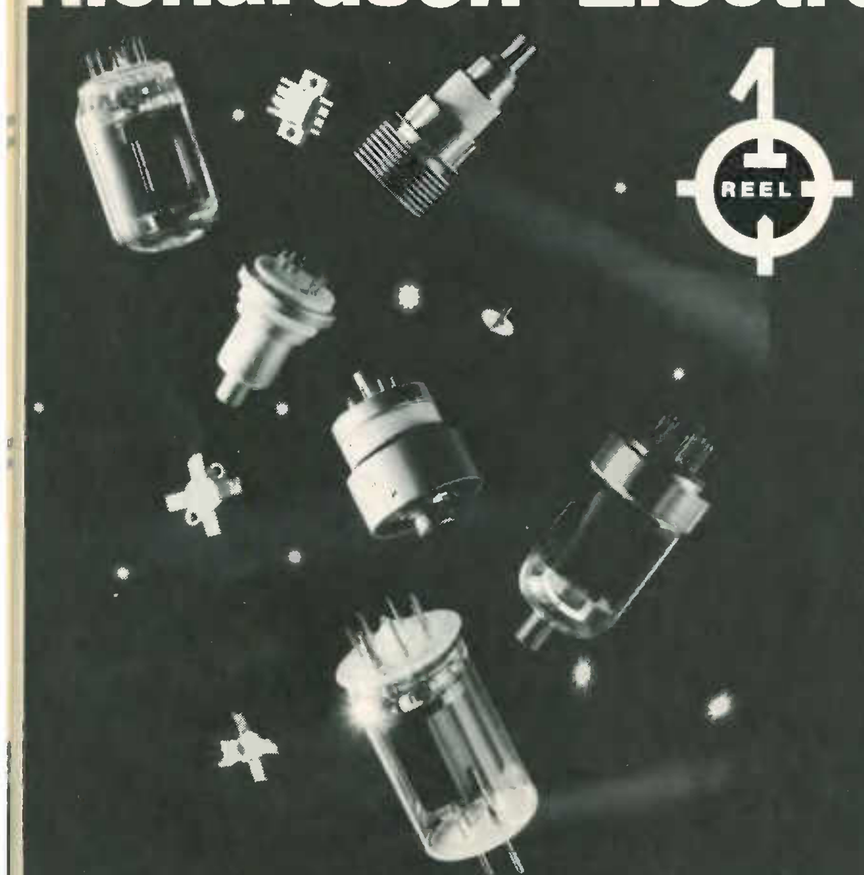






Breaking the loop — Nyquist revisited

By A. Verimus

Usually formulated in terms of signal voltage loop-gain, the Nyquist criterion for the stability of a feedback amplifier is extended to emphasize the power aspect.

When, in the late 1950's and early 1960's, a new logic gate circuit configuration seemed to appear every few months there was much discussion at meetings devoted to the subject of 'noise margins' and 'noise immunity'. Noise voltage margins were usually given some prominence but relevant impedance levels were not always so readily supplied by those proposing the new schemes. A correspondent * recently re-activated the discussion in comparing the relative merits of t.t. and c-mos logic. This triggered me into writing these associated thoughts that have been lying dormant for some years, and deal with an area of a subject that has not, as far as I am aware, been covered in a satisfactory manner in standard electronics textbooks.

When the concept of feedback was first proposed by Black — a flash of inspiration on an American ferryboat on his way to work — vacuum-tube voltage amplifiers, with their attendent distortion, were all the rage in the design of telephone repeaters. Later, a wealth of elegant mathematical knowledge was built up, notably by Nyquist and by Bode, on the 'stability' of amplifiers using these devices having near-infinite input resistance. Unfortunately, a basic difficulty arising in practice is that many feedback problems are not directly solved by using the simple idealized block schematic forms and associated elementary assumptions encountered at the introductory level. To quote one: the bipolar transistor, for many years the basic amplifying device, has an incremental input resistance which in most applications just cannot be regarded as infinite.

The problem then, for those intending to use practical devices in proposed designs, is how to interpret the Nyquist criterion in its simplified received forms.

*'Logic noise margin', T.Hartigan. *Wireless World* (Correspondence) March 1984, p.52.

Consider Fig. 1 which shows a simple, conventional, voltage-amplifying circuit, comprising a single-loop system employing the type of feedback usually met with in an introductory treatment. Amplifier A and network β are assumed to be unilateral, non-interacting blocks. Thus signal flow is from left-to-right only in A, which is assumed to have an infinite input impedance and zero output impedance. Similarly, signal flow is right-to-left only, in β, which is assumed to have zero output impedance. From elementary algebra, taking due note of arrow directions, $v_i + v_{fb} = v_g = v_o/A$. Also, $v_{fb} = \beta v_o$, and so

$$A' \triangleq v_o/v_i = A/(1-A\beta) \qquad (1)$$

In this simple derivation we have used a convention popular with electronics engineers, that the signal fed back is added algebraically to the input signal in the input circuit. There is no attempt *yet* to define a polarity of feedback. This approach contrasts with the different but equally acceptable convention adopted by control engineers who, being interested in error-actuated systems, assume the fed-back signal intentionally to be subtracted from the intput signal in some mixing process in the input circuit.

The difference in the two conventions leads to a '+' sign for Aβ in the control approach. I shall adhere to the 'electronics' approach. If $|1-A\beta| > 1$ the feedback degenerative or 'negative', i.e. the magnitude of the overall gain is less than that obtained with the amplifier alone. The benefits gained constitute the well-known list of 'goodies'. Important among these for electronics engineers is the densensitization of A′ with respect to tolerances and changes in A resulting from environmental variations, such as temperature. (The mutual conductance of a bipolar transistor changes about 0.3% per deg.C).

The price to be paid for the benefits arises because factors A and β are never real numbers. A′ might well have a negative sign associated with it — that is not the problem. The trouble is that A and β are complex numbers describing the physical existence of frequency-dependent phase shifts in the amplifier and feedback network. Whereas we would normally arrange for negative feedback over the signal frequency range of interest, its polarity could change to positive ($|1-A\beta| < 1$), becoming regenerative over a range of frequencies which might be absent from the Fourier spectrum of the input signal. Self-sustained oscillations are then possible, without the requirement for an externally applied input signal.

It took the genius of Nyquist, and his followers, to show that the behaviour of the system with the loop closed could be predicted from a knowledge of the behaviour with the loop opened-up. In a proposed design such as Fig.1 imagine the loop cut or broken at the position of the crosses. A test signal v_g, is inserted into the opened-up loop and the fed-back voltage v_{fb} appearing at the cut observed. The ratio v_{fb}/v_g is the loop-gain parameter, Aβ. A polar, or Nyquist, plot of the variation in magnitude and phase of Aβ over the whole frequency range from zero to infinity indicates whether the system will function satisfactorily as an amplifier when the loop is closed. A concise wording for the Nyquist criterion could be: 'The feedback amplifier system of Fig.1 will not oscillate if $|A\beta| < 1$ when $\angle A\beta = 0°$, one of many possible formulations).

Applying this condition to the three stage direct-coupled amplifiers having the plots shown in Fig.2 we see that the system giving curve (i) is stable. At d.c.($\omega \to 0$), $A = -A_o$, $\beta = +\beta_o$, where A_o and β_o are real positive numbers: $|A\beta| = A_o\beta_o$; $\angle A\beta = 180°$. Thus, for $\omega \to 0$, $A\beta = -A_o\beta_o$, $|A'| < |A|$ and feedback is negative. As ω increases, $|A\beta|$ decreases and $\angle A\beta \neq 180°$. However, $|A\beta| < 1$ when $\angle A\beta = 0$. The

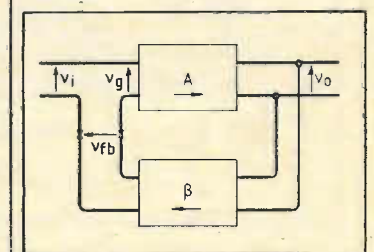


Fig.1. **Conventional idealized feedback amplifier system. Arrows in boxes A and β show the direction of unilateral signal flow.**

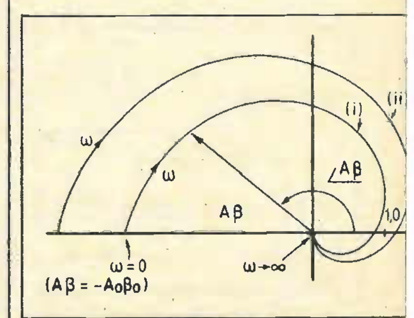


Fig.2. **Circuit of Fig.1 will not oscillate if it has characteristic (i) : oscillations occur for curve (ii).**

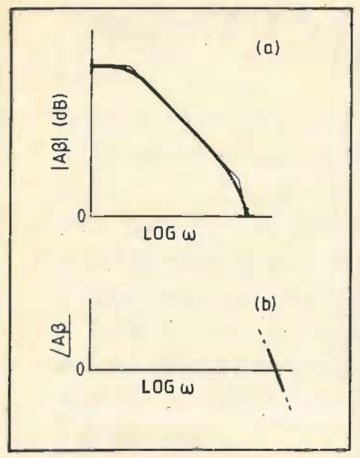


Fig.3. **Bode plot representation of amplifier having curve (i) of Fig.2.**

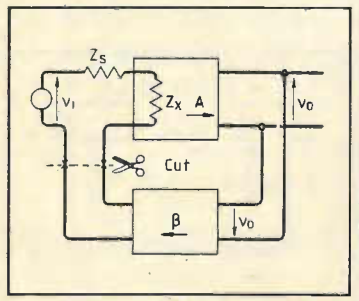


Fig.4. **Practical amplifiers have impedances that load the network.**

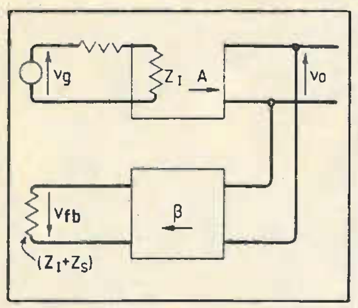


Fig.5. **Loop gain for the circuit in Fig.4 is obtained by opening up the loop but maintaining the impedance levels shown.**

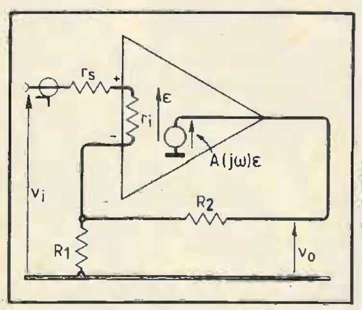


Fig.6. **A pratical non-inverting op-amp scheme for investigation of stability, analysed in Figs 7 & 8.**

system giving curve (ii) indicates that $|A\beta|>1$ for $\angle A\beta = 0$ and would be unsuitable as an amplifier.

An alternative, and frequently more convenient, graphical method of examinating stability is to use 'Bode plots', which represent $|A\beta|$, in dB, and $\angle A\beta$ versus log β. The Nyquist criterion then requires that for stability $|A\beta|_{db}<0$ when $\angle A\beta=0$. The Bode equivalent of curve (i) of Fig.2 is represented by the pair of plots in Fig.3(a), Fig.3(b). In Fig.3(b), for convenience, only that part of the phase characteristic near $\angle A\beta = 0°$ is shown. Clearly $|A\beta|$ when $\angle A\beta = 0°$ so the system is stable.

Impedances in the loop

So far I have been setting the background. But what happens when we consider finite impedances in the loop? In Fig.4, A and β are still considered unilateral but A has a finite input impedance Z_i and β has a finite output impedance (not shown). Ω_i has a source impedance Z_s. To investigate stability we again make a cut as shown in Fig.4 but in so doing we must make sure not to alter the d.c. conditions and impedance levels that existed before the cut was made. The circuit for calculation of loop-gain υ_{fb}/υ_g is that shown in Fig.5. In answering the question *why* we have to follow this procedure we will see that we will return to the central formulation of the Nyquist Criterion.

Op-amp example

Nowadays, amplifiers are not usually shown as rectangular boxes. Furthermore, feedback is rarely applied as shown in Fig.4. Take a more realistic case. Fig.6 shows an op-amp non-inverting stage. To keep the algebra simple, consider the op-amp to have an incremental input resistance r_i and a frequency-dependent differential voltage gain A(j ω). Feedback components ($R_1 R_2$) are resistive and the source resistance is r_s.

First, analyse the circuit in a straightforward manner — just regard it as a problem in circuit analysis. Then cut the circuit and examine stability with the loop opened-up. We should, of course, obtain the same result (concerning the stability of the system) by both approaches. Fig.7 is an equivalent version of Fig.6. We have merely used Thévenin's Theorem on the feedback network: r_{eq} is defined as R_1 in parallel with R_2. It is easily shown (see appendix) that

$$\upsilon_o/\upsilon_i = \frac{A(j\omega)r_i/(r_i+r_s+r_{eq})}{1-\{-A(j\omega)R_1r_i/(R_1+R_2)(r_i+r_s+r_{eq})\}}$$

By comparing this quantity with the form of equation 1 the loop gain is identified as

$$(LG)_1 = -A(j\omega)R_1r_i/(R_1+R_2)(r_i+r_s+r_{eq})$$

On a Bode plot of voltage gain we calculate and plot, in dB, the loop gain:

$$20\log_{10}|(LG)_1| \qquad (2)$$

in which subscript 1 refers to the first analysis.

We can cut the loop at any point: the choice is normally one of convenience. We choose to open-up the loop by making a cut at the inverting input terminal, and attach appropriate termination. Apply test signal υ_g. (We suppress υ_i: frequency stability has nothing to do with the nature of the input signal — it is dependent on the charateristics of the loop. A simple calculation gives

$$(LG)_2 = -A(j\omega)R_1r_i/(R_1+R_2)(r_i+r_s+r_{eq})$$

Where subscript 2 refers to the second analysis. Now, as υ_g and υ_{fb} are both developed across the same value of resistance r_i+r_s, the magnitude P_g of the loop power gain (i.e. the ratio of the power fed back to the input circuit to the power supplied to it) is

$$P_G(dB) = 10\log_{10}|\upsilon_{fb}/\upsilon_g|^2$$
$$= 20\log_{10}|\upsilon_{fb}/\upsilon_g|$$
$$= 20\log_{10}|(LG)_2| \qquad (3)$$

Because $(LG)_2 = (LG)_1$ expressions 2 and 3 are identical. A requirement for non-oscillatory behaviour is $P_G<0$ dB when $\angle\upsilon_{fb}/\upsilon_g = 0°$. This suggests the generalization of the power condition as follows:

'A sufficient condition for the avoidance of self-sustained oscillations in a simple single-loop linear amplifying system is that the signal loop-power-gain is less than unity (0dB) at any frequency for which the total phase shift around the loop, comprising both the amplifier and the feedback network, is zero'.

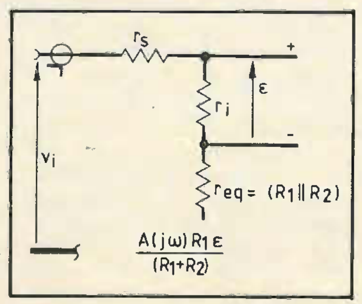


Fig.7. **Equivalent circuit of Fig.6 for straightforward circuit analysis.**

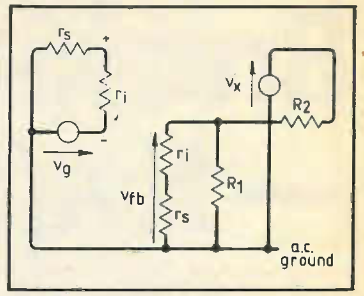


Fig. 8. **Redrawn version of circuit of Fig. 6 opened-up by making a 'cut' at the inverting input terminal. Resistor r_i+r_s connected across R_1 takes into account power fed back into the circuit.**

The word 'sufficient' rather than 'necessary' is chosen to take care of the case of 'conditional' stability, which is arguably best avoided in a first encounter with the Nyquist criterion. (Other similar formulations involving the *power* concept are possible.)

Concluding thoughts

For an electronic feedback system to function as an oscillator the requirement is for an appropriately 'phased' supply of energy so that there is no net energy loss per cycle of oscillations.

An attraction of the proposed formulation of the conditions for oscillation avoidance in an amplifier, is a conceptual one: it shows the importance of the power aspect in the analysis of feedback systems rather than that of voltage gain (or current gain). There is no need to alter our standard graphical plots, provided that amplifier and feedback network loading effects are taken care of in the formulation of the loop-gain function.

Appendix

(a) From Fig.7, by inspection, $\upsilon_o =$

$$A(j\omega)[\upsilon_i - \{R_i\upsilon_o/(R_1+R_2)\}][r_i+r_s+r_{eq})].$$

Manipulating this gives $(LG)_1 =$

$$-A(j\omega)R_1r_i/(R_1+R_2)(r_i+r_s+r_{eq}).$$

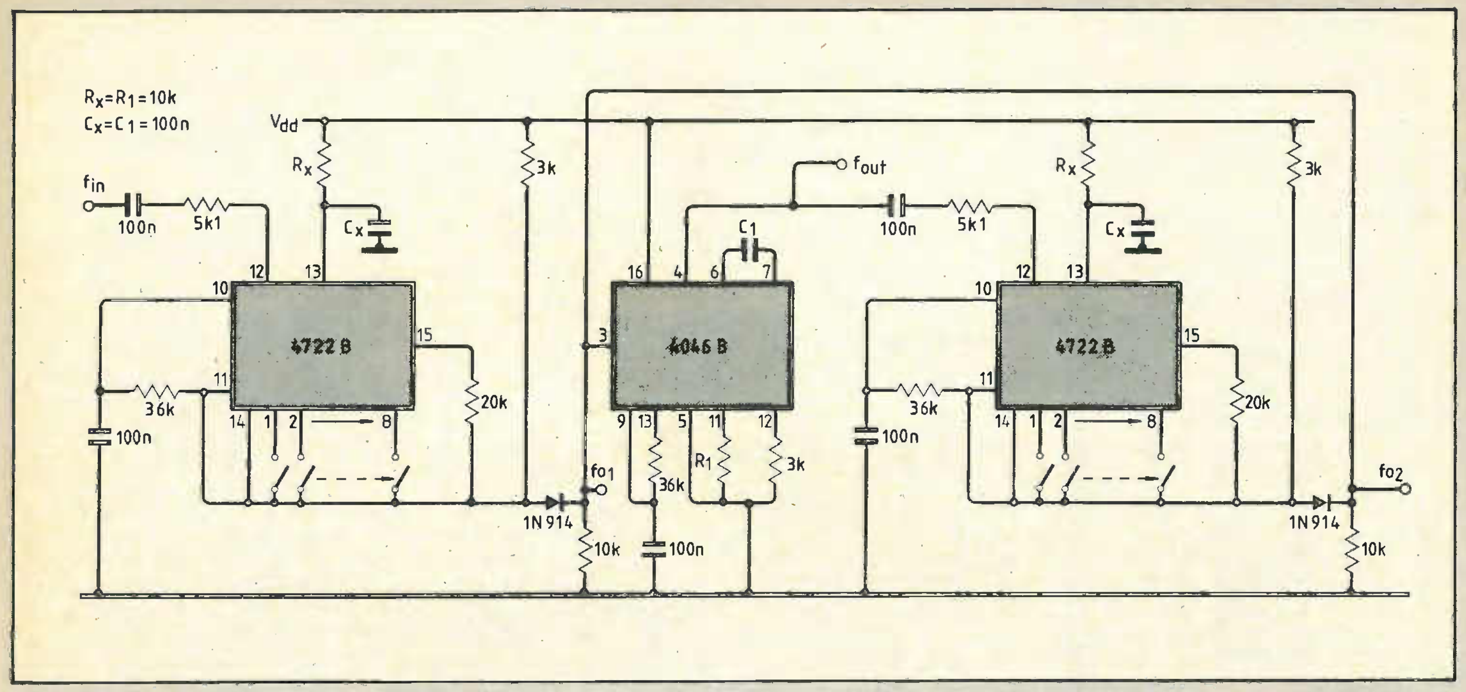
(b) From Fig.8, by inspection,

$$\upsilon_x = -A(j\omega)\upsilon_g\{r_i/(r_i+r_s)\}.$$

$$(LG)_2 = \upsilon_{fb}/\upsilon_g = \frac{r_i/(r_i+r_s)\}A(j\omega)\{(r_i+r_s)R_1/(r_i+r_s+R_1)\}}{R_2 + \dfrac{(r_i+r_s)R_1}{r_i+r_s+R_1}}$$

Simplifying,

$$(LG)_2 = -A(j\omega)R_ir_i/(R_1+R_2)(r_i+r_s+r_{eq})$$



Supply insensitive current source

Often in instrumentation and measurement, one needs a source that produces a preset direct current that is only weakly dependent on supply rail variations. Thus, a preset current, 0.1mA, 1mA, etc., can be passed through a component whose resistance value is unknown and the resulting potential difference, monitored by a high input-resistance digital voltmeter connected across it, gives the resistance value directly.

There are many techniques for producing a 'constant' current, some using operational amplifiers, but they may be unnecessarily complicated for the job in hand. This current-source technique has a calculable supply-rail sensitivity that is low in value. It can be made even lower by cascading stages.

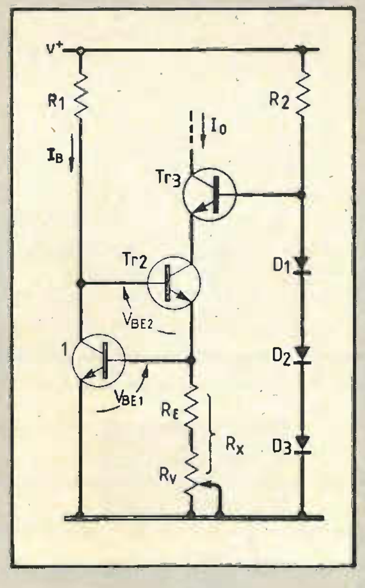
The basic circuit gives

$$I_B = (V^+ - V_{BE1} - V_{BE2})/R_1.$$

Feedback connection of Tr_1 and Tr_2 forces Tr_1 to pass a collector current effectively equal to I_B if small base currents are ignored. Corresponding V_{BE1} causes an emitter current in Tr_2 approximately V_{BE1}/R_x which is also the value for output current I_o if small base currents are again ignored.

Sensitivity factor S defines dependence of I_o on V^+ thus,

$$S^{I_o}_{V+} = (\delta I_o/I_o)/(\delta V^+/V^+)$$



Now, large changes in V^+ cause only small changes in V_{BE1} because of the logarithmic dependence of V_{BE1} on I_B.

It can be shown that for

$$V^+ \gg V_{BE1} + V_{BE2}$$

$$S^{I_o}_{V+} \approx V_T/V_{BE1}$$

where V_T is thermal voltage KT/q (K is Boltzmann's constant, T is absolute temperature and q is electronic charge magnitude). As $V_T \approx$ 25mV at room temperature and $V_{BE1} > 625$mV (typically), $S^{I_o}_{V+} <$ 0.04. Thus a 10% change in V^+ produces a change in I_o of some 0.4%.

Transistor Tr_3 and diode string $D_{1\text{-}3}$, together with their bias resistor R_2 give a cascode output stage.

Low-frequency incremental output resistance r_o is

$$r_o(k\Omega) \approx \beta \times 100/I_o(mA)$$

In this, β is the common emitter direct-current gain of Tr_3. Using I_o in place of I_B in a further cascaded stage, employing p-n-p transistors virtually eliminates the effects of power supply variations.

Selection of semiconductor devices is uncritical but a convenient low-cost choice is ZTX300 for the transistors (Ferranti) and 1N4148 for the diodes. Choosing V^+ as 5V and R_1 as 3.6kΩ gives $I_B \approx$ 1mA and $V_{BE1} \approx$ 650mV. Thus if R_E = 560Ω and R_v is a 250Ω potentiometer the setting I_o of 1mA is achievable. A value of 3.3kΩ is convenient for R_2. Taking β > 100, the incremental output resistance can be expected to exceed 10MΩ.

B.L. Hart
Leigh-on-Sea
Essex

Dividing by fractions using p.l.l.

The main feature of this circuit for dividing by fractions is its wide frequency range. It uses two 4722B programmable timers and a 4046B phase-locked loop i.c. allowing direct multiplication of the input frequency by a fraction. The timer section is connected for harmonic synchronization.

Output frequency of the first timer, f_{o1}, is

$$f_{o1} = \frac{m}{M+1} f_{in}$$

where $1 \leq m \leq 10$ is the harmonic number and $1 \leq M \leq 255$ is the programmed counter modulus. For the second timer

$$f_{o2} = \frac{m}{N+1} f_{out}$$

As $f_{o1} = f_{o2}$ is a function of the p.l.l.,

$$f_{out} = \frac{N+1}{M+1} f_{in}.$$

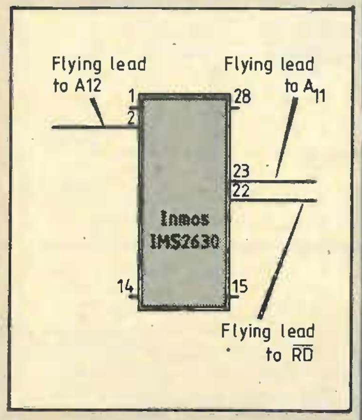
So the input signal is multiplied by a fraction of (N+1)/(M+1) and 65 025 is the number of possible frequencies.

Kamil Kraus
Rokycany
Czechoslovakia

This circuit's predecessor appeared on page 35 of the February 1984 issue — Ed.

8K dynamic ram inside ZX81

This modification extends memory of a ZX81 from 1K to 8Kbyte without using an external memory pack. Existing memory chips — usually two 2114s — are replaced by an 8K by 8bit dynamic ram, the Inmos IMS2630 as follows.



Remove the existing ram i.c. or i.cs and clear out the holes for the 28 pin package, preferably using a desoldering tool. Fit a 28-pin socket to the board and bend pins 2, 22 and 23 so that they do not fit in the socket when the IM 2630 is inserted. Finally, solder these pins to the circuit board as shown.

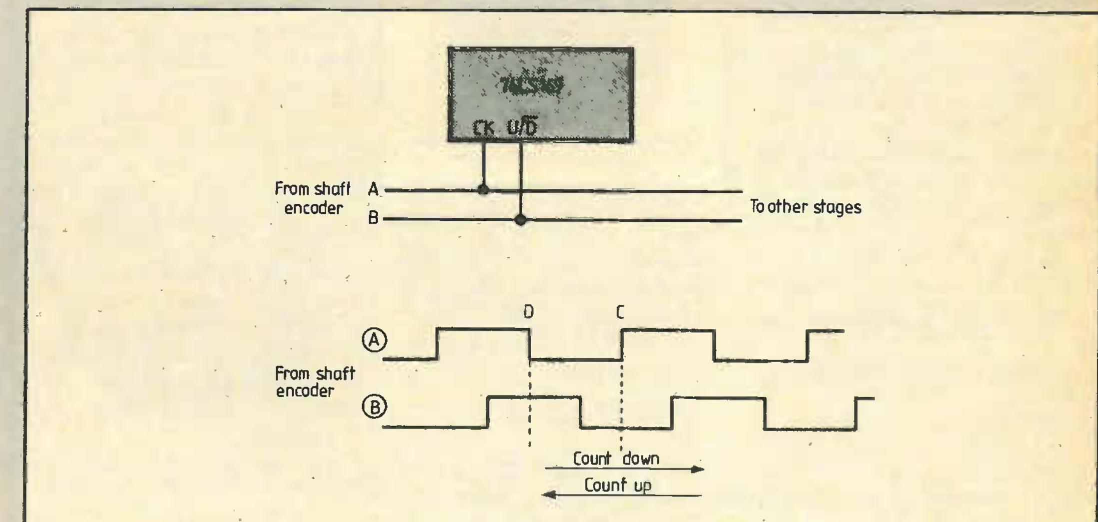
K. Ball
University of Manchester

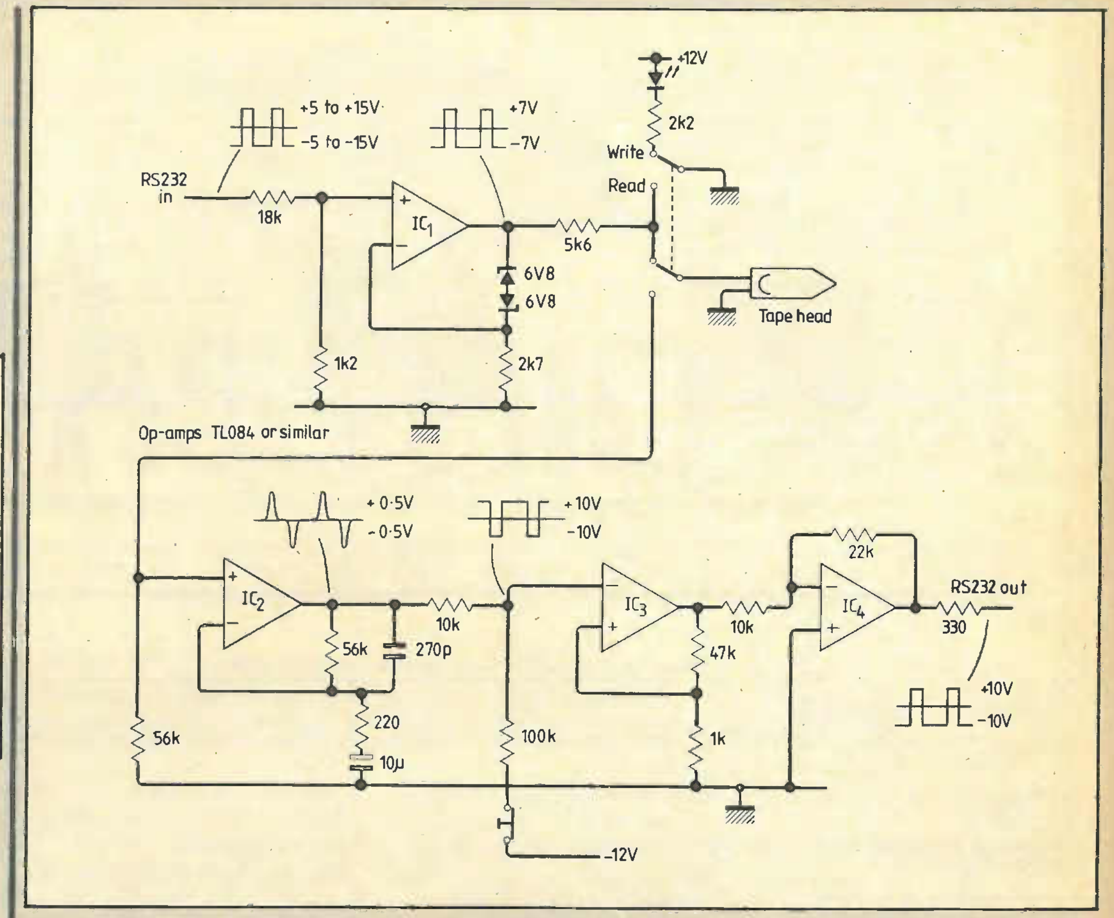
Shaft encoder counting

Assuming that the shaft encoder gives two pulses in quadrature, this counter will count up or down depending on the direction of rotation. Turning the shaft one way produces positive edges at points C. Because the U/$\overline{D}$ input is low, the counter counts down. The LS169 is a synchronous device so changing any input has no effect until an active clock is received.

Rotating the shaft in the other direction, the timing diagram is read from right to left. Postive edges now occur at points D when the counter U/$\overline{D}$ input is high therefore the counter counts up.

A.J. Crofts
Leamington Spa
Warwickshire





RS232 data recording

Built as a development aid for microsystems, this circuit records data on cassette tape directly from an RS232 serial line at whatever rate is received and plays it back at the same rate. The design is simple and reliable; it has been used at up to 4800 baud.

Incoming serial data is limited to ±7V and fed to the recorder head, giving full saturation of the tape. On playback, only flux changes give any tape-head output, so a differentiated version of the original signal is available. This is amplified through IC_2 whose response is tailored to minimize noise pickup, and fed to a bistable circuit IC_3 to regenerate the original waveform.

Threshold levels of the bistable circuit may be varied to suit the tape head by changing the 47kΩ feedback resistor. Output of IC_3 is buffered to give suitable levels and the buffer output is given some protection by a 330Ω resistor.

Since the state of IC_3 will be indeterminate on power up, and could change with such events as motor switching, a push switch is included to keep the i.c. in its reset state until the play button is pressed. For the prototype, I found a pair of normally-closed contacts on the cassette unit but a microswitch could easily be added.

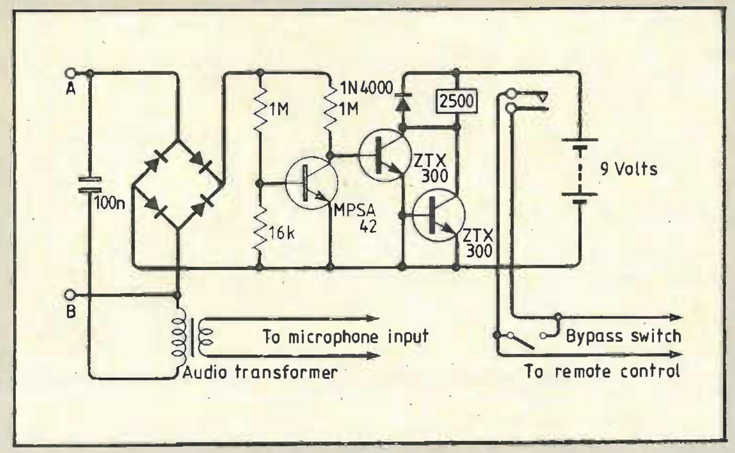
K.A. Cooper
Ipswich
Suffolk

Automatic telephone recording on cassette

All telephone calls can be recorded automatically on a conventional cassette recorder using a simple interface.

Telephone lines A and B are connected to a voltage sensing circuit through a bridge rectifier to allow for either polarity of line voltage. When the telephone is not in use line voltage exceeds about 37V and the MPSA42 high voltage transistor is turned on. The Darlington-connected ZTX300 transistors are turned off, the relay is not energised, and its contacts remain open.

During a call, line voltage falls to much less than 37V so the MPSA42 transistor is turned off, the ZTX300 transistors are on, the relay is energized, and its contacts are closed. Contacts connect to a 2.5mm jack plug fitted to the recorder remote-control input.



Speech from the telephone is fed through a 100nF blocking capacitor and step down audio transformer, such as type LT44 or LT700, to a 3.5mm jack plug on the recorder microphone input.

A switch by-passes the relay contacts so that the recorder may be operated when the telephone line is not in use without unpluging the circuit e.g. for rewinding and play back. The circuit could be adapted to switch mains power to the recorder. When the telephone is not in use, current drawn from the 9V battery is negligible.

The 3.5mm plug may be fitted to the output of the recorder for replaying, recordings over the telephone line. The voltage sensing circuit draws about 100µA from the line when the telephone is not in use; this current could be further reduced with different voltage-sensing arrangements. An attenuator of volume control may be connected between the transformer and the recorder microphone input.

H.T. Wynne
Glasgow

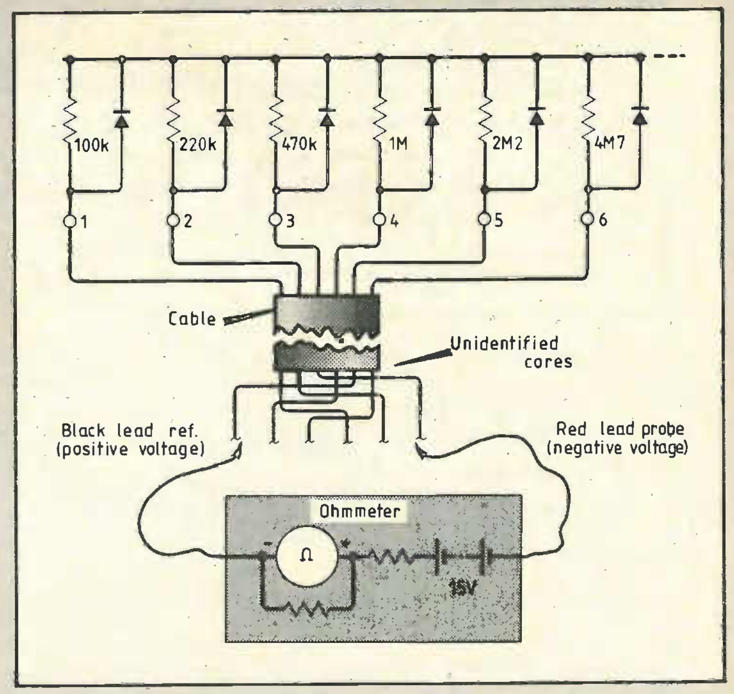
Cable-core identifier

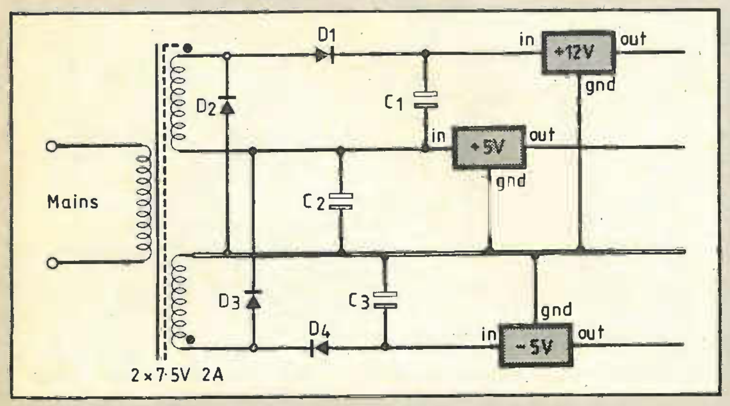
With the aid of an ohmmeter, this simple tool speeds up identification of cores within a cable. The meter must use a measurement voltage of at least 15V and have a high-resistance range reading of about 1MΩ at half scale, such as an AVO model 8 multimeter.

After connecting the unknown cores to the circuit at one end, the black meter lead is connected to any core at the other end and used as a reference. The black meter lead supplies a positive voltage whenever the red lead is connected to any of the other cores. This means that the diode in the black reference lead is forward biased and the meter reads the value of the resistor in the core connected to the red meter lead.

Identity of the core connected to the reference is determined by elimination but it may be verified by selecting a different core for the reference connection. Factors limiting the number of cables that can be identified are resolution of the meter, core-to-core leakage, cable e.m.f. (which can be checked beforehand), core resistance, internal resistance of the meter and to a lesser extent differences in forward characteristics of the diodes.

H.T. Wynne
Glasgow



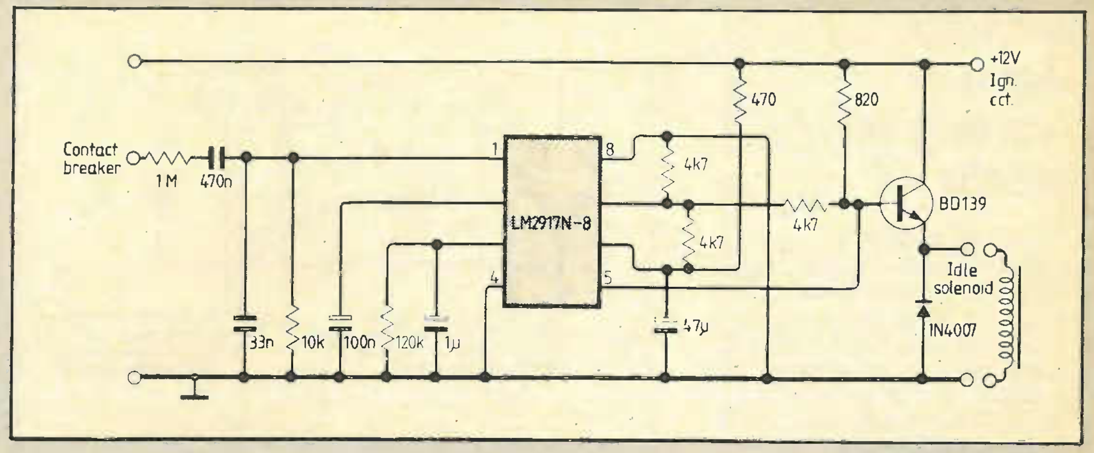


Three-rail supply uses few components

The d.c. supply shown, using a readily available dual-secondary transformer, was designed for a microprocessor-based instrument needing a high-current +5V supply and +12V and −5V for serial interfaces, d-rams, etc. Its major feature is diodes D_2 and D_3 which alternately charge capacitor C_2 on both halves of the a.c. cycle, thus forming a full-wave rectifying system. Diodes D_1 and D_4 and capacitors C_1 and C_3 form simple half-wave rectifiers which are acceptable in view of the usual lower current requirement for +12 and −5V supplies.

Luis de Sa
Universidade de Coimbra
Portugal

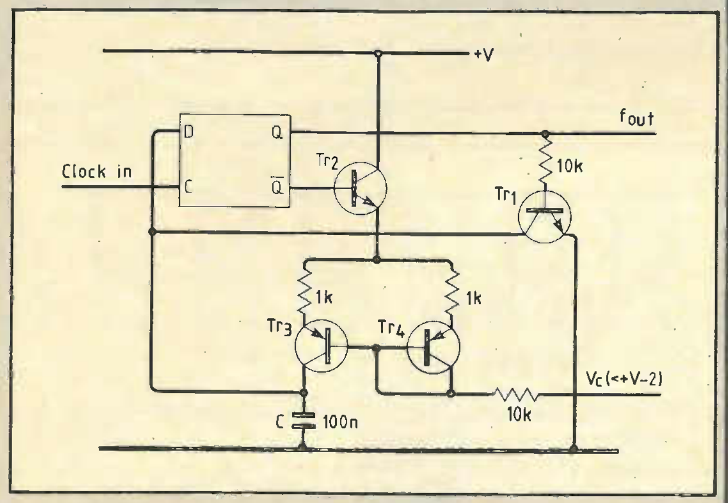
Fuel saver



While a car is decelerating, its engine does not require fuel. On many modern cars, the carburettor has a solenoid that stops idle fuel supply when the ignition is turned off to prevent 'running on'. The circuit shown switches this solenoid to shut off idle fuel supply when engine speed rises above 1800rev/min. Above this speed, most of the fuel is supplied by the main jet so engine performance is not affected.

When decelerating, the throttle butterfly and idle supply are closed and no fuel is used. When engine speed falls below 1200rev/min, the solenoid operates normally to allow the engine to idle correctly. The circuit is connected to the ignition side of the positive terminal so the solenoid closes as intended when ignition is switched off.

R. Lowman
Milton Keynes
Buckinghamshire



Voltage-controlled frequency divider

As part of a low-frequency digital waveform generator, this voltage-controlled variable frequency source provides output pulses synchronized with an external circuit.

Normal $\bar{Q}$-to-D connection around a D-type bistable i.c. is replaced by a time delay consisting of the current mirror $Tr_{3,4}$ and capacitor C. Current through Tr_4, controlled by variable external voltage V_c, is mirrored in Tr_3 and varies charging time of the capacitor.

When Q goes high, Tr_1 resets the circuit by discharging the capacitor, hence a sync. pulse with a period equal to that of the clock is provided followed by a continuously variable delay determined by V_c.

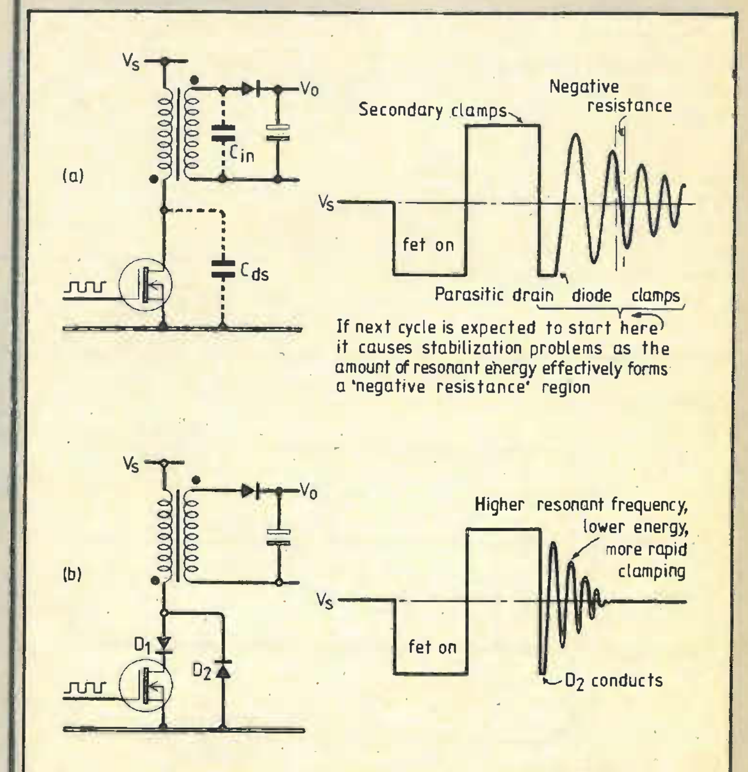
H.R. Banton
Manchester

Greater efficiency in power converters

In a single-ended power converter, a resonant circuit is formed by the combination of transformer internal capacitance C_{in} and drain/source capacitance of the power fet driving it. There is often enough energy to cause great problems in stabilizing the overall system unless excessive snubbing is included, which wastes energy.

This simple modification makes a great deal of difference in many cases. Diode D_1 effectively isolates drain-source capacitance from the transformer and raises the resonant frequency of the system, while D_2 allows energy recovery. Less snubbing is needed as there is less energy circulating.

Richard Aston
Sutton
Surrey



Humidity control

There is a diode missing at the left-hand side of this circuit published in the October issue. This diode replaces the link between the junction of R_1 and the 7.5Ω resistor and the positive rail. The diode cathode connects to the positive rail.

Modems

This microprocessor-based low-speed modem covers speeds of up to 1200 bit/s. Special features include an auto-dialler and a speed conversion buffer for access to viewdata from terminals (such as the IBM p.c.) which cannot send and receive at different rates.

Sending data by telephone is becoming faster and cheaper, for business and home users alike.

Interest in data communications over the telephone line has grown enormously with the development of personal computing.

But the modem — or modulator-demodulator — has been with us for something like two decades. The earliest types were simple devices, if bulky; but they offered simultaneous two-way data transfer of 300 bits per second, a speed which was fast by comparison with the teleprinter. And the transmission standard they used still remains in widespread use for public-access systems.

Today, compact 300 bit/s modems can be bought by home computer users for the price of a few games cassettes. So, too, can 1200/75 bit/s versions which give access to videotex systems such as British Telecom's Prestel.

The buyer now has a very large range of low-speed modems to choose from, though the introduction of special-purpose modem i.cs has seen to it that the hardware differences between one model and another are sometimes slight. However, some include special additional features, such as multi-standard operation, automatic call answering and data-rate selection, auto-dialling and diagnostics.

The more advanced modems are microprocessor-based and can often be controlled entirely through software. In some cases they conform to the so-called Hayes protocols, which have been widely adopted as a sort of unofficial standard and so allow the use of a wide range of ready-made communications software.

But the most striking technical advances have occurred in the world of the high-speed modem. Many businesses and other large organizations make heavy use of the telephone network for sending computer data; and they can reduce their line costs considerably by installing complex modems to maximize the transmission rate.

Higher speeds

Because of the bandwidth restrictions of an ordinary dial-up telephone connection, a rate of 1200 bit/s is close to the upper limit for reliable performance — given the conventional frequency-shift keying of low-speed modems. But by abandoning f.s.k. in favour of more complex modulation systems, manufacturers have been able to push speeds much higher.

Phase changes can be used in place of frequency shifts as the signalling medium, with as many as eight defined phase states. Through the addition of two amplitude levels per phase (a technique known as quadrature amplitude modulation, q.a.m.), a speed of 9600 baud is possible on ordinary two-wire public circuits.

At the highest speeds, the V.32 and V.33 standards incorporate a coding method (trellis coding) which, by building a degree of redundancy into the signal, enable it to be decoded with enhanced accuracy.

Synchronous or not?

In low-speed transmission, the modem transmmitter reverts to the 'mark' or logic 1 tone for at least one bit-period at the com-

Table 1: CCITT modem standards for the public switched telephone network and for private lease-lines.

CCITT rec.	Data bit/s	Mode	Modulation scheme	Circuit type pstn	2-wire	4-wire
V.21	300	async	f.s.k.	■	■	
V.22	1200	sync/async	d.p.s.k.	■	■	
V.22 bis	2400	sync/async	q.a.m.	■	■	
V.23	1200	async	f.s.k.	◪	◪	■
V.26	2400	sync	d.p.s.k.			■
V.26 bis	2400	sync	d.p.s.k.	◪	◪	
V.27 bis	4800	sync	d.p.s.k.		◪	■
V.27 ter	4800	sync	d.p.s.k.	◪		
V.29	9600	sync	q.a.m.			■
V.32	9600	sync/async	q.a.m.	■	■	
V.33	14400	sync	q.a.m.			■

key: ◪ half duplex (i.e. each end sending in turn)
■ full duplex (i.e. both ends can send simultaneously)

Duplex operation at 9600 baud over a two-wire telephone line is possible using a modem such as this one, the DM4962X from BT. Such a communication speed over a standard line requires a little more than frequency-shift keying circuits, though. This unit uses quadrature amplitude modulation.

pletion of every character sent. This period is known as a stop-bit. To signal the start of the next character, the modem sends a further 1, or start-bit. The minimum possible interval between succeeding characters is thus two bit-periods; but the next character can begin at any time afterwards, and so this method of transmission is described as asynchronous.

To achieve higher rates, it is possible to dispense with these packaging bits; but the sending and receiving modems must then run synchronously, the receiver extacting from the incoming data stream the clock signal needed to decipher it. If there is no data to send, the channel must be filled with padding characters.

In multi-user systems, it is therefore a common practice to keep the lines busy by multiplexing several work-stations into each communications channel. This helps to reduce the telephone bill but inevitably lengthens the response time of the network.

But with any system, deficiencies of the telephone line such as noise, distortion and echo can make decoding difficult by smearing each symbol into the next. However, this inter-symbol interference may to a large extent be cancelled out by careful equalization of the line. And in the fastest modems, adaptive equalizers monitor the interference continuously and act to minimize it.

The trend towards fully automatic operation is a feature of the high-speed modem market, and it is noticeable that the most technically-advanced modems require the least understanding on the operator's part. There are no adjustments to make and the user can simply connect the modem and forget about it.

Even if the telephone line fails, the modem may be capable of dialling up a substitute without human assistance.

CCITT recommendations

Transmission standards for modems are defined by the Comité Consultatif International de Télégraphie et Téléphonie, CCITT, a committee of the International Telecommunications Union. This organization has produced a series of recommendations, the V series, which deal with all aspects of sending data over telephone lines. Those which concern modems specifically are summarized in Table 1.

In North America other standards are found, of which the Bell 103 (300 baud duplex) and Bell 202 (1200 baud half duplex) are possibly the best known. These two low-speed standards differ significantly from CCITT V.21 and V.23 and are not compatible with them.

The RS232C interface commonly used for exchanging data between modem and data terminal is referred to in CCITT-speak as V.24.

Modem software requirements

Without good communications software, modems are little more than an expensive novelty. Computer software for controlling modems, varying greatly in price, quality, form and complexity, needs careful consideration before the choice of a modem is made. There is a wide range of communications packages for most common mini and microcomputers and price is not necessarily representative of quality or the number of facilities offered.

In business systems, modem control software may be an integral part of a large operating system and the user may not notice any difference between sending data to another terminal in the same office and sending it to one thousands of miles away. Modem setting, data buffering, dialling and line connection/disconnection can all be done automatically.

For business use, the choice of modem software is often determined by the type of computer, operating system or modem available. Software for general-purpose microcomputers is much more varied and while it is more difficult to use, it can allow a great deal more flexibility and experimentation.

Ideally, software for engineers and experimenters is both versatile and convenient. Much computer software used for modem communications is designed for the more general application of sending and receiving data through an RS232 link. This means that the software will be capable of sending and receiving serial data in many different ways, and not necessarily in conjunction with a modem. With this type of program, a lot of setting up may be necessary before data can be transferred using a telephone modem with 'standard' data formats.

To be versatile, communications software must allow you to choose all speeds and formats of serial data for sending/receiving within the limitations of the computer and it must allow data to be transferred in different ways to suit the person at the outer end of the link.

General-purpose software should allow you to set all possible functions of the computer's serial/parallel converter. Engineers and experimenters need to be able to select standard data rates, the number of data/stop bits in a serial data character and whether or not an odd or even parity bit is used. Some modem software packages designed for communication with specific data bases or other terminals with the same kind of software do not allow you to alter these settings.

The RS232 standard is concerned only with the data signal itself and does not define the means by which it is transmitted. The 25-way D-connector is currently in common use; but for reasons of economy, the proposed S5/8 standard (an RS232C-compatible arrangement based on an eight-pin DIN connector) is likely to become widespread.

Generally, seven data bits are required for communication using standard Ascii codes and eight bits for for binary file transfer. Asynchronous communications using two stop bits instead of one are rare, as are those using fewer than seven data bits, but most computer serial/parallel converters can be set to handle two stop bits and between five and eight data bits with and optional odd or even parity bit. The parity bit, intended for error checking, is usually present in the serial data character but not always used.

Prestel communications require seven bit data words, one stop bit and an even parity bit. On some computers the serial/parallel converter, often a universal asynchronous receiver/transmitter or uart, allows only one data rate for both input and output which makes Prestel-type 1200/75 baud communications impossible without using one of the special modems with its own buffer and data rate converter.

It is also important to be able to route data from the modem either to a buffer within the computer or to one of its peripherals. Similarily the source of data for sending to the modem needs to be selectable.

At a basic level, keyboard input is routed to the modem for sending out and data from the modem is displayed on the screen. This facility is important, especially while experimenting, but larger amounts of data need to be stored for use after the expensive telephone connection is broken.

Usually a data buffer is defined within the computer memory by the communications software, but this buffer can soon become full. With common eight-bit microcomputers, an option within the software allowing files to be transferred directly to and from disc is important if more than the equivalent of just a few sheets of A4 text is to be transferred at one go.

Convenience is as important as versatility. General-purpose communications software bought mainly for use with a modem should allow all the above manipulation, but as a secondary function. Primarily it should allow a group of parameters for communicating with say a Prestel terminal or bulletin board to be set using only one or two key strokes.

Automatic selection of frequently used data rates/formats and of telephone dialling procedures are useful features. Telephone lines are noisy and some kind of automatic error checking — and correction — is advantageous if your are transferring short data files or programs and essential for long ones. Automatic answering is helpful for businesses in that it allows data to be transferred in cheap (cheaper) telephone periods out of office hours, but it is not necessary for the average home user. Both automatic dialling and answering require special hardware within the modem.

With most modems, automatic answering and calling requires that both ends of the communication link are set to the same data rate, format and standard and that one end is set to originate the call and the other to answer it.

There are however so-called 'intelligent' modems that can set certain parameters by themselves depending on the signal sensed on the telephone line and others which can send signals automatically to tell a 'remote' modem what to set itself to.

Dialling a distant modem and finding that you have made an error in the setting up can be expensive and frustrating. Communications programs designed specifically for low-speed modem use with fixed 1200/75 or 300/300 baud settings are available for many computers and while they may not have the versatility of the more engineering-oriented packages, they are certainly much more convenient for jobs like home banking and shopping.

A number of large and complex modem programs are available for the most widely used microcomputer operating system, CP/M. They offer auto-dialling, error detection and allow large files to be transferred between different systems. Several such programs are available from the extensive software library of the CP/M Users' Group (UK), which distributes them freely to members (though a small copying charge is made). Programs can be supplied in over 60 disc formats, including those for Amstrad computers and the BBC computer Z80 second processor. Further details can be obtained from the Group at 72 Mill Road, Hawley, Dartford, Kent DA2 7RZ.

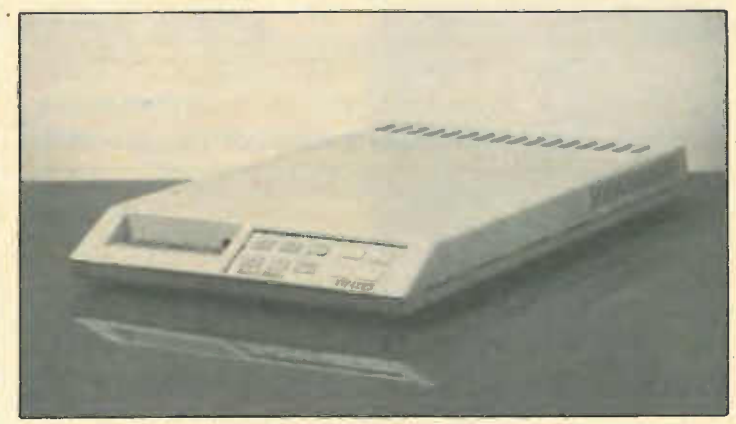
Members of the SC84 user group interested in modem programs should write to John Hodson at 12 Broughton Road, Basford, Newcastle-under-Lyme ST5 0PQ, enclosing an s.a.e. SC84 is a 4/6MHz CP/M computer, full hardware details of which were published in the May, June, July and September 1984 issues of *E&WW*.

Further reading

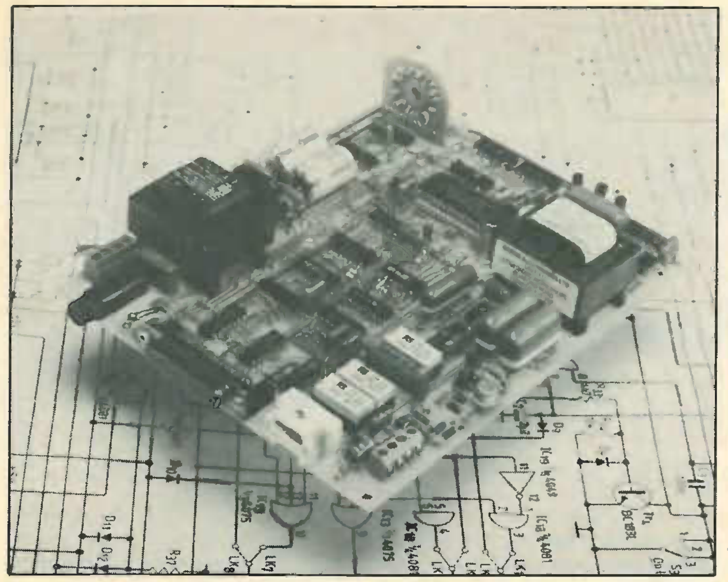
Latest modem standards and details of all types of modems from 300 to 9600 bit/s are covered in a practical manner in

The Transam M1 is the first modem designed for the cellular radio user. Its automatic error-correction copes with the momentary breaks in communication caused by radio fading and by switching action in the cellular network.

This software-controlled V.21/V.23 modem is upgradable to V.22 and V.22 bis and can be factory-fitted with a system to prevent unauthorized access to data.



Racal's VI2422 intelligent modem covers V.21, V.22 and V.22 bis, and can switch itself to suit the modem at the other end. On lease-lines, it can dial a back-up if the normal circuit fails.



Wireless World **modem: this low-speed two-wire modem, based on the Am7910 i.c., covers the V.21, V.23 and corresponding Bell modes and costs around £70 to make (E&WW, May-July and December 1984; the p.c.b. is still available). A series by Martin Allard describing a personal electronic mail system for the constructor began in the August issue. And a microprocessor-based multi standard terminal unit was described by John Walker in October's issue.**

Bits and bauds

In the V,21 and V.23 modes data is carried by a pair of simple audible tones: one travelling in either direction and each of them shifting in frequency between two states which symbolise 0 and 1 respectively. Thus the rate at which data bits can be carried is limited to the rate (expressed in baud) at which the tone can change state.

In other words, in a V.21 system, 300 baud (that is, 300 transitions per second) gives a maximum data rate of 300 bit/s. This speed amounts to roughly 30 characters of text per second, since it takes ten bits or so to send each letter.

With more advanced modulation methods, it is possible to increase the number of bits represented by each symbol in the transmission medium. For example: with phase-shift keying, four possible phase shifts can be used to denote 11, 10, 01 and 00. Each symbol thus carries two bits, giving data transfer at 2400 bit/s on a 1200 baud circuit.

Further increases in speed can be contrived by defining additional phase states and by switching the level of the carrier.

The data rate is normally a simple multiple of the signalling rate.

the recently revised edition of The V Series Report: Standards for Data Transmission by Telephone. Details of this 60-page paperback book can be obtained from the publishers, Bootstrap Ltd, at Unit 1F, Sandyford Industrial Estate, Foxrock, Dublin. Its price is £10 sterling.

A useful primer describing the subject from the user's point of view is the CASE Pocket Book of Computer Communications. Its 84 pages, which selflessly omit to mention any of the company's products, explain serial transmission of data, communications lines and services, multiplexing, packet-switching techniques and complex protocols such as the ISO open systems interconnection model. There is also a useful glossary. The booklet is distributed by Computer and Systems Engineering p.l.c., P.O. Box 254, Caxton Way, Watford Business Park, Watford WD1 8XH.

To be concluded with a survey of currently-available low and high-speed modems and a list of suppliers.

Built-in test facilities and software control are becoming increasingly common. The Hyacinth modem from Telindus has a front-panel l.c.d. screen and a membrane keyboard for entering set-up commands; a password is needed to alter them.

Telephone lines

Telephone circuits come in three basic forms:

- The familiar dial-up connection over the public network: a two-wire circuit at the subscriber's end
- the two-wire lease-line, which may be equalized for data communications
- the four-wire lease-line, which is equivalent to two independent circuits, one in each direction. Leased data lines are graded according to the degree of noise and distortion to be expected: British Telecom offer four categories.

A simple 300 bit/s V.21 modem is still sufficient for many purposes: this direct-connect model is by Answercall.

Eprom programmer software

Enhancements to July's listing for controlling John Adams' intelligent eprom programmer.

by Norman Sargent

These additions to my program published on page 45 of the July issue will prove useful to readers developing and manipulating data in memory.

In the software, on returning to the program after editing memory, the eprom-list menu is entered and the default disc drive is then reselected. With these changes, the program returns to command mode with the selected eprom and drive numbers intact.

After editing memory, key f0 is used to return to the program instead of the break key. This function key, and any others that you may want to define for use during memory editing, is defined in line 140. If you need to define several keys, this line could be replaced by a procedure. The function is disabled by line 150 and re-enabled by the memory editing command to prevent spurious entries when the computer asks for input and you press the wrong user key.

To reset the programmer after it has locked up, which can happen for example when the break key is pressed inadvertently or a command is issued and no eprom is fitted, a simple momentary push-to-make switch can be connected from ground through a 1kΩ resistor to pin four of IC_5 on the programmer. This will also remove any programming voltages on the slave socket to allow removal of the eprom.

There are no problems with reading and programming 8048 and 8049 processors, but note that bits in these devices are at zero when erased, and not all high as with a standard eprom. The program detects this during an erase-verification command.

I have fitted sideways ram to my computer and use Toolstar's *MCOPY command to shift blocks of data around in memory. This, in conjunction with the user-defined keys and these program modifications, allows speedy development of eprom-based programs.

Finally, I omitted to mention connection of the RTS signal to the RS423 lead in the original article. This should be wired from pin three of the microcomputer plug to pin 20 of the programmer plug.

Procedure PROCdisable is necessary to disable the cursor and copy keys after editing memory as Toolstar re-enables them when using *MDUMP. Disabling the function keys is necassary for returning to the program.

```
  60 DIMcode%110:oscli=&FFF7:f1%=&79
 140 *KEY0PROCdrive_no(-1)|MPROCdisable|MGOTO330|M
 150 PROCdisable
 160 :
 180 REM 9600 baud
 210 :
 220 :
 330 VDU28,0,24,39,2:CLS:PRINTTAB(0,0)SPC11STAB(13,1)"COMMAND LIST"'
 470 PROCrestore:PRINTTAB(0,21)b$bg$c$"'ESCAPE' to edit"TAB(0,22)
     b$bg$c$"'f0 to exit";:VDU28,0,21,39,2:*FX225,1
1920 osbyte=&FFF4
2530 PROCdisable
2540 *FX4,1
2550 *FX11
2560 *FX200,1
2570 *FX225
2580 ENDPROC
```

Linear IC Equivalents and Pin Connections by Adrian Michaels. Bernard Babani (publishing) Ltd, 247 pages 195×265mm, soft covers, £4.95. Lists the European, U.S. and Japanese equivalents of a wide range of i.cs. The tables are supplemented by 90 pages of connection diagrams. From the same author and publisher, and at the same price, comes a companion volume, **Digital IC Equivalents and Pin Connections** (320pp).

BSI Catalogue 1985. British Standards Institution, soft covers 493 pages. Available by post from the Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE; price to non-members is £19. How to obtain specifications for just about every product or activity you can think of: from A-series paper sizes to Zones of comfort in earth-moving machinery, from wine-tasting glasses (BS5586) to ethylene glycol (BS2537). Of particular interest are the BS9000 series and the many other specifications relating to the electronics industry. An introductory section outlines the work of the BSI and lists centres in Britain and overseas where complete sets of British Standards are available for reference. A table lists corresponding IEC and ISO standards.

IEC Yearbook: World standards for electrical engineering. International Electrotechnical Commission, soft covers, 583 pages (parallel text in French and English). Price 48 Swiss francs, from IEC Central Office, 3 rue de Varembé, 1211 Geneva 20, Switzerland. IEC committees, their activities and publications.

Micro-Prolog and Artificial Intelligence by A.A. Berk. Collins, 164 pages, soft covers, £9.95. List processing, artificial intelligence and expert systems for the beginner. Easy-to-follow, well-presented text with numerous examples based on Acornsoft micro-Prolog.

Modern Electronics and Integrated Circuits by B.J. Stanier. Adam Hilger, 148 pages, price £7.50 (paperback) or £19.50 (hard cover). Intended as an undergraduate-level text for physicists or as an introductory survey for electronics students. Chapters cover the physics and manufacture of semiconductor devices, signals in electronic systems and their characteristics, amplification, signal conditioning, electronic instrumentation, digital electronics and computer techniques.

Within the BBC Microcomputer by Roger Cullis. Losco Ltd (P.O. Box 4, Cranleigh, Surrey GU16 8BQ), wire bound, £11.95 plus £1.80 postage. Invaluable reference book for advanced programmers, giving about as much information on the Acorn roms as could be hoped for, short of a commented assembler listing. Sections cover the 1.2 operating system, Basic 1 and 2, Hi-Basic for the 6502 second processor, the 0.90 disc filing system, the 3.34 Econet rom and others. For each rom the author gives a general description, a plan of its zero-page and other work-space, a gazetteer explaining the function for each line of code and (most useful) a reference table showing the calling locations of jumps, subroutine calls and look-ups.

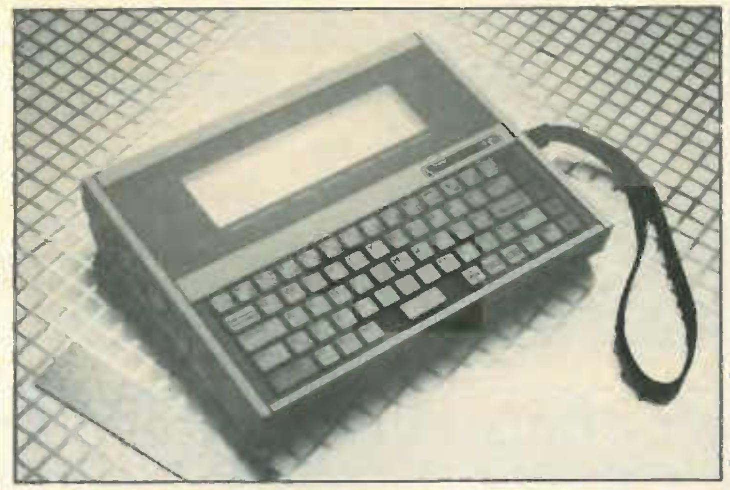
Radio and Television Servicing, 1984-85 models, edited by R.N. Wainwright. Macdonald, 772 pages, hard cover, £22.50. Servicing information on a wide range of recent models, including some pocket stereo sets; brands include most major European and Far Eastern names.

Cost-effective Electronic Construction by John Watson, revised edition. Macmillan Education, 142 pages, soft covers, £5.95. Ten projects for the hobbyist and a further eighteen circuit ideas, all designed with value-for-money in mind: among them an automatic porch light, a feedback drill controller, xenon strobe, temperature alarm, computer interface and a radio-control system. Each project is clearly explained and, to help the beginner, detailed shopping lists are given at the back of the book.

Fundamental Forth by Richard Olney and Michael Benson. Personal Computer News Library, Pan Books, 239 pages, soft covers, £6.95. In the first 30 pages is a general introduction to computers, programming and Forth; then follows an at-the-keyboard guided tour of the language. Topics covered include string handling and the use of discs. Six appendices describe the syntax of Forth words in Fig-Forth, Forth-79 and Forth-83 versions.

Radio Systems for Technicians by D.C. Green. Pitman Publishing, 282 pages, soft covers, £7.25. An omnibus edition of the author's two previous books, Radio Systems II and Radio Systems III, designed to provide full coverage of the Business and Technician Education Council syllabus units. Chapters deal with modulation methods, modulators and demodulators, aerials and transmission lines, transmitters, radio propagation, receivers and communications systems. Readers can test their knowledge in an extensive exercise section at the back.

Lap-sized CP/M computer



Designed and built in the UK, Microscibe 600 is little larger than a paperback book, yet incorporates 128K or ram and 64K of rom, runs CP/M and a version of Basic. It is battery driven, and can have an auto-dial CCITT V21 full duplex modem fitted within its case.

The 600 is run by an HD68A140 c-mos processor which uses a superset of Z80 instruction codes. Ram may be increased to 256 or 320K and the firmware includes the CP/M operating system, Locomotive Basic interpreter, ram controller and an optional toolkit rom for software developers. The computer communicates through two RS232 ports to printers, bar-code reader or any other serial device. The case can be easily extended during manufacture to include a built-in printer or other peripheral. The keyboard has the conventional qwerty layout, though it is smaller than on a typewriter. All 67 keys are reprogrammable to any function.

Display is through an eight line, 40-character liquid crystal which can be used for graphics. The screen memory allows for an 80-character by 24-line screen and the l.c.d. acts as a window on this larger virtual screen.

A real-time clock features a 'wake' facility so that the computer can switch itself on and perform a pre-programmed task, such as transmitting a message in off-peak telephone charge times. It can also be woken on receipt of a call through the auto-answer modem. The internal NiCd batteries run for about 40h after an overnight charge.

The makers see the computer as being of most use in specific applications and for bulk buyers they can alter the operating system and/or language to suit an application. Some of its predecessors have been used in data gathering for a botanical survey in Borneo and on the ill-fated Virgin Atlantic Challenger.

For bulk buyers the computer costs about £500 and a fully implemented version with CP/M, basic and a modem, about £800. Microscribe Ltd, Llantarnam Industrial Park, Cwmbran, Gwent EWW 205

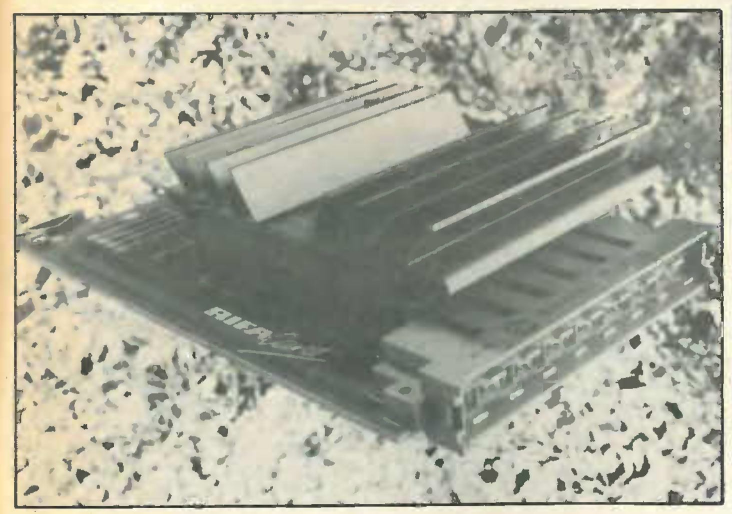
BBC+68008

An additional rom and p.c.b. converts a BBC Micro into a multitasking computer capable of running the OS-9/68000 system and high-speed, high resolution graphics. The 'Upgrade' from Cumana includes 516K ram, double-density floppy disc controller, SASI interface for one or more hard discs, battery-backed real-time clock, and a comprehensive collection of software. The p.c.b. is about the same area as the BBC's own main board. It plugs into the 6502 c.p.u. socket and the c.p.u. is plugged in the upgrade board.

On power-up, the computer is running the 6502 in normal BBC mode with the 68008 disabled. In this mode, the expansion board is transparent to the computer apart from the floppy disc controller, the calender clock and the hard disc interface which are available as normal i/o devices. By typing *OS9 the 68008, running at 8MHz, is enabled and the OS-9 operating system is loaded from disc. OS-9 is then in full command of the hardware and the 6502 is used as d.m.a. controller for the discs. This use of the 6502 permits the system to operate full multitasking in real time without waiting for disc transfer.

The OS-9 system is similar to Unix in operation and is compatible with Unix at the C source-code level. However it has certain advantages over Unix; it is written in assembly code rather than C and is consequently smaller and faster. OS-9 does not need to swap discs for multitasking. It is fully interrupt-driven and so is suitable for control and monitoring applications.

The hardware is packaged with OS-9, Stylograph word-processing system, Dynacalc electronic spreadsheet, Sculptor database, interactive Basic 09 which incorporates many Pascal-like structures, compilers for C and ISO-Pascal, and assembler, and a graphics kernel that offers windowing facilities and multiple character fonts. All for about £700. A similar board is available for the QL. Cumana Ltd, The Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3BH. EWW 207



D.c. conveter on a card

This d.c. conveter is the Rifa PKA which has an integral heatsink and can provide 40W power. Mounted on a Eurocard by Campbell Collins, the user can add a bridge rectifier and a reservoir capacitor for an a.c. input; a trimmer for output voltage adjustment and a status indicator on the board. The Rifa converters use a very high frequency switching rate which give then high efficiency, quoted at 80% and an m.t.b.f. of over 200 years. The card produces 5V at 8A for an input of 48V. The outputs may be connected in parallel to provide more power. Campbell Collins Ltd, 162 High Street, Stevenage, Herts. EWW 217

IBM PC boards from one source

Fed up with trying to locate suppliers and technical support for plub-in boards for the IBM-PC, Deltek Electronics have now set up their own company to supply such boards. They aim to supply as many of the industry-standard boards as possible, and offer full technical support from their own engineers who are also PC users. Ranges to be stocked include Techmar, Comway, Hercules and Deltek's own range. As a major distributor they are able to stock some of the more unusual boards ssuch as image processor and other specialist products. They already offer a similar service for the Sanyo 550 Computer and can offer a complete package to the customer including monitors, printers etc. As an introductory offer Deltek are discounting up to 20% off a wide range of products. Deltek PC Support Ltd, The High Street, Staplehurst, Kent TN12 0BH. EWW218

Swept functions up to 2MHz

Sine. square and triangular waveforms over a frequency range of 0.1Hz to 2MHz can be generated by the Enertec 4416/2. The frequency can be selectedby the front panel controls, an external direct voltage or through the general-purpose interface bus. Output levels are variable up to 10V peak-to-peak with or without voltage offset. In addition the generator anables the frequency to be swept up to 1000: 1 with swep times variable from 30ms to 30s. Full control of the waveform selection, amplitude, frequency and offset is possible through the interface Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH. EWW 216

Technical computer

Designed and produced in the UK, the Technical Computer from Positron is specifically intended for engineering and scientific applications. It is based around two Motorola 6809E processors and operates under OS-9 and Basic 09 (see also item on Cumana's OS-9 Upgrade.)

The computer features multi-user access. Four v.d.u. stations may be used for control and/or system design. Several background operations, such as printing, plotting and instrument control can be performed concurrently while the workstations continue to operate interactively. Real-time operation means that the system is fast enough to receive, process and respond to data from external sources.

Basic 09 is an advanced, version of Basic which in many ways is similar to Cobol, importing many of the facilities from Pascal which enable programs to be modular, structured and capable of using a range of data structures. The system includes a text editor, run-time interpreter and a high-level interactive bug-hunter.

The OS-9 operating system is high speed and offers multi-user software development through a range of access rights together with record locking within three structures directories. Each workstation has a c.r.t. display with 24 lines by 80 characters and a 25th line for the use of the operator or the display of status. It also has a graphics display of 640 by 400 dots and a drawing speed of 16million dot/s.

A graphics plotter provides hardcopy and a graphics tablet may be used for input. Positron Computers Ltd, Deacon Trading Estate, Newton-le-Willows, Lancs WA12 9XQ. EWW 213

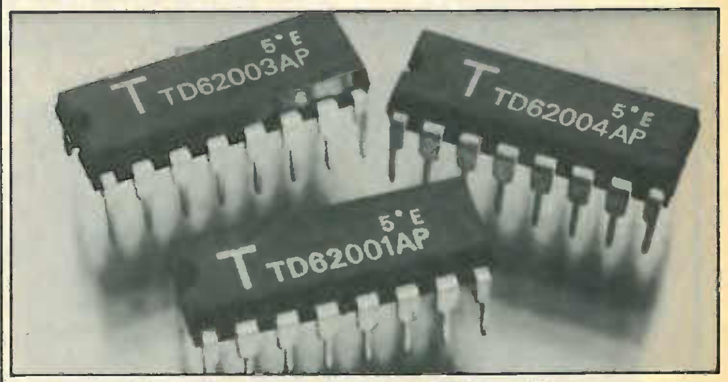
Cellular phone

'The first car telephone designed specifically for the UK cellular radio system' is the claim of Philips for their M7000, inferring that other sets are adaptations from American or Scandinavian models. In addition to the facilities offered normally by such telephones — storage of frequently used numbers, on-hook dialling and security locking — this model also has number scrolling, re-dialling of the most recent number and automatic switching-off. The scrolling facility enables the user to review all 40 of the numbers stored in memory and removes the need to remember the code used to call them and the need to keep a separate directory. Misdialling a digit can be corrected without having to start again. It is also possible to listen to the coversation over a separate loudspeaker while entering a number in the handset's scratchpad.

The set also includes a signal-strength meter as a guide to the likely quality of a call when operating in the fringe of a coverage area. The display automatically varies its illumination to cope with different light conditions. Pye Telecommunications Ltd, St. Andrews Road, Cambridge CB4 1DW. EWW 215

Darlingtons-in-line

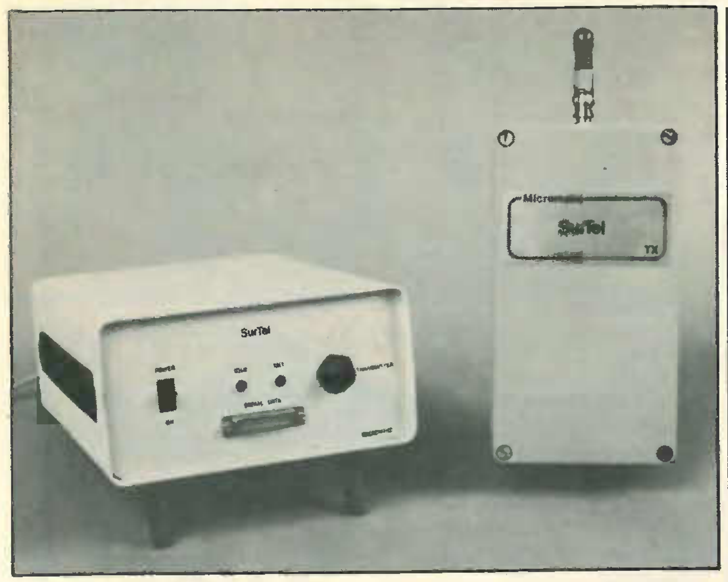
Seven Darlington transistor pairs are enclosed in a 16-pin d.i.l. package from Steatite. The packages feature integral clamping diodes for use with inductive loads and bypass resistors to improve the switching characteristics. The transistors may be used to drive devices up to 500mA. The output sustaining voltage can be as high as 50V and the device offers a current gain of 1000, at V_{ce} of 2V. The maximum power dissipation is 0.52W. Versions are available for use with t.t., c-mos and p-mos logic circuits with operating voltages from 5 to 25V. Steatite Microelectronics Ltd, Hagley House, Hagley Road, Edgbaston, Birmingham B16 8QW. EWW 210



Bright-light indicators

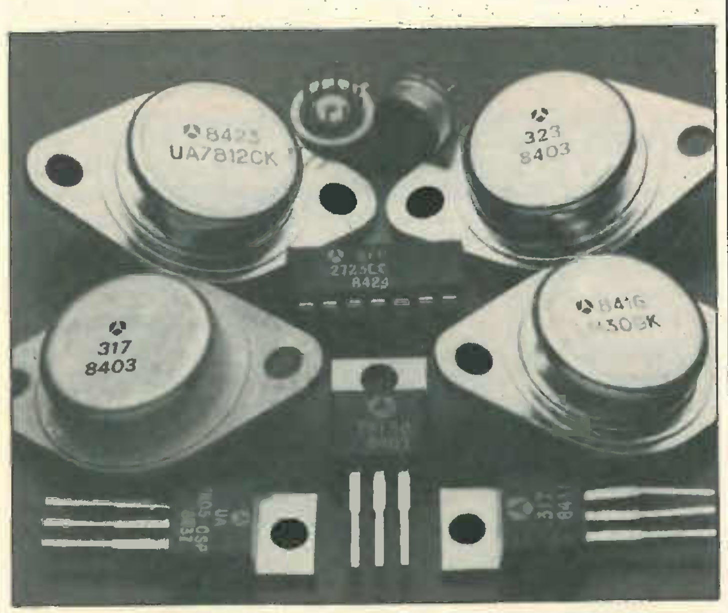
Alphanumeric characters, four in a row, can be viewed in sunlight says their manufacturer Hewlett-Packard. To do so, they need heat sinks and suitable contrast- enhancement filters but they do offer three colours; yellow, red and green.

Four five-by-seven dot-matrix characters fit into a package 12in (304mm) wide which is capable of being stacked both in rows and columns. A full set of characters may be displayed. The green version is suitable for viewing through pilots' night-vision goggles. Hewlett-Packard Ltd, Eskdale House, Winnersh, Wokingham, Berks RG11 5DZ. EWW 212



U.h.f data link

Developed for telemetry in hydrographic surveying, SurTel has many applications in engineering and computing. It consists of a single-channel u.h.f. transmitter and receiver operating in the 458MHz band to provide simplex computer-to-computer data links and serial communication with a variety of sensors or other peripherals. An optional interface unit converts data into RS232 format, modulates it and provides power to the remotely mounted transmitter. A similar module at the receiving end is used to output RS232 signals. The system is used in line-of-sight positions and operates at 1200 baud. The transmitter has an e.r.p. of 500mW to comply with UK regulations, though alternative antennae and power boosters can be supplied for use elsewhere. Micromake, 1 The Holt, Hare Hatch, Upper Wargrave, Berks RG10 9TG. EWW 206



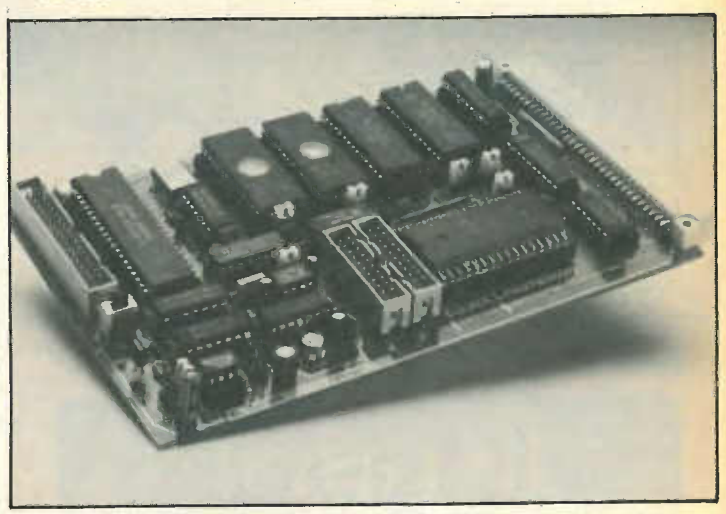
Voltage regulators

A wide range of Thomson voltage regulators are available from stock at Steatite. They include devices with output voltages from 5 to 25V at currents up to 5A. As can be seen in the picture, a number of different packages are used, including surface-mounted devices. Steatite Microelectronics Ltd, Hagley House, Hagley Road, Edgbaston, Birmingham B16 8QW. EWW 219

Maths software for engineering

Math Advantage is a software library of algorithms for engineers and scientists. Using the well-documented subroutines, the software development engineer does not have to re-encode commonly used, mathematically complex routines, and can concentrate on problem solving rather than on writing, testing and documenting codes for difficult algorithms. Subroutines in the library can be called from programs written in either Fortran or C.

The software has been developed by Quantitative Technology specifically for Honeywell computers and can be inplemented on the DPS8, 88 and 90 main-frame computers operating under GCOS 8. The routines have been written to provide maximum speed, using techniques such as loop-unrolling for vector computers or loop-ordering for two-dimensional arrays. The library is divided into categories of algorithms to provide a core for various applications. Available from Honeywell distributors. The cost in the US is $10 000.



Eurocard controller

An adaptable new single Eurocard computer that may be programmed in Basic, Forth or Assembler lends itself to industrial instrumentation and control. The Essex Chameleon is based on Rockwell's 6501AQ 2MHz single-chip computer and features 2 × 16 bit counter timers, 54 parallel input/output lines, full duplex serial channel to RS422/423 (RS232, four 28pin memory sockets with a total capacity of expandable 64K bytes ram/eprom with 8K of ram fitted as standard, and full compatibility with the Essex range of cards. Essex Electronics Centre, Wivenhoe Park, Colchester, Essex CO4 3SQ. EWW 220

Printer buffer

A range of printer buffers are available that can free your computer fromm waiting while documents are being printed.

The series from PMCL include many options of memory size and whether serial or parallel (or both) interfacing is required. Versions are available to fit inside Epson and IBM printers and free-standing models can be used with any printer. These last-mentioned models also include additional features such as the ability to pause between single pages or produce multiple copies. The range starts at £75 for an 8K buffer that will plug inside an Epson printer with either serial or parallel interfacing. Top of the range is a 256K free-standing model that includes both parallel and serial links for £370. Kits are available to upgrade the chosen buffer for future expansion. PCML Ltd, Royal Mills, Esher, Surrey. EWW 208

NEW PRODUCTS

Data aquisition module

Remote monitoring and control of any electrically operated machinery is possible with the Scatterbrain. The makers claim that error-free information may be relayed over long distances from any type of sensor or actuator. Any number of units may be linked to provide status checks on a plant complex. The unit is programmed in "plain English" and can be operated by non-technical people through a keyboard and a monitor screen. The units can linked to a computer where monitor data is produced as ASCII characters and is capable of being processed at high speed. Dynamic Logic Ltd, Industrial Products, The Western Centre, Western Road, Bracknell Berks RG12 1RW. EWW 218

High-speed maths chip

A world's first is claimed for the TRW c-mos multiplier/accumulator as it is manufactured using 1-micron internal architecture. The TMC2110 is organised as 16 by 16 bits and operates with a cycle time of 100ns. Input data can be specified as two's-complement or of unsigned magnitude, giving a full precision 32-bit product. Products can be accumulated into a 35-bit result. Features include: individually-clocked flip-flop input and output registers to maximize the device's speed and simplify bus interfacing; selectable accumulation, subtraction, rounding, and preloading; and operation from a single +5V supply.

Applications include array, video, radar, and general-purpose digital signal processing as well as micro/minicomputer acceleration. The TRW device is available through Hi-Tek Electronics Ltd, Beadle Trading Estate, Ditton Walk, Cambridge CB5 8QD. EWW214

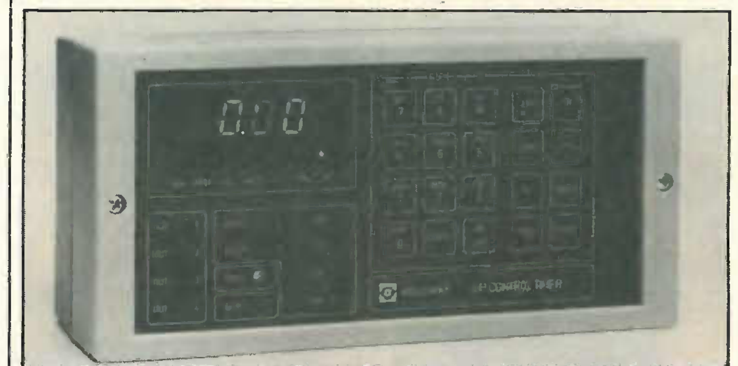
E.c.l. and t.t.l. share same gate array

An 1800-gate bipolar gate array from AMD features input/output interfaces that can be configured for mixed emitter-coupled and transistor/transitor loogic operation the AmMPA1850 incorporates the same set of internal macrocells that are used in Motorola's MCA-1 library along with additional propriety functions developed by AMD. The advantage of the combined e.c.l. and t.t.l. is that it may be used for high speed applications such as video graphics and disc storage systems.

The device is available in a variety of packages from 28 to 120 pins. AMD offers an 8-week turn around from receipt of the customers net list to delivery of first samples. They use a development system that combines a logic simulator with test program generator, automatic placement and routing, and an electrical design rule checker. Designs can be completed from a logical net list, a finished layout or any interim stage. Advanced Micro Devices (UK) Ltd, Goldsworth Road, Woking, Surrey GU21 1JT. EWW205

Frequency meter for the pocket

Enclosed in the unmistakable case of a Thandar instrument, bequeathed to them by Sinclair Radionics, is their new frequency meter which can count between 20Hz and 200MHz with a 0.1Hz resolution. It features a sensitivity of 10mV, a timebase accuracy of 2p.p.m. and an 8-digit display. It is powered by internal batteries and low power is indicated by the simultaneous lighting of all the decimal points. Optional accessories include prescalers, a.c. adaptors. a carrying case and a service manual. Available through Electronic Brokers Ltd. 140 Camden Street, London NW1 9PB. EWW 211



Control timer

The use of a microprocessor and a non-volatile memory in Velleman's control timer enables the programming of 40 steps (with additional memory expandable up to 240) with four relay outputs. The steps can be programmed for any time interval up to a year and the unit is seen as of particular use in controlling the time signals for shifts in factories, meal breaks, or school lesson times. Velleman (UK) Ltd, PO Box 30, St. Leonard's-on-Sea, East Sussex TN37 7NL. EWW 214

Precision thermistors

Two families of disc-shaped thermistors are available from Iskra. The Elveterm range have specific resistance values between 10^{-1} and 10^{6}Ωcm. The families are divided between the UN2 which are of 10.5mm diameter with a maximum dissipation of 1W and the UN3 range measures 5.5mm in diameter with half the power dissipation of the others. Both families are available with resistance tolerances of 5, 10 or 50% with the UN2 range varying from 8.2Ω to 33kΩ, while the UN3 ranges from 33Ω to 100kΩ. The devices are suitable for use in temperature control and measurement, remote control of liquid levels and flow rates, time delay relays, and voltage stabilization. Iskra Ltd, Redlands, Coulsdon, Surrey CR3 2HT. EWW 209

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made in the UK by the famous **REDIFFUSION Co.** for their own professional computer system this monitor has all the features to suit your immediate and future monitor requirements. Two video inputs: **RGB** and **PAL** Composite Video, allow direct connection to the **BBC** and most other makes of micro computers and **VCR's**. An internal speaker and audio amplifier may be connected to your systems output or direct to a VCR machine, giving superior sound quality. Many other features included PIL tube, Matching **BBC** case colour, Major controls on front panel, Separate Contrast and Brightness – even in **RGB** mode, Two types of audio input, Separate Colour and audio controls for Composite Video input, **BNC** plug for composite input, 15 way 'D' plug for **RGB** input, modular construction etc etc.

This Must be **ONE OF THE YEAR'S BEST BUYS**
Supplied **BRAND NEW** and **BOXED**, complete with DATA and 90 day guarantee.
SUPPLIED BELOW ACTUAL COST – ONLY £149.00

DECCA 80 16" COLOUR monitor. RGB input.
Little or hardly used manufacturer's surplus enables us to offer this special converted **DECCA RGB** Colour Video TV Monitor at a super low price of only **£99.00**, a price for a colour monitor as yet unheard of!! Our own interface, safety modification and special **16"** high definition **PIL** tube, coupled with the tried and tested **DECCA 80** series TV chassis gives 80 column definition and picture quality found only on monitors costing **3 TIMES OUR PRICE**. In fact, **WE GUARANTEE** you will be delighted with this product, the quality for the price, has to be seen to be believed. Supplied complete and ready to plug direct to a **BBC MICRO** computer or any other system with a **TTL RGB** output. Other features are: internal speaker, Modular construction, auto degaussing circuit, Attractive **TEAK CASE**, compact dimensions only 52cm W x 34 H x 24 D, 90 day guarantee. Although used, units are supplied in **EXCELLENT** condition, **ONLY £99.00** + Carr.
DECCA 80, 16" COLOUR monitor. Compositve video input. Same as above model but fitted with Composite Video input and audio amp for **COMPUTER**, VCR or **AUDIO VISUAL** use. **ONLY £99.00** + Carr.
REDIFFUSION MARK 3, 20" Colour monitor. Fitted with standard 75 ohm composite video input and sound amp. This large screen colour display is ideal for shops, schools, clubs and other **AUDIO VISUAL** applications. Supplied in AS NEW or little used condition **ONLY £145.00** + Carr.

BUDGET RANGE EX EQUIPMENT MONOCHROME video monitors.
All units are fully cased and set for 240v standard working with composite video inputs. Units are pre tested and set up for **80** column use on **BBC** micro etc. Even when MINOR screen burns exist – normal data displays are unaffected.
12" KGM 320-1 B/W high bandwidth input, will display up to 132 x 25 lines. **£32.95**
12" GREEN SCREEN version of **KGM 320-1** Only **£39.95**
9" KGM 324 GREEN SCREEN fully cased very compact unit Only **£55.00**
9" HITACHI VM-906E/K Black and White screen **£49.95**

Carriage and insurance on all monitors **£10.00**

D.C. POWER SUPPLY SPECIALS

GOULD OF443 enclosed, compact switch mode supply with DC regulated outputs of +5v @ 5.5a, +12v @ 0.5a, –12v @ 0.1a and –23v @ 0.02a. Dim 18 x 11 x 6 cm. 110 or 240v input. **BRAND NEW** only **£14.95**
GOULD G6-40A 5v 40 amp switch mode supply NEW £130.00
GREENDALE 19A-BOE Switch mode 60 watt open PCB with a fully regulated DC output of 5v @ 6 amps, and three semi regulated outputs of +12V, –12V +15V @ upto 1 amp. Dim only 11 cm x 20 cm x 5.5 cm. Similar to RS 591-994. **110** or 240v AC input. **TESTED** ex equipment. **Only £24.95**
AC-DC Linear **PSU** for **DISK** drive and **SYSTEM** applications. Constructed on a rugged ALLOY chassis to continuously supply fully regulated DC outputs of +5V @ 3 amps, –5V @ 0.6 amps and +24v @ 5 amps. Short circuit and overvoltage protected. 110 or 240 V AC input. Dim 28 x 12.5 x 7 cm **NEW £49.95.**
Carriage on PSU's £3.00

SPECIAL 300 BAUD MODEM OFFER

Another **GIGANTIC** purchase of these **EX BRITISH TELECOM, BRAND NEW** or little used 2B data modems allows US to make the **FINAL REDUCTION**, and for **YOU** to join the exciting world of data communications at an **UNHEARD OF PRICE OF ONLY £29.95**. Made to the highest **POST OFFICE APPROVED** spec at a cost of hundreds of pounds each, the 2B has all the standard requirements for data base, business or hobby communications. All this and more!!

- 300 baud full duplex
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- Supplied with full data
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- Direct isolated connection
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- Standard RS232 serial interface
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- 1 year full guarantee
- Just 2 wires to comms. line

NOW ONLY £29.95

BT 600 Jack plug and cable £2.25 Carriage and Ins. £10.00

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Standard VDU data entry terminals at give away prices!!
QUME QVT108. Current product, state of the art terminal with detachable keyboard, 12" green screen, 2 page RAM, TVI 925 emulation, 25 x 80, Clock, Swivel and tilt base, Printer port, Function keys etc. **BRAND NEW** and BOXED AT ALMOST **HALF PRICE** Only **£425.00**
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ADDS 520 – Dumb terminal, used, 12" b/w screen RS232 interface and printer port. **TESTED. ONLY £125.00**
Carriage on terminals £10.00
100's of other terminals in stock,
CALL for more details.

DISPLAY -ELECTRONICS-

ll prices quoted are for U.K. Mainland, paid cash with order in Pounds Sterling PLUS VAT. Minimum order value ***£2.00***. Minimum Credit Card order ***£10.00***. Minimum BONAFIDE account orders from Government Depts., Schools, Universities and established companies ***£20.00***. Where post and packing not indicated please ADD £1.00 + VAT. Warehouse open Mon-Fri 9.30-5.30. Sat 10.30-5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export

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Telephone 01-679 4414 Telex 894502 Data 01-679 1888

ERS — PRINTERS — PRINTERS — PRINTERS

SUPER DEAL? NO – SUPER STEAL
THE FABULOUS 25 CPS "TEC STARWRITER"

Made to the very highest spec the **TEC STARWRITER FP1500-25** features a very heavy duty die cast chassis and **DIABLO** type print mechanism giving superb registration and print quality. Micro-processor electronics offer full **DIABLO/QUME** command compatability and full control via **CPM WORDSTAR ETC.** Many other features include bi-directional printing, switchable 10 or 12 pitch, full width 381mm paper handling with up to 163 characters per line, friction feed rollers for single sheet or continuous paper, internal buffer, standard **RS232** serial interface with handshake. Supplied absolutely **BRAND NEW** with 90 day guarantee and FREE daisy wheel and dust cover. Order **NOW** or contact sales office for more information. Optional extras **RS232** data cable **£10.00**. Tech manual **£7.50**. Tractor Feed **£140.00**. Spare daisy wheel **£3.50**. Carriage & Ins. (UK Mainland) £10.00.

SUMMER OFFER ONLY £399.99!!

DIY PRINTER MECH

Brand New surplus of this professional printer chassis gives an outstanding opportunity for the **Student, Hobbyist** or **Robotics** constructor to build a **printer – plotter – digitiser** etc, entirely to their own specification. The printer mechanism is supplied ready built, aligned and pre tested but **WITHOUT** electronics. Many features include all metal chassis, phosphor bronze bearings, **132** character optical shaft position encoder, **NINE** needle head, 2 x two phase 12V stepper motors for carriage and paper control, 9.5" Paper platten etc. etc. Even a manufacturer's print sample to show the unit's capabilities!! Overall dimensions 40 cm x 12 cm x 21 cm.

Sold **BRAND NEW** at a **FRACTION** of cost **ONLY £49.50** + pp £4.50.

TELETYPE ASR33
DATA I/O TERMINALS

Industry standard, combined **ASCII** 110 baud printer, keyboard and 8 hole paper tape punch and reader. Standard **RS232** serial interface. Ideal as cheap hard copy unit or tape prep. for CNC and NC machines. **TESTED** and in good condition. Only **£235.00** floor stand **£10.00**. Carr & Ins. £15.00.

EX NEWS SERVICE PRINTERS

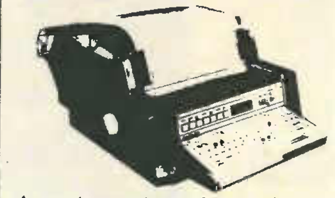
Compact ultra reliable quality built unit made by the **USA EXTEL Corporation.** Often seen in major Hotels printing up to the minute News and Financial information, the unit operates on **5 UNIT BAUDOT CODE** from a Current loop, **RS232** or **TTL** serial interface. May be connected to your micro as a low cost printer or via a simple interface and filter to any communications receiver to enable printing of worldwide **NEWS, TELEX** and **RTTY** services.

Supplied **TESTED** in second hand condition complete with **DATA, 50 and 75 baud xtals and large paper roll.**

TYPE AE11 50 Column	**ONLY £49.95**
Spare paper roll for AE11	**£4.50**
TYPE AF11R 72 Col. + Ribbon	**£65.00**
TYPE AH11R 80 Col. ASCII/BAUDOT	**£185.00**

Carriage and Insurance £7.50

GE TERMIPRINTER



A massive purchase of these desk top printer terminals enables us to offer you these quality **30** or **120** cps printers at a **SUPER LOW PRICE** against their original cost of over £1000. Unit comprises of full **QWERTY**, electronic keyboard and printer mech with print face similar to correspondence quality typewriter. Variable forms tractor unit enables full width – up to 13.5" 120 column paper, upper – lower case, standard **RS232** serial interface, internal vertical and horizontal tab settings, standard ribbon, adjustable baud rates, quiet operation plus many other features. Supplied complete with manual. Guaranteed working **GE30 £130.00. GE1200 120 cps £175.00**
Untested **GE30 £65.00** Optional floor stand **£12.50**. Carr & Ins. £10.00.

SEMICONDUCTOR 'GRAB BAGS'

Mixed Semis amazing value contents include transistors digital, linear, IC's, triacs, diodes, bridge recs, etc. etc. All devices guaranteed brand new full spec with manufacturer's markings, fully guaranteed.
50+ £2.95 100+ £5.15
TTL 74 Series. A gigantic purchase of an "across the board" range of **74 TTL** series IC's enables us to offer **100+** mixed **"mostly TTL"** grab bags at a price which two or three chips in the bag would normally cost to buy. Fully guaranteed all IC's full spec. **100+ £6.90, 200+ £12.30, 300+ £19.50**

20,000 FEET OF ELECTRONIC AND COMPUTER GOODIES
ENGLAND'S LARGEST SURPLUS STORE – SEEING IS BELIEVING!!

DEC CORNER

PDP 1140 System comprising of CPU, **124k** memory & MMU 15 line RS232 interface. RP02 40 MB hard disk drive. **TU10** 9 track 800 BPI Mag tape drive, dual track system. VT52 VDU, etc. etc. Tested and running.	£3,750.00
BA11-MB 3.5" Box, PSU, LTC	£395.00
DH11-AD 16" x RS232 DMA interface	£1,900.00
DLV11-J4 x EIA interface	£350.00
DLV11-E Serial. Modem support	£190.00
DUP11 Synch. Serial data i/o	£650.00
DQ200 Dilog – multi RK controller	£495.00
DZ11-B 8 line RS232 mux board	£650.00
KDF11-B M8189 PDP 1123 PLUS	£1,100.00
LA30 Printer and Keyboard	£80.00
LA36 Decwriter EIA or 20 mA loop	£270.00
MS11-JP Unibus 32kb Ram	£80.00
MS11-LB Unibus 128kb Ram	£450.00
MS11-LD Unibus 256kb Ram	£850.00
PDP11/05 Cpu Ram, i/o etc	£450.00
PDP11/40 Cpu, 124k MMU	£1,850.00
RT11 ver 3B documentation kit	£70.00
RK05-J 2.5 Mb disk drives	£650.00
KL8 JA PDP 8 async i/o	£175.00
M18E PDP 8 Bootstrap option	£75.00
VT50 VDU and Keyboard – 20 mA	£175.00
VT52 VDU and RS232 interface	£250.00

Give your **VT100** a Birthday!!!
Brand New **VT100** Keyboards only **£85.00**

1000's of **EX STOCK** spares for **DEC PDP8, PDP8A, PDP11** systems & peripherals. Call for details. All types of Computer equipment and spares wanted for **PROMPT CASH PAYMENT.**

MAG TAPE DRIVES

Many **EX STOCK** computer tape drives and spares by **PERTEC, CIPHER, WANGO, DIGIDATA, KENNEDY** etc. Special offer this month on **DEI** Cartridge tape drives **ONLY £450.00 each.**

CALL FOR DETAILS

COMPUTER/SYSTEM CABINET & PSU

All in one quality computer cabinet with integral switched mode PSU, mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the psu is fully screened and will deliver a massive **+5v DC at 17** amps, **+15v DC at 1 amp** and **–15v DC at 5 amps**. The complete unit is fully enclosed with removable top lid, filtering, trip switch, **power** and **run** leds mounted on ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. Give your system that professional finish for only **£49.95** + carr. 19" wide 16" deep 10.5" high. Useable area 16" w 10.5"h 11.5"d.

Also available less psu, with fans etc. Internal dim. 19"w, 16"d, 10.5"h. **£19.95. Carriage £8.75**

66% DISCOUNT ON ELECTRONIC COMPONENTS EQUIPMENT

Due to our massive bulk purchasing programme, which enables us to bring you the best possible bargains, we have thousands of ICs, Transistors, Relays, Caps, PCBs, Sub-assemblies, Switches etc. etc. surplus to OUR requirements. Because we don't have sufficient stocks of any one item to include in our ads we are packing all these items into the **BARGAIN OF A LIFETIME**. Thousands of components at giveaway prices. Guaranteed to be worth at least 3 times what you pay. Unbeatable value and perhaps one of the most consistently useful items you will every buy!!! Sold by weight.

2.5kls £5.25 + pp **£1.25** — **5 kls £6.90 + £1.80**
10kls £11.25 + pp **£2.25** — **20kls £19.50** + pp **£4.75**

CENTRONICS 710 PRINTERS

Ex **RENTAL** Heavy duty full width carriage printer up to **132** columns on 17" fan fold sprocket fed paper. 60 cps print speed with standard **RS232** or 20 mA loop interface. Supplied in **TESTED** used condition with data. **ONLY £85.00** carriage and insurance **£10.00.**

MAINS FILTERS

CURE those unnerving hang ups and data glitches caused by mains interference with professional quality filters. **SD5A** matchbox size up to **1000 watt 240 V** Load **ONLY £5.95. L12127** compact completely cased unit with 3 pin fitted socket up to **750 watts ONLY £9.99.**

EPROM COPIERS

The amazing **SOFTY 2** The "Complete Toolkit" for copying, writing, modifying and listing **EPROMS** of the **2516, 2716. 2532, 2732** range. Many other functions include integral keyboard, cassette interface, serial and parallel i/o UHF modulator ZIF socket etc.
ONLY £195.00 + pp £2.50.
"GANG OF EIGHT" intelligent Z80 controlled 8 gang programmer for ALL single 5v rail EPROMS up to 27128. Will copy 8 27128 in ONLY 3 MINUTES. Internal **LCD** display and checking routines for **IDIOT PROOF** operation. Only **£395.00** + pp £3.00.
"GANG OF EIGHT PLUS" Same spec. as above but with additional **RS232** serial interface for down line loading data from computer etc. **ONLY £445.00** + pp **£3.00**
Data sheets on request

1000's of other EX STOCK items including POWER SUPPLIES, RACKS, RELAYS, TRANSFORMERS, TEST EQUIPMENT, CABLE, CONNECTORS, HARDWARE, MODEMS, TELEPHONES, VARIACS, VDU'S, PRINTERS. POWER SUPPLIES, OPTICS, KEYBOARDS etc. etc. Give us a call for your spare part requirements. Stock changes almost daily.
Don't forget, ALL TYPES and QUANTITIES of electronic surplus purchased for CASH

CIRCLE 79 FOR FURTHER DETAILS.

Appointments

Advertisements accepted up to 12 noon November 6 for December issue

DISPLAYED APPOINTMENTS VACANT: £21 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £4.50 per line, minimum £30 (prepayable).
BOX NUMBERS: £10 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant. Sutton, Surrey SM2 4AS).
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15% VALUE ADDED TAX NOT INCLUDED
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Call us now for posts in Design, Test, Sales or Field Service, at all levels from £6,000 — £18,000.

Technomark
Engineering & Technical Recruitment
11 Westbourne Grove, London W2. Tel: 01-229 9239. (1935)

Trinity House Lighthouse Service, London
has a vacancy for a
Professional and Technology Officer Grade One
(Radio and Development)

Salary Commences at £12,345 p.a. rising to £14,775 p.a.

The successful applicant will occupy the post of Radio Engineer responsible to the Senior Radio and Development Engineer for all matters of radio engineering including all aspects of planning, procurement, installation and commissioning of radio navigation and communication systems on lighthouses, light vessels and service support vessels. Attendance at international meetings concerning radio navigation will be necessary.

A degree in radio and light current engineering or equivalent qualifications leading to Corporate Membership of the Institute of Electronic and Radio Engineers or the Institution of Electrical Engineers together with a knowledge of LF, VHF, UHF and microwave techniques is essential.

Application forms from the Personnel Manager, Trinity House, Tower Hill, London, EC3N 4DH, or telephone 01-480 6601 Ext 302. (81)

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2 AIRFIELD RADIO/RADAR TECHNICIANS

Commencing Salary £9458 (salary currently under review)
Post Pensionable - Shift Work
Closing date for applications 31st December 1985

Write or telphone
The Airport Director,
British Airports Int. Ltd.,
Southampton (Eastleigh) Airport,
Southampton, S09 1RH
Tel. (0703) 612341 (64)

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If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar fields:

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We have vacancies in all areas of the UK
Salaries to £15,000 pa

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(24 hours)

CAPITAL APPOINTMENTS LTD
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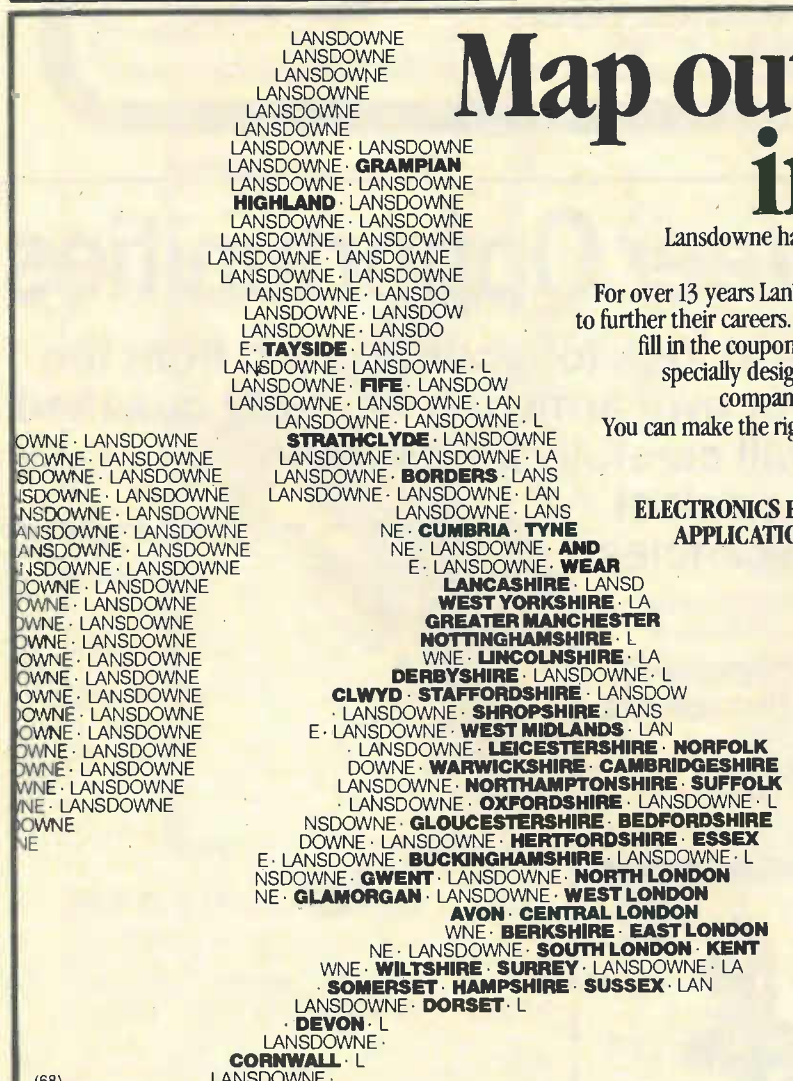

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(68)

NOTTINGHAM HEALTH AUTHORITY

ELECTRONICS TECHNICIAN
Medical Physics Department
General Hospital — Nottingham

A Medical Technician Grade III or Grade IV required to join the Electronics Service Section.

The prime function of the post is to assist with the servicing, maintenance development and calibration of medical equipment (including three Linear Accelerators). Participation in research and development activities occurs when time permits.

Candidates for the MPT IV Grade should have three years qualified experience in the electronics/electrical servicing field.

Appointees to the MPT IV Grade will receive comprehensive in-service training.

MINIMUM QUALIFICATIONS

B TEC. NC/HNC or equivalent in an appropriate scientific subject.

Salary
MPT IV £5404— £7104)
MPT III £6408 — £8283)under review

For further details contact Mr D Challoner Nottingham 476161 Ext. 641 or 337

Application forms and job description from: Personnel Department, General Hospital, Nottingham. Telephone Nottingham 476161 Ext. 310

Closing Date: 25.10.85 (78)

BRUNEL UNIVERSITY
TELEVISION SERVICE — AUDIO VISUAL CENTRE

Applications are invited for the post of TV STUDIO CONTROL ROOM TECHNICIAN (Grade 6)

The successful applicant would be required to take charge of video and audio operations in the TV Studio, as well as on location, and be responsible for videotape recordings, editing and transcription, and be able to set up colour cameras and broadcast/industrial type recorders.

Applicants should have suitable experience with studio as well as mobile ENG type video and audio equipment, and preferably qualifications to HNC or C & G Final Level.

Salary in the Grade 6 scale:
£7548 – £9015
PLUS £545 p.a. London Allowance.

Send self-addressed envelope for application form to: The Personnel Secretary, Brunel University, Uxbridge, Middlesex, UB8 3PH.

Closing date for receipt of applications: 31 October 1985.

Brunel University is an Equal Opportunity Employer. (72)

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USA training on ATE systems. Suit experienced repair technician.
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To maintain VAX PDP11 & flight simulation systems.
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Fault-find data-proocessing equipment to componant level. Some systems involvement.
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Mobile radiocommunications equipment.
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Phone/write/call Roger Howard C.Eng MIEE, Cliveden Technical Recruitment Consultants, 92 The Broadway, Bracknell, Berks RG12 1AR. Tel: Bracknell (0344) 489489 (six lines) (2598)

UNIVERSITY COLLEGE LONDON
Department of Phonetics & Linguistics
RESEARCH ASSISTANT — HEARING RESEARCH

PHYSICIST required to work in the field of electrocochlear stimulation in the totally deaf. An existing MRC-funded post in an established multi-disciplinary group with collaborating members in London (University College London and Guy's Hospital) and Cambridge (Laboratory of Experimental Psychology). The successful applicant will be based in London. Work involves speech signal processing, biocompatible materials, practical prosthesis design and work with individual patients. Preparation for a higher degree is possible.

Salary: (under review)
£6,600 — £10,720 + £1,297 LA.

Applications (no form) should be sent to: Professor A.J. Fourcin,
Dept. of Phonetics & Linguistics,
University College London,
4 Stephenson Way,
London NW1 2HE. (92)

"HIGH TECH" HOT LINE is 0494 3017

Mathematician	£18,000
V.L.S.I. CCT Design	£18,000
Operational Analyst	£18,000
Microwave Product Manager	£20,000
R.F. Design Eng's	£13,000
Quality Engineer	£16,000
Software Engineer	£15,000
Hardware Systems Eng	£14,000
Commercial Manager	
M.O.D.	£18,000
A.T.E. Programmer	£14,000
Design Draughts Person	£13,000
Mechanical Des Eng	£12,000
Systems Eng Sonar	£15,000
Systems Eng Telemetry	£15,000
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Production Eng's	£15,000
Tech Authors	£12,000
R.F. Component Design	£16,000
Electronic Projects Eng	£17,000
Graduate M.Sc.	£ NEG

To generate a fresh career opportunity call, 0494 30517 (Ansafone after hours) or write to Daton Recruitment Ltd., 23 Easton Street, High Wycombe, Bucks HP11 1NY. (74)

Senior Hardware Engineer

...to join an image analysis venture company

c £17,000

One of the UK's leading analytical instrument manufacturers is currently developing an advanced micro-processor based image analysis product developed initially by the Medical Research Council.

As part of the core team a Senior Hardware Engineer is required to undertake conceptual design in the field of electronic image analysis by high speed digital signal processing and related mini and micro computers. This will involve work on charge coupled devices, high speed analogue/digital and digital/analogue conversion and multi-processor computer systems.

Candidates must be graduates with at least two or three years experience of electromechanical/optical mechanisms. They should be able to develop designs to pre-production prototype stage and will preferably be able to assist with the move into batch manufacturing. Within this rapidly expanding team there will be an opportunity to gain an overview of the total system, interface with software engineers and operate with minimum supervision.

Salary is negotiable, around £17,000. The location is North Cheshire. Applicants should write with full c.v. quoting ref. AR/072, to: March Personnel Services, 33 King Street, Manchester M2 6AA.

(64)

MARCH
PERSONNEL SERVICES

UNIVERSITY OF OXFORD
DEPARTMENT OF ENGINEERING SCIENCE

Technician in Electronics (Grade 5)

Applications are invited for the above position in the Department's Electronics Workshop. The position involves the construction, repair and calibration of electronic and microprocessor based equipment. Applicants should have completed a suitable training, and have a minimum of a further 4 years of experience. Minimum qualifications required are ONC, TEC or equivalent. Salary (under review) on the University Technicians scale Grade 5 (£6581 to £7684 per annum). Further details may be obtained from the Administrator, Department of Engineering Science, University of Oxford, Parks Road, Oxford OX1 3PJ, to whom applications should be sent together with a Curriculum Vitae and names and addresses of two Referees.

(75)

HARINGEY HEALTH AUTHORITY
NORTH MIDDLESEX HOSPITAL

MEDICAL PHYSICS TECHNICIAN III/IV

To assist in the provision of an electronic maintenance service for Haringey Health Authority, including equipment maintenance for Intensive Care Unit.

Preference will be given to men and women with experience in electronic maintenance and design work but newly qualified applicants will be considered.

Qualifications: ONC/HNC or equivalent.

SALARY: Grade IV £6052-£7752 per annum inclusive of London Weighting
-Grade III £7056-£8931 per annum inclusive of London Weighting (entry to this grade requires three years relevant experience).

Further information from Mr D Bailey 01-807 3071 ext 678

Application forms and job descriptions available from the Personnel Department, North Middlesex Hospital, Sterling Way, Edmonton, N18 1QX, or telephone 807-3071 ext 571.

CLOSING DATE: 30 October, 1985.

(77)

Professional Video

Service Engineer

Your expertise, Our technology

As an individual within Professional Video you're aware that Sony's reputation for well designed, high quality, high performance products extends beyond the consumer market. Our range of professional video products which includes cameras, projectors, monitors and the market leading 'U-Matic' system is at the forefront of non-consumer video technology.

We hope in fact that you've already worked on such products in some capacity, because this is a role for an experienced Service Engineer, to carry out, on the bench, fault finding and repair work for our complete professional product range.

Such an opportunity within the small service team of a manufacturer and innovator such as Sony creates excellent potential to build on your sound technical experience in this field. Working very much on your own initiative, on the most up to date products with equally advanced test equipment, whilst receiving on-going training, will keep your expertise at the highest level.

Service Administrator

Combine your technical, admin and communication skills

Acting as the first point of contact between 'end-users', dealers and the Sony Service Team, this is a role which demands a range of abilities.

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(86)

SONY®

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(80)

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OLYMPUS

(54)

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(39)

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