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Broadening the stereo image

Compact Disc players

Modems surveyed

Receiving satellite broadcasts

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<th>Product</th>
<th>RRP</th>
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<td>Mono Display with Refresh</td>
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<td>High Res Color Graphics</td>
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<td>Automatic Time/Date with Batteries</td>
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<td>Video Drivers Including Software</td>
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<td>IEEE Controller for Apple II</td>
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Energy transfer
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Causality

Cybernetic Applications’ Naiden robot, whose description starts on page 46, is a desk-top micro robot designed to give experience in robotics, safety 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 van. 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 to form 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 and routing. The desk has four different configurations built into it that are 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 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.

Neve's digital signal processing (DSP) desk is the first of its kind 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.

We are wasting money, equipment and human talent under the present system," he says.

"Instead of dual use of equipment between schools and youth centres, there are micros in schools sitting idle for 20 to 30 usable hours a week. Instead of joint or voluntary statutory projects, there is little discussion 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 readdressed.

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 usable hours a week. Instead of joint or voluntary statutory projects, there is little discussion 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 readdressed."

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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 video-data systems, not unlike a form of teletext, interfere with normal reception of broadcasting. Early results from the IBA investigation have shown that those 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 in the Greater London area is endorsed by the BBC 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 service could provide information to specific interest groups on a subscription scheme.

Acorn: 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 been used by the BBC 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 incorporating this chip, Acorn says 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 is many instructions which are sub-divided into five groups. It operates at 3 million instructions per second and is used as a BBC second processor is said to perform at the standard benchmark mark three times as fast as the IBM PC-AT 16-bit technical computer. It is sold as an aid to an IBM code twice as fast as a VAX11/780 microcomputer.

Acorn takes a risc

Home-designed fault tracer wins prize

While welcoming the two-year community radio experience, the Communication Research 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 today concern the minimum of 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 100. It is hoped that a Rolling experiment will have over 200 members nationwide, yet areas as large as Scotland are virtually excluded". Ricky McCarthy director of Neve’s Afro-Caribbean 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 majority."

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

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 licence is estimated by BT to saving them up to 30 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.

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Friendly r.f.

The long-debated controversy about the possible non-thermal biological effects of non-ionizing electromagnetic radiation continues in the correspondence columns of The Lancet and in the depiction of local residents to the long e.i.f. antennas due to be erected in Scotland. Less attention, however, is being given to the development of electromagnetic energy for therapeutic purposes. This includes not only r.f.-induced hyperthermia which was sometimes eradicated malignant tumours but also the investigation of the possible success of r.f. energy for bone healing and experimentally for skin and nerve regeneration.

According to a recent survey by Robert Shapar and Ned Horshack of the Indiana University School of Medicine (IEEE Spectrum, June 1985) r.f. radiation for bone healing, using the technique of Food and Drug Administration (FDA) approval six years ago, is an area of medical research which has already been used by 6000 orthopedic surgeons to treat over 15,000 cases in the USA with a success rate close to 85%, although bone fractures treated previously had failed to heal over months or even years, often requiring repeated surgery. Altogether it is claimed that over 60,000 patients with bone fractures have been treated by r.f. radiation in the USA, many of them over a decade prior to FDA approval.

Two new products were introduced at one time is a train of positive pulses lasting 280μs followed by 28μs during the refractory period. Furthermore, it seems unlikely that any cardiac r.f. generators have been designed for use in a well-established hospital setting and in a dedicated operating room. The development of new r.f. generators has been hindered by the lack of adequate safety measures in most hospitals. The new r.f. generators are designed to be used in a non-invasive manner, such as for bone healing and procedure of bone repair.

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 that the effectiveness of this technique has been limited by the inability to focus the energy on the target tumour with minimal damage to normal tissues.

In the United States, r.f. heating of tumours has been used successfully to treat over 15,000 cases with a success rate close to 85%, although bone fractures treated previously had failed to heal over months or even years, often requiring repeated surgery. Altogether it is claimed that over 60,000 patients with bone fractures have been treated by r.f. radiation in the USA, many of them over a decade prior to FDA approval.

Two new products were introduced at one time is a train of positive pulses lasting 280μs followed by 28μs during the refractory period. Furthermore, it seems unlikely that any cardiac r.f. generators have been designed for use in a well-established hospital setting and in a dedicated operating room. The development of new r.f. generators has been hindered by the lack of adequate safety measures in most hospitals. The new r.f. generators are designed to be used in a non-invasive manner, such as for bone healing and procedure of bone repair.

Two-way video

The recent formal opening of the BT testbed public international video conferencing service with West Germany demonstrated the progress and the problems that still surround the age-old dream of the virtual office 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 of transmission is more than adequate, though processed pictures degrade considerably in the presence of fast motion. Broadcasters tend to think in terms of 3Mbit/s for high-definition satellite links for news or sports, and overcome the lack of being able to operate with component rather than composite waveforms.

Bringing pictures down to 2Mbit/s means in effect that the transmission capacity is reduced to about 30% of that used on telephone circuits compared with the 1000 or so required for good quality analogue pictures. For the videocassette links with North America the bit rate is brought down even further to 1.5Mbit/s and BTI have also used 960bit/s.

For West Germany the videocassette transmission charges are £600/month, a cost that is reasonably economic for large multinational businesses with factories in both countries requiring frequent telephone conferences.

The problem for the occasional user is the cost of the digital processing with a small BTI codec manufactured by GEC-McMann costing £41,500 (or £15,000 as a normal rental), significantly more than the colour monitor cabinet used for the telephone terminal (£29,500 six-shot, £23,700 three-shot).

Telecommunication companies, since the financial disaster of the Bell Labs in the USA, have been cautious of betting all their eggs on video conferencing. In Japan, however, where the telephone and the video telephone have been well received by the public, there is a consensus that the technology is a vital part of the future of the telecommunications industry.

In the more immediate future, however, the technical and financial issues remain, and the challenge is to develop a technology which will allow high-quality, cost-effective, and reliable video conferencing service. The potential of video conferencing is enormous, and the development of such a technology is eagerly awaited by many.
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Communications Commentary

28MHz opens Sunday, October 27 is the 50th birthday of 28MHz, the leading publication for the amateur radio community. This special issue marks the anniversary of the first issue of 28MHz, published on October 27, 1973. The editors welcome new subscribers and encourage existing readers to continue supporting the magazine.

If you would like to contribute an article or in the future, the editors encourage you to submit your work for consideration. Please visit the website for more information.

No-fault liability

As a result of Parliament recently amending the Abolition of Radio liability, the UK is committed to introducing tougher consumer Electronic & Wireless World November 1985

 transmitting authorities tend to present problems mainly to amateur radio events, but the advice given in the book should prove useful for all but the most advanced users. The book is available in the UK for 1.75 complete with battery. 

Tone-controlled power amplifiers have become a fast-growing market in the US.

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### Integrated Circuits

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### Video Spares

#### Video Heads

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#### Audio Tape Heads

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### ELECTRONICS & WIRELESS WORLD NOVEMBER 1985

CIRCLE 50 FOR FURTHER DETAILS.
From Submarine to Satellite

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 communications. Radio signals at normal m.f., h.f., v.h.f. 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 (GB) 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 five 40 baud teletypewriter channels on one carrier. Even at 14 kHz penetration of the sea water is not very deep. Extra low frequencies in the range 200 kHz to 30 kHz 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 the possibility of cable laying in Scotland to build an e.i.f.f. station. At e.i.f.f. antenna lengths are measured in miles: two e.i.f.f. installations currently being installed in Wisconsin and Michigan have antennas 28 and 56 miles long! For the Scottish e.i.f.f. station, the Admiralty is proposing to use a 12 mile-long antenna mounted on four metre poles. At 100 kHz 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.i.f.f. Global coverage can be achieved at e.i.f.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 latest version of a widespread h.f. warship communication system was shown at the exhibition, which offers a number of different h.f. drive transmitters to feed into a common wideband 'power bank'. The equipment, Marconi's LCS3, 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 systems. Marconi introduced a new h.f. receiver, the H5242, covering 15 kHz to 30 MHz 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 MFT range consists of an h.f. drive, and 10kW amplifiers, and the new receiver. The H5242 has a 1Hz read-out and can be used for c.w., a.m., s.s., l.s., and i.s.b.

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

Swordfish covers 30 to 40 MHz in the three ranges 30 to 40 MHz in the three ranges 30-88 MHz, 108-175 MHz and 220-400 MHz and has an output of 100W on f.m./s.s.b./ and 90W on a.m. Optional modems include continuous watch keeping facilities on the 121.5 and 243 MHz 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 the transmitter output at just 1MW away from the 100W carrier is 160dB down on the main carrier.

Skyfi's Rs800 v.l.f. multichannel receiver covers the range 10 to 200 kHz and is primarily designed for naval use. As part of a contract to upgrade the RN's v.l.f. facilities, Skyfi are also supplying new v.l.f. transmitter drive units, EWW 300
Powertran's "Hebob II" and "MicroGrasp" kits offer unrivalled value for money.

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Inside the November issue
O DATA SERVICING PROJECTS — VIDEO DEVELOPMENTS

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BEEB CUTS
A scene in the September issue of Wireless World on BBC plans to save money was interesting but not of much help to the amateur radio enthusiast. I understand that the bulk of the cuts are to be made in BBC

FEEDBACK

As a last point, I should mention that I built a WW project some three years ago — the Linsley-Hood design. A single-ended design, it certainly needs coupling capacitors and I used the usual inexpensive Matsushita electrolytics 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 copying manufacturers led me to the procurements of some top quality Sprague 6720 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 owner, and no, the inexpensive unit is not better. Nor is it even close. So here is a case where a difference exists even between electrolytics, as I seem to have expected would expect at a 30 to 1 price differential. If it is not a distortion difference of some kind, then what is it? Since the best capacitor is in second unit at all, I look forward to my next winter’s project, which is to build Mr. Linsley-Hood’s designs from January 1965. I’m sure I’ll expect the results to be more marvellous.

The first issue of Radio & Television News magazine was published in 1946. Over the years, the magazine has covered a wide range of topics related to television and radio technology, including circuit design, component selection, and troubleshooting. The magazine has also featured articles on the latest developments in the electronics industry, with a focus on television and video equipment.

The November issue of the magazine included articles on security modules, television servicing projects, video developments, and feedback from readers. The feedback section included comments on the Linsley-Hood head amplifier design and a request for more information on the BEEB cuts affecting BBC plans to save money.

Overall, the magazine provided valuable information for enthusiasts and professionals in the electronics industry, covering both theoretical and practical aspects of television and radio technology.
FEEDBACK

WIRELESS?

Mr John Beud (Letters, 7 April) asks how the law prevents the circulation of wireless transmitters of spectrum bands. The answer is that the law is much more complex than the question suggests. The law in question is the Communications Act 1993, which regulates the provision of telecommunications services. The law requires that anyone wishing to provide telecommunications services must hold a licence from the Office of Communications (Ofcom). The licence holder must ensure that the services they provide do not interfere with other telecommunications services.

It is not a straightforward matter to determine whether a particular service is providing a telecommunications service. The law defines a telecommunications service as one that provides for the exchange of information between two or more points. This definition covers a wide range of services, including voice, data, and internet services.

In the case of wireless services, the law requires that the licence holder must ensure that the service is provided in a way that is compatible with other telecommunications services. This means that the licence holder must take steps to ensure that the service does not cause interference with other services.

In conclusion, the law prevents the circulation of wireless transmitters by requiring that anyone wishing to provide telecommunications services must hold a licence from the Office of Communications. The licence holder must ensure that the services they provide do not interfere with other telecommunications services.

RELATIVE AND ABSOLUTE

I have been greatly saddened by the recent developments in wireless technology. The proliferation of wireless devices has led to a significant increase in the amount of interference to our wireless systems. As a result, we have found it necessary to increase the level of protection that we provide to our wireless systems.

We have developed a new software algorithm that allows us to filter out interfering signals. This algorithm is based on a combination of advanced signal processing techniques and machine learning algorithms. As a result, we are able to provide a high level of protection to our wireless systems.

In conclusion, the recent developments in wireless technology have led to an increase in the amount of interference to our wireless systems. However, we have developed a new software algorithm that allows us to filter out interfering signals. This algorithm is based on a combination of advanced signal processing techniques and machine learning algorithms. As a result, we are able to provide a high level of protection to our wireless systems.
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 "nucleus" atom of Ernest Rutherford in 1904, according to which all atoms were composed 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 Niels 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 hypothesies 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, mesons, 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 particles with such peculiar properties, however well performed, it would have been rejected as absurd, and physicists would have sought a better answer. More recently, dissatisfied physicists had 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 Hove

One notes how many contributors to Mr. Catt's esquires into the existence, or otherwise, of electric 'current', have been folk steeped in lineal conduction knowledge. And who as such have been able to clearly distinguish between R for aspect of practical transmission system. The question which has been lodged in the writer's mind, even if Mr. Catt's views, is "what is the behaviour of a long line subject when such conditions superimposed upon itself?" The answer coming from the source of "apPLIED M.E." is neither 'R' or 'R-C'. One imagines the velocity of light (even if the source is at an expanded space by radiation 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 observing 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 slow, and that those that are "stationary" or moving at constant velocity in space, are in fact, waiting for a less-srawly view.

Exactly the same results that you would obtain using temporal perspective. The Doppler-Fizeau effect is a common sense to calculate the "apparent", and "non relativistic" time shift on moving objects. E. S. I. Leeward Middlesex

CAUSALITY

Although somewhat belated (February 1985 issue of EWF) 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 circuit. The popular view of Hume-Ayer etc. is that there is no such a link between events that a constant conjunction of such discrete events can be 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 causal 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 in i.e. e.m.f., Photon-electron motion. And this is where the reply of D 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 even more so on the logic of ordinary language. And here is where that school makes its greatest error in scientific law. It assumes with Aristotle and Plato 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 expected, nature follows and laws of mathematics and not the sterile tautologies of philosophy. In the language of mathematics as applied to natural one finds that necessity not found in mere tautologies, and which binds events into a set of necessary relations. It is only when the philosophers of tautologies go to work on the notion of natural necessity with their a priori logical model that nature falls into an instant constant conjunction of events, on the one hand, and a series of events tautologically on the other hand. This is the fatal divorce that makes so much of modern philosophy of science into an empty scepticism or a hollow relativism of language systems. G. Gindoes

Letters

Letters for publication are always welcome, but the editors reserve the right to accept or reject any letter. I try not to edit original letters, but sometimes they are far too long, therefore cut them to the writers' specs. Please keep your letters short.

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ELECTRONICS & WIRELESS WORLD November 1985
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 Radiocommunications Conference (WARC) of 1977,forty channels are assigned to the 800MHz-wide band extending from 1.17 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 the number of channels in the 800MHz band could be increased if all four channels in a country were used. These possible increases in the 800MHz band might be desirable because rejection of transmissions intended for other areas might be required.

The satellite occupies a number of positions in the equatorial plane and the transmitters intended for any one country all come from a satellite at one position. As the Earth rotates, 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 parabolic satellite. The Table shows elevation and azimuth angles for 0°W and 51.5°W (roughly corresponding to London). The UK satellite position is 31.7°W giving an elevation of 24.3°. For locations farther north this reduces, and a typical figure for Northern England is 21°. The antenna does not have to be on the roof as is often assumed. Despite this it will be possible to mount it on a south-facing wall in many cases, provided that the diameter does not exceed the 0.5 metre maximum envisaged for domestic use.

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 this would seriously affect the performance: the concentration would have to be maintained at 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 extension, this is about 10dB for a satisfactory standard of performance. To allow for impairment due to errors, and atmospheric conditions, it is 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.

The bowser of the antenna must point directly towards the satellite and a line of sight to it must be maintained. Because this 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 parabolic satellite. The Table shows elevation and azimuth angles for 0°W and 51.5°W (roughly corresponding to London). The UK satellite position is 31.7°W giving an elevation of 24.3°. For locations farther north this reduces, and a typical figure for Northern England is 21°. The antenna does not have to be on the roof as is often assumed. Despite this it will be possible to mount it on a south-facing wall in many cases, provided that the diameter does not exceed the 0.5 metre maximum envisaged for domestic use.

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\[ T = T_a + f \cdot (17) \]

where \( T_a \) is the antenna temperature, \( F \) is the noise figure and \( T \) is the dipole's temperature (290K). A practical antenna temperature is assumed, and a typical noise figure is 4dB or 2.5 times, giving a T value of 595K. Translating this and the other units into decibels relative to the units concerned gives:

\[ 7.27B + \text{Bolzmann's const} \approx 228 \text{dB} \]

\[ 27 \text{MHz bandwidth} \approx 64.3 \text{dB} \]

\[ 126.6 \text{dB} \]

Signal power

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

\[ \text{Power flux density} = 103\text{dBW/m}^2 \times 0.38 \text{m}^2 = 41.4\text{dBW} \]

\[ \text{efficiency} = -3 \text{dB} \]

\[ \text{errors} = -2 \text{dB} \]

\[ \text{signal} = -112\text{dBW} \]

This is 0.5dB greater than the figure calculated above, but as the discussion by the carrier-to-noise ratio far greater is being done by the Electronics & Wireless World November 1985

Table 1. Reception angles at longitude 0°, latitude 51.5°W. For no other noteworthy locations the angles will be lower.

<table>
<thead>
<tr>
<th>Position</th>
<th>Elevation</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>37°W</td>
<td>21.8°</td>
<td>43.9°</td>
</tr>
<tr>
<td>37.5°</td>
<td>24.3°</td>
<td>-10.3°</td>
</tr>
<tr>
<td>27.0°</td>
<td>28.5°</td>
<td>30.1°</td>
</tr>
<tr>
<td>22.0°</td>
<td>31.3°</td>
<td>12.7°</td>
</tr>
</tbody>
</table>

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 feasible to design an automatic tuning aid to cope with this variation without undue expenses, so that the price will not be excessive. However, if it is felt that some kind of indication will be helpful as a tuning aid for antenna alignment, a.a.c. may almost certainly be a necessity. Remember that the down converter will be subjected to wide variations in frequencies in the region concerned, 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 drawn that no more than 100kHz of any part of the spectrum is assigned to any particular area which is separated by an even multiple of the channel spacing of 19.1MHz. The condition mentioned above can therefore be achieved by choosing a second f.i.f. which corresponds to an odd multiple and the solution to the problem is to be diagrammed by the band channels or spacing or 134.25MHz.

When the carrier frequency is 27MHz, the band covered will extend from 120.76 to 127MHz. There is a variety of interference due to direct broadcast at second i.f. from terrestrial services, including the 2-metre amateur band. For this reason, it will be necessary to screen the indoor unit and to provide an efficient high-pass filter at the input.

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Compact disc players 2

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

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, exhibit a certain amount of error 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 the other current bits plus one at least significant bit to an accuracy of rather better than one I.s.b. In this simple four-bit example, the necessary m.s.b. accuracy is better than one in 16 (2^4), but for a 16-bit system this becomes one part in 65,536 or about 0.004%. 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 clocking, 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 must be 2^16 times the sampling rate, which for CD this would be 2.96 GHz! Clearly some refinement, if necessary, are necessary to allow these converters 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. This generates a ratio of 1:1.25 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 1.5 s-word length, 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 2^4 times the sampling rate, or about 11.2 MHz. As the output is a ramp, the clock must run faster than this to leave time during the sample period for the analogue vol
DIGITAL AUDIO

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) have 50% duty cycle, resulting in two current shares going to right hand output. Division is thus into 1:12:1

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 monotonous, and the capacitor must have low dielectric leakage to prevent non-linearity. It is only the ratio of current 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 operates at twice the sampling rate of CD. In the CDP-101, it is driven at a clock rate of 45MHz, and alternately converts two pairs of opposite channels. This results in a saving of components and a time displacement between channels of 125ns (44100) = 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 a nice place to 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 analog addition; this results in h.f., roll-off. With this exception, other factors have a much larger bearing on subjective sound quality than the use of multiplexed d.c.a.s.

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 impulse spectrum (sampling frequency and harmonics) with a baseband audio spectrum. Although the sidebands above 20kHz are inaudible, the slightest non-linearity in subsequent stages would result in modulation distortion, to say nothing of possible distortion 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 sinc x wave shape, and if the filter response 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.

The reconstruction process only operates 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 sinc x sine 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 method simply passes the peak voltage of the delay after the current source has 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.

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.

Oversampling 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 between are 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 arbitrary close to the theoretically perfect. The continuous analog signal is the sum of sinc x waves due to each of several adjacent samples, as Fig. 5 shows. Because a sinc 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 x2 oversampling system. The impulses immediately left and right are multiplied by 0.64 and those next nearest away are multiplied by -0.21, and so on, and the products added to obtain the intermediate impulse response.

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 a shift register gives rise to the term 'transversal filter', also known as a finite impulse response filter.

The process can be extended for x4 oversampling, Fig. 8 (c). 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.

The way the output sample rate will become four times the input rate. Following multiplication in the filter, the sample word length will have increased greatly beyond 16 bits, and will be rounded off in some way. The required word length 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 20 possibilities, so the information rate is 16F. The same information rate is obtained in (b), where half as much information is transmitted twice as often. As each code now only needs one 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 of 15-bit data, and oversampling by a factor of 4 wayout input sample rate will become four times the input rate. Following multiplication in the filter, the sample word length will have increased greatly beyond 16 bits, and will be rounded off in some way. The required word length is not immediately obvious.

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(c) Transferring this result to the CD system, oversampling by two allows the use of 15-bit data, and oversampling by a factor of 4
allows the use of 14-bit data, provided that the reduction in wordlength done in an optimum fashion. This is not implied 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 0.02 dB higher. Simple truncation, then, will not allow us to obtain the results predicted by information theory.

The roundoff 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 fraction is in fact the reciprocal of the oversampling factor. For example, 4X 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 = 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 4X oversampling system where two bits are to be lost. With a steady input, the system will produce 0110011... If this one-bit signal is filtered, it will result in a dc level equal to the duty cycle of 1, 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 takes advantage of the aperture effect by using zero-order hold on the d.a.c. which oversamples at X4. 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 above 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 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 Discs are described in the next part of this series.

References
The hidden message in Maxwell's equations

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

by Ivor Catt

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, and this led him to reassert Faraday's idea of the propagation of transverse [electric] magnetic [waves]. So the concept of electric charge and electric current preceded the concept of a transverse electromagnetic wave, and it is generally agreed (but not universally) that the t.e.m. wave follows from the prior postulation of electric charge and current.

A strong case can be made for the view that the t.e.m. is a far more fundamental Primitive, or starting point, for electromagnetics, than electric charge and electric current.

When light and heat reach us from the sun, it is by the mechanism of a t.e.m. wave, not electric charge and current.

Kip" says that the energy dissipated in a resistor entered sideways, and was transported into the resistor by the t.e.m. wave.

In 1898 J.A. Fleming" wrote that "although we are accustomed to speak of the current as flowing in the wire. . . . (b) is the term electric extinction current 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.e.m. wave, not the electric current, must be the mechanism by which energy is transferred. The last two arguments are even more powerful and fundamental.

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

$$\delta = \frac{\partial w}{\partial t}$$

Again from first principles, we can write

$$\frac{\partial w}{\partial t} = \frac{\partial v}{\partial t}$$

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

$$\frac{\partial w}{\partial t} = \frac{\partial v}{\partial t}$$

Equations 2 and 4 define as Catt's Equations of Motion for a wooden plank.

Consider a plank of wood taping 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 y velocity which relates the change of height with forward distance to the change of height at a point with time. From first principles, we can write

$$\frac{\delta h}{\delta x} = \frac{\partial w}{\partial t}$$

(Cf. refs. 7 & 8).

We postulate that the thickness T is proportional to the density of the wood ρ, so that

$$T = \frac{\rho}{\rho}$$

(To picture this, think of spontaneous combustion.

Catt's equations 2 and 4 now become

$$(\delta \delta) - \frac{\partial w}{\partial t}$$

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 vast equations of Maxwell's Equations for a vacuum.

$$\frac{\partial E}{\partial x} = \frac{\partial H}{\partial t}$$

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 textbooks (ref. 2):

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

Our problem is that whereas the equations for planks have con...
Historical background reading

What did Maxwell do? What did he say that he did? Today, what do the electro-dynamic scientists believe that he did? Did Maxwell postulate the "Extra Current", now called Displacement Current, to resolve an anomaly which arose from the condenser in a closed circuit? Or did he later falsely claim it as his own? Or does it merely the false shadow of history given in the textbooks? It is possible to argue that for his purpose of the contemporary body scientific and its associated with historical detail — creates a new relationship between the ‘historic facts’ and the truth.

Generally, I attempt to bypass these niceties, in order to create an unclouded discussion of the technical flaws in today's science. By contrast, historians, lacking proficiency in electromagnetism, are unaware that this situation is sound, and the only problem is that there are errors in the text, and we are led to question how we reached it.

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Polyphonic keyboard

part 3

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

Software for the 8086 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 2byte cache ram for hardware memory 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 8086 memory map known as voxcons. These voxcons are stored in a 2Kbyte 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.

Port 1 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 are initiated 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 8086 is given a power-on reset which causes it to start execution at address FFFF0, which is in the eprom.

First it initializes variables in its own memory map and then sends the table of squares to the I wild 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:

On button press:

- scan keyboard, turning on or off notes that have changed since the last scan.
- send values to the d-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 80' 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 (negatives) of the DIN socket using a 1mA 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. The pin is only earthed at the transmitting end. The connector chassis is not connected and pins one and three are unused.

Data is transmitted serially at 31,250 baud. The least significant byte of the five-bit word is transmitted 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 set to one. In the second byte of the word, this bit of the command byte is a channel number, n. Subsequent bytes are parameter bytes and have values between zero and 127.

The bus is logically divided into sixteen channels, referred to as one to sixteen, but the course of 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 Midi is no exception.

Several different channel numbers allow 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 kkk is zero to lowest C3 for top C. If a number greater than 3C (60 decimal) is received then the instrument keyboard was 16 shifted so that the keyboard were continued to the right, provided that the key was still within the instrument's pitch range. The actual highest value will depend on how the keyboard is currently transposed.

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

Midi output

If transmit-out 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, 9k, 9v) which notifies any device on channel n that key k has just been pressed on the keyboard, (5k kkk) which notifies any device on the channel that key k has just been released, (5n 0v 0v) used to adjust sound-generating parameters of other instruments and (9 0 014) 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 8086 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 bi-mapped image of general-purpose buttons 1-6. | BUT2, port 7, is a bi-mapped image of buttons 7-16. All these buttons are push-to-make and produce a zero when pressed. | CONTACD, this bit allows analogue-to-digital conversion under software control so that the Midi bus can read the knob position.

BUT 2 is zero if the sustain foot switch was depressed.

BUT 1 is one if the clavier key index is above the value last written to CONTACD is currently held down.

INFULTE, 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 saw waveform for tremolo and vibrato and can be varied from about 0.2 to 10Hz.

CODE 010, tremolo depth, varies the amplitude of the track oscillator with the multipurpose of the main audio d-a converter. This changes the amount of tremolo in the sound by amplitude modulation.

CODE 011, fine pitch, varies the intensity of the track oscillator with the multipurpose of the main audio d-a converter. This changes the amount of tremolo in the sound by amplitude modulation. |
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 \( v \). Value \( v \) 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 (8n kk 40), note on command, which plays a Digipoly note exactly as if a key was pressed, (8n kk 40) which has the same effect as releasing key kk on the keyboard, (Cn Op 00) for selecting a present voice in the range 0-15, (Dn 78 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 notes that can be played simultaneously. The command for selecting a preset voice has the same effect as using the pull button on Digipoly's front panel and the turn-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 LLI 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 Gravetye Way, Chalgrove, Oxford, OX4 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 LLI processor code are £5.50 and £4 respectively. Please include £1 for UK postage and make cheques payable to J. Groves. Brave readers can obtain a copy of the hexadecimal listing by sending a large stamped addressed envelope and a cheque for £1.30 to our editorial offices. Please make the cheque payable to Business Press International.

Digipoly's main board. The LLI processor is in the upper left area. Microcode prom, op-code latch, op-code decoder, 100nS register memory and the two a.lus are in the top row of LLI. Analogue circuits to the lower right include the output low-pass filter, vibrato and tremolo (note the glass-encapsulated thermistor) sections and the d-a converter influence sample and hold circuits. To the right is a small perpenderal 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.
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.

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.

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

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.

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 3 to give larger radius. Dimension 2 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.

The working envelope is usually a partial cylinder as in Fig. 5, where the cylinder has been replaced by a rectangular block. This is a more practical solution for a central column taller than the movement required. When moving large loads there would be a big lifting 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 capacity of more than about 20% above horizontal level. Their main application is the relocation of very heavy components such as engine castings and sacks of cement.

Figure 3. A robot having its two rotary axes and one linear axis the working envelope of a turret robot is that of a partial spherical block. 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 joined 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 gamma to the waist. The versatility, however, results in a complicated relationship between axis angles and world coordinates, and it is often 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 correct location. Data concerning to these axis coordinates which resolved to this final position are then stored.

The leading-through of the arm may be accomplished in a number of ways such as by switches on a control panel, computer keyboard, or by manipulation of a model of the robot, called a simulator. This last technique is partic-
lead to tilting of the component leading to jamming. Like many robots, scars operate mostly on the horizontal axis 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 work 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.

Fig. 5. Articulated joints of this robot mean it ‘reaches the parts other robots cannot reach’, making it suitable for many varied applications from automatic 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.

Fig. 6. Pantograph coupling on an articulated arm ensures that the component is always perpendicular to the work station when the shoulder axis is moved.

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 workspace in the gripper orientated in the same direction irrespective of positions of theta 1 and theta 2.

Fig. 8. Diaphragm is clamped between two parts of cylinder and attached to the piston forming totally leakproof yet fully moveable chamber (a). When chamber pressure increases very low friction, and robot arm operated by this actuator have very smooth movement particularly important when small movements are called for.

The lack of static friction allows very small and slow (slow) motor without judder driving, making very accurate servo control practical. An additional benefit of the rolling diaphragm is that it fully seals in 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 capacity is needed, the control system (including the axes via electric motors) is adequate.

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

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 robot on which the rapid changes of position and loading can cause steps to be missed. Steps are missed when the motor shaft stops during the static loading prevents the motor shaft from reaching one stable position quickly. If the load on the output increases in the chamber, piston is pushed along the cylinder and diaphragm rolls along between the piston and cylinder wall. As well as being leakproof this system offers very low friction, androbot arm operated by this actuator have very smooth movement particularly important when small movements are called for.

To be continued
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 tool or as the processor board of a larger system, connecting to a wide range of ready available peripheral cards through its 646 bus. This second article describes the circuit.

Address decoding is performed by a three-to-eight-line decoder, $K_0$ of Fig.1.(lower). The three most significant address lines $A_{17-15}$ are decoded, splitting the 16Mbyte memory map into eight 2Mbyte blocks. Four outputs select eprom, ram, 68681 dual universal asynchronous receiver/transmitter (dual), 68230 peripheral interface (p.i.t.) and the G64 bus.

None of these five devices actually requires a 2Mbyte address space, the dual outputs only need 32 bytes. As a result, each device is repeatedly addressed throughout the 2Mbyte block — addressing for the dual is repeated 65536 times! This may seem a waste of addressing space but for a small system such as Kaycomp it adds adequate memory capacity while greatly simplifying address decoding. Figure 2 above shows the memory map.

Eeprom and ram outputs are further gated with the upper and lower byte eeprom and ram. The three enable outputs of $K_0$ also qualify the output strobes.

Address strobe $AS$ allows an output signal whenever a valid address appears on the address bus. To ensure that the outputs are only selected when the data bus carries valid data, the two data strobes are combined in $K_0$, as shown.

Valid data is indicated by one or both of the timing requirements being low, which occurs later in the cycle than AS. This is to satisfy timing requirements of the G6230 P.L.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, $K_0$ pin six inhibits output pulses during an interrupt acknowledge cycle during which the processor sets $A_{15-12}$ high. Without the inhibit signal, in the case of user- vectored interrupts output seven would be selected to cause reading of the 646 bus at the same time as the interrupting device placing its vector on the data bus.

Data acknowledge

To satisfy the requirements of asynchronous bus transfers, an acknowledge signal — ITACK must be sent by the memory or peripheral to the processor to indicate 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 input. DTACK input along with a pull-up resistor. Eeproms 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 currents 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.

Chip enable (CE) of 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.

Eeprom and ram select outputs of $K_0$ are combined in $K_0$, at pin eight and then inverted by the open-collector inverter $K_0$ at pin eight, pulling DTACK low if either select output goes low.

Outputs one, three and six of $K_0$ are not used. If the processor tries to access a vacant part of the memory map no ITACK signal will be generated and so the processor will insert wait states indefinitely. Resetting is necessary to recover the situation.

One output from $K_0$, 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.

Output pin seven of $K_0$, going low pulls the 68000 VPA input low through $K_0$, pin eight.

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 08000 peripheral Line 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 outputs are memories in the processor read/ write strobe connected with the address strobe.

G64 bus interface

Circuits IC118 to buffer on-board signals to the G64 bus, which can be a wide range of peripheral cards. The G64 bus specification maps a valid memory address to memory map (10MB) to be dedicated to peripheral cards, thus reducing the complexity of the memory map being available for memory. Where a bus interface is accessed by a particular card, it is indicated by either "valid memory address" or "valid peripheral address" being asserted low. These names are not to be confused with the 6800’s 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 memory block is only 10KB large so only address lines A2 to A6 are needed. Once again the lack of an A7 line means that the G64 address lines are driven by the next higher 68000 address line and the provision to become 2KByte in size.

Although G64 has 16 data bits, any peripheral card can use eight bits and so IC6 buffers just D0 to D7, to the external bus. The remaining D8 to D15, are in a 2KB memory block. These are not connected to the processor to use them as external address lines and are not connected to the next higher 68000 address line. So the provisions to become 2KB in size.

Although G64 has 16 data bits, any peripheral card can use eight bits and so IC6 buffers just D0 to D7, to the external bus. The remaining D8 to D15, are in a 2KB memory block. These are not connected to the processor to use them as external address lines and are not connected to the next higher 68000 address line. So the provisions to become 2KB in size.

The direction of transfer through IC6 is controlled by the read/write line and the buffers are transparent. As there is a unique bus which is also used as the G64-VPA signal after buffering by IC6.

Signal VMA’ is derived by logic associated with the processor during read/ write cycles. The read/write outputs are memories in the processor which accesses the G64 bus. IC6 pin 5 goes low when IC6 IC118 input pin 10 low, the output of which takes VPA low, initiating a synchronous bus transfer.

During this synchronous cycle, the processor takes VPA low for use as the G64-VPA signal for the selecting relevant G64-bus peripheral devices. As IC6 is VMA is qualified by IC6’ outputs 6 to 15, IC6 is drivers VMA if IC6 is high, it is not an interrupt acknowledge cycle.

The level of VMA is declared "auto- vectored" interrupt acknowledge cycle also asserts VMA. The read/ write outputs of the bus signals will become clear later when the interrupt handling is discussed.

As mentioned last month, there are two types of interrupt processing 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 and IFL, are connected to G64 bus NMI and IRQ lines. The third, IPL is common to both the interrupt output and may be optionally connected to the two interrupt outputs of the MPU.

When the processor recognizes an interrupt on one of the IRQ lines, it asserts the interrupt acknowledge bus cycle. A function code of all copy axes appears on the FC6 outputs which causes pin six IC6, to go high. This signal is inverted by open collector buffer IC6 pin 2 to a low level. The lower half of the IC6 output is low so it can assert VPA low. The same occurs when forcing a synchronous bus cycle.

If VPA is taken low during an interrupt acknowledge cycle, the processor does not mean a request for an auto-vectored interrupt and not a non- synchronous bus cycle. It is responsible by taking VMA low, which is only done by IC6 asserting VMA and VPA serving dual purposes. Thus an interrupt’ IC6, is vectorable, or, an interrupt, (no IC6) generates an auto-vectored interrupt.

The bus signal C65 to which the processor IC6 pin 15 is connected, is driven to the CPU external bus as the interrupt acknowledge logic output. Interrupt request output IRR is taken to the processor IC6 input, thus the bus can generate a level two vectored interrupt.

According to manufacturer specifications the dual internal data rate generator requires an external processor to be driven to the CPU external bus as the interrupt acknowledge logic output. Interrupt request output IRR is taken to the processor IC6 input, thus the bus can generate a level two vectored interrupt.

It is possible that during write cycles, the external processor IC6 pin 7 goes high when the 68000’s clock is used to time synchronous bus transfers, read/write and reset.

Half/Reset

A full processor reset is applied to the system when both halt pins are taken low, either at power-up or when error occurs. The processor pins VMA and reset pins are shorted. At power-up or after opening the reset contacts, the level at IC6 pin 5 rises very slowly due to charging of C65 through two series resistors RH and reset pins become active. As C65 charges, RH holds the reset and input pins low as voltages across C65, IC6 outputs 6 to 15, a high level, triggers latch gate here ensuring clean switching.

Half 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-pull switch if required. If "Kaycomp" is not mounted in a case, a p.s. covers the area together provides a crude but effective switch.

The 68681 is a dual asynchronous receiver/transmitter which can drive two independent serial ports, a data rate oscillator and a number of general purpose I/O pins. The oscillator is a time base, a clock, and the A/D converter.

The serial port includes two characters at pin 32 may also be used to drive the processor clock if processing speed is limited. The clock for IC6 pin 3 or IC6 pin 4 can be supplied, and C65, R6 and C68 are omitted and a word clock used to connect IC6 pin 32 to the processor. The connections for IC6 does not have to be at an I/O version.

On the peripheral side of the IC there are two each of serial outputs and inputs plus six general purpose t.i.l. and six general purpose t.i.l.

The inputs, IFP, may be used as RS232/C (clear to send) inputs and two of the outputs, OPF, as RS232 (ready to send) output. The serial interface is buffered by an RS232 line driver IC6, and line codes are optionally selectable.

There is one problem with using IC6. It is not the serial port on both terminal and modern manufacturer see to have its own interpretation of the standard and one continued on page 64

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For further information on the CA 7000 Series Controller contact.

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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 on the system and initiated on reset of the microprocessor. A complete list of internal 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 sequence 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**
- **PROCESS KEY INPUT IF ANY**
- **UPDATE TIMING REGISTERS AND PERIODICAL 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 they are no longer required.

If a scan is to be performed then a display 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 'editor' 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 simulated 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, those may be corrected using the editor before the final program is installed. Light time 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 'alarm' (alarm number condition) contains zero if no alarm has been requested, a positive number when the light only mode is required and a negative number if there is no one in the house. If an alarm condition is detected in mode 3, the routine 'alarc', which is responsible for sounding the alarm when there is no person in the house. If an alarm condition is detected in mode 3, the routine 'alarc', which is responsible for sounding the alarm when the premises are empty. 'Alarc' starts with a delay and then operates 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 a few seconds before retesting in mode 3.

For tests simulate and silent entry are also made in mode 3. If the location 'simul' is not zero then the routine 'simul' is required. 'Simul' performs one operation in this case: when 'simul' (simulate timer) reaches the next value held in the data table 'simul', the inside lights are turned on and the outside lights are turned off. The table of data is turned on at zero-page hex 80 page and continues to page one if this simplifies the required. The last item of data in 'simul' must be so that the routine is cancelled and the next switch is made.

Data is used in blocks of 3 bytes as follows:

- Byte 1 When to turn on the next light. This byte is compared with simul + 1 which is a timer that starts at 00 and counts 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 byte number representing the length of time that the light is to remain on. This number is incremented to zero at FF hex and is a short time (about 6 min.) and 70 hex is over 1 hour etc. Numbers to 01 hex may be used. Lights are turned off by another part of the program.

When 'simul' equals byte 1 then the 3 bytes are read and execute the routine.

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

When the alarm is set in mode 2, mute outside bedroom doors are tested first, if any are found to be open, the routine 'alarc' (alarm number condition) contains zero if no alarm has been requested, a positive number if the door is open, and a negative number if there is no one in the house. If an alarm condition is detected in mode 3, the routine 'alarc', which is responsible for sounding the alarm when the premises are empty. 'Alarc' starts with a delay and then operates 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 proce-
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 tabs are used for the 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-off section is performed which turns on each light and sets its time 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 commands as contained in the register 'key' and key will be executed for values 1-5, but not if '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 user literature. Key is called the 'override' (override light) subroutine, which is responsible for turning on any light at keyboard request. "Override" uses the 'wait' subroutine 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 'override' may be edited through a register 'w基本' (timer constant for light extensions).

The last routine in the main loop is the time update section, which increments program timers until they become zero. Timers are not incremented each time round the loop. The incrementing takes place when a register 'timeis' becomes zero. Register 'timeis', 2, 3, and 4 are used to set the main timing of the program, and in turn are set by zero page constants 'main1' 'main2' and 'main3'. This can be edited if corrections are to be made. Time is 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 give an approximate duration of 255 X 6 minutes, 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 and may be used for long delays. 'Wait' is 12800 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 years, 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 'off', to allow this option. It would simply be necessary to keep a record of the calling contact and time between calls to recognize the faulty position. This code could be masked from the alarm routines.

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 'slack' if required.

The low-cost control hardware should make units that are more sophisticated than this available to a large number of householders at a realistic, 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. Also any type of control 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 the 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 is 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 overwriting 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 mains was not 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 designed itself is noise-free. Averaging input signals has proved to be an effective way to eliminate most noise from peripherals, which may be particularly evident if screened cable is not used.

Finally, making a low-voltage control connection 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 infra events such as decorating, burst pipes etc. More expensive options for mains connection must be considered, but the method described should prove cost effective providing mains isolation is assured.

Software

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

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CIRCLE 54 FOR FURTHER DETAILS.
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.

An ideal sound reproduction system is one which is capable of reconstructing the waveform 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 closely located listener mainly at low frequencies, depending on the geometrical displacement of the speakers relative to the listener.

It has been observed previously that images tend to broaden as they are displaced along the stage width. The reproduction of correctly reproducing images has led to the development of many theories of localization and several ways of improving stereophony have been proposed. 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 towards generating well-defined stereophonic images.

What causes image broadening?

The answer to this question can be found by considering stereophony as a waveform reconstructor and examining the extent to which the fundamentals of sound reproduction practice are observed. The plane-wave component of the waveform reconstituted by two spatially located sources around a listener's head provides the fundamental direction information of the apparent source producing that field. Other components of this reconstituted 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 waveform from the reconstituted 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 waveform reconstituted by two speakers in Fig.1 along the x-axis can be expressed as

\[ F(x) = \text{real} [X_1(x) + X_2(x)] \]

where \( X_1(x) \) and \( X_2(x) \) are the amplitudes of the right and left channels respectively and \( k = 2\pi /\lambda \). Ignoring the complex multiplicative term, as it carries no directional information, leaves

\[ F(x) = 2\text{real}(\sin(kx)) + (R - L) \]

with \( R \) and \( L \) representing the plane-wave components.

The phase \( \phi(x) \) of the waveform is of interest because it is this which determines image direction.

The waveform \( F(x) \) 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 waveform \( F(x) \) into its spatial components. For simplicity, consider the case of equally driven speakers, that is \( R = L \). Under this condition equation 1 simplifies to

\[ F(x) = 2\text{real}(\sin(kx)) \]

To decompose \( F(x) \) into its harmonic components, \( F(x) \) can be defined as a repetitive function

\[ F(x) = X_1(x) + X_2(x) \]

so that the Fourier series expansion can be applied, where \( X_1(x) \) and \( X_2(x) \) are the

function with period \( 2\pi /\lambda \) equal to the head width. Under this condition the head will still sense only \( F(x) \) alone because of the band-limited nature of the process.

For \( X_1(x) \) and \( X_2(x) \), the series expansion of \( F(x) \) is

\[ X_m = \frac{2}{\pi} \sin(m\phi) \]

where \( m = 1, 2, 3, \ldots \)

The use of equation 3, to determine \( A \), 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 waveform \( F(x) \) over a region of \( X_1(x) \) and \( X_2(x) \). No assumption need be made in generating \( F(x) \). By least-squares methods the best-fit phase slope is fitted into the phase of the waveform \( F(x) \). The average of the amplitude of the generated waveform 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. That r.m.s. of the residual signal divided by 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 width of 1.4m 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. The image position is expressed as an linear displacement off-centre divided by the stage width. (The velocity of sound has assumed to be 343m/s).

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 \( f = 2500Hz \) 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 from stage centre.

In this agreement with equation 3 which suggests that

\[ \text{image width factor} \approx \frac{2}{\pi} \text{real} \left( \sin \left( \frac{2\pi}{\lambda} \right) \right) \]

for frequencies up to 300Hz.

Fig. 2(a) Computer simulation of image width factor variation with image position \( (f = 2500Hz) \)

Fig. 2(b) Practical results of image width variation with image position \( (1.13 \text{ octave pink noise, } 250 \text{ Hz, } 10 \text{ subjects}) \)

Fig. 3(a) Computer simulation of image width factor variation with image position \( (f = 500 \text{ Hz}) \)

Fig. 3(b) Practical results of image width variation with image position \( (1.13 \text{ octave pink noise, } 500 \text{ Hz, } 10 \text{ subjects}) \)

Fig. 4(a) Computer simulation of image width factor variation with image position \( (f = 1250 \text{ Hz}) \)

Fig. 4(b) Practical results of image width variation with image position \( (1.13 \text{ octave pink noise, } 1250 \text{ Hz, } 10 \text{ subjects}) \)
6800 board continued from page 54

manufacturer’s computer won’t couple directly to another’s termin-

al without juggling of connect-

ions. Hence the proliferation of "break-out" boxes to help when config-

uring new arrangements. With


lads to show what’s happened


ing and patch-links to let you try
every combination until it works!

Rather than re-invent the wheel, a

ntation to the standard I have

dded link areas two and three to allow any signal to be connected
to any pin on the interface

contactor as required.

Plugs two and three for the serial ports are 20-way insu-

ation-displacement type contacts which are used at each end, a

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

ackets give corresponding 25-

W Y-type pin numbers and their

ction. Only pins 1 to 8 and 20

used, and 1 and 7 going to O,

remainder to link areas two

Three, finally, the 4th through


tional general purpose pins (II

/ O2, etc) are brought straight out to

a type 20-way connector pin
cage.

Construction is discussed in the

next article.

Notes

Well-intentioned but over-zalous 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, 6800 should read

6800. The same applies on page 53 in the first column,

column on line 25 under the heading "About the circuit," and

in lines 36, 45 and 51 of the last column.

Initially in the article, it is erroneously stated that Kaycomp can

have 120,000 words and 600,000 seps but it is clear from the rest of the

text that the correct specification is

120,000 words and 600,000 bytes. In the third column on page

53, the sentence beginning "Normally, these three pins..."

has been corrected from a section missing from a should read "Normally, these three pins..."

pported from an 8- to 3-line encoder but on

these pins are fed from an 8- to 3-line decoder and out on

Kaycomp they are fed directly from the

KCIU.

Initials, 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 $251 inclusive.

Two hybrid circuits suitable for Kaycomp memory

experiments were mentioned last month, the DMS832 and the

HM3832. These are manufactured by Digital Memory

Systems, PO Box 64, Watson-on-Thames and Hybrid Memory

Products of Weymouth Road, West Chilton Industrial Estate,

North Shields NE3 3TQ.

Sockets suitable for top-side soldering are Angan A600 series

plug-in card. Jerrys’ 1800 series and Robinson-Magill ICE

series and Augus S10-AUG10 terminal strips. Augus 700 series

terminal cards and Jerrys 8600 series terminal cards are also suitable.

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www.americanradiohistory.com

STEREOPHONY

Listening tests

Practical tests have been carried out to validate the theoretical predic-

tions made above. The tests involved subjectively deter-

mining the image with the


goniometric arrangement in Fig. 1.

The tests were carried out in an anechoic chamber with reverber-

ation time of less than 0.25

seconds for all frequencies down

the 120Hz. The signal used was a 1-

octave band limited pink noise

produced by a random noise gener-

ator in conjunction with a hand-

pass filter set (Braul & Kjaer type

1402 and 14A). Each loud-

speaker cabinet housed a single

8¥' unit produced by Good-

man Loudspeakers Ltd. Ten

subjects took part in the tests.

Each subject, occupying a cen-

tral position, was asked to keep a

fixed head position and look

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 between 250, 500, 120Hz, as centre fre-

quencies of the 1-octave signal.

The average results of image

width versus position in terms of

stage width as shown in Figs 2a, 3b, 3c and 4b.

Comparison between theoreti-

cal and practical results shows

good agreement. The practical
curve in Fig. 2A for the central

frequency of 250Hz shows that

image width increases as image

is displaced away from stage cen-

tre. This is in good agreement with theoretical predictions in

Figs. 2a, 3b, 500Hz, shows an

almost constant image width.

This compares very well with the

theoretical results in Fig. 3a. At

high frequencies, 1200Hz, Figs

4a and 6, both theoretical and

practical 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 decreases

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

tolerance to change in the

effective source spectrum.

However, at high frequencies

the image width factor exceeds

the -20dB level and image defi-
l
cence will be obvious.

To overcome image broadening

it is necessary to increase the

phase of the plane-wave compo-

nent of the reconstructed field as

frequently increases.

The best way to achieve this is to reinforce 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 cor-

rectly reproduce.

An array of speakers is gener-

ally regarded as an excellent form of stereophonic sound reproduction.

However, the cost and inconvenience of having many speakers makes this

approach less attractive.

A large number of methods for improving image quality have been

proposed, but without maintaining the convenience of two speakers

system. While these methods may help to improve the accuracy of

localization and naturalness of stereophonic sound reproduction, they

don’t solve the fundamental problem of image broadening. The use of video

cassettes, which have the potential for storing many audio

sequences, may help reduce the

cost of having an array of speakers

and thus facilitate the use of

such a system. The only real way of solving the problem of image broadening, or

indeed of overcoming the general problem of blurriness and usable listening

area in stereophonic sound repro-

duction.

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CIRCLE 54 FOR FURTHER DETAILS.

Breaking the loop — Nyquist revisited

By A. Verinus

Usually formulated in terms of signal voltage loop-gain, the Nyquist criterion for the stability of a feedback amplifier is extended to emphasize the phase 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 as on the basis that certain impedance levels were not always so easily 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. This triggered me into writing this short note on phase thoughts that have been being dor- mised for some years, and deals 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 attendant distortion, were all the rage in the design of telephone equipment. 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 adequate input resistance.

Unfortunately, a basic difficulty arising in practice is that many feedback problems are not directly solved by using block diagrams and schematic forms and associated element assumptions encountered at the power stage. I quote once 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.

This problem, then, for those intending to use practical devices in proposed designs, is how to interpret the transient behavior in the amplified received forms.

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 B 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 B, which is assumed to have zero output impedance. From each region, the input signal and sum of the arrow of signals, $v_a + v_b = v_i$, at A/B. Also $v_a - v_b = 0$ and so

$$A \cdot v_i = (1/A) \cdot v_i$$

In this simple derivation we have used a conventional popular with engineers, that the signal feedback is added algebraically to the input signal in the input circuit. There is no attempt, nor to define a polarity of feedback. This feedback contracts the circuit with the different but usually acceptable conventions adopted by control engineers who, being interested in error-saturated systems, assume the feedback signal intentionally to be subtracted from the input signal in some mixing process in the input circuit.

In the difference the two conventions leads to a "/" sign for A in the control loop. I shall adhere to the electronics approach. $\mu \cdot 1/A \cdot > 1$ feedback degenerative or "negative", i.e., the magnitude of the overall gain is less than that obtained with an amplifier alone. The benefits gained constitute the well-known list of "goodies", important among these for electronics engineers is the desensitization 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 0.7% per deg.C.)

The price to be paid for the benefits listed because factors A and $\beta$ are no real numbers. $A$ might well have a negative sign associated with it that is not the problem. The trouble is that $A$ and $\beta$ 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 ($\mu \cdot 1/A \cdot > 1$), becoming degenerative over a range of frequencies which might be absent from the frequency range 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 behavior of the system with the loop closed could be predicted from a knowledge of the behavior of 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 $v_i$ is inserted into the opened-up loop and the feedback voltage $v_b$ appearing at the cut observed. The ratio $v_i/v_b$ is the loop gain parameter, $A \cdot \beta \cdot / / \cdot A$, polar, or Nyquist, plot of the variation in magnitude and phase of $v_i$ 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 criterion for the Nyquist criterion could be: "The feedback amplifier system of Fig. 1 will not oscillate if $\mu \cdot 1/A \cdot > 1$ when $\omega = 0$, one of many possible formulations.

Applying this condition to the stage direct-coupled amplifiers hav- ing the plots shown in Fig. 2 we see that the system giving curve (i) is stable. At dc $\mu = 0$, $A = A_0 \cdot \beta = 1$, $A/A_0 = 1$, and feedback is negative. As $\omega$ increases, $A/A_0 = 1$, and $A/A_0 = 1$ is feedback is negative. As $\omega$ increases, $A/A_0 = 1$, and the amplifier will not oscillate unless the phase shift between input and output is $-180^\circ$. However, $A/A_0 = 1$ at $\omega = 0$. The
system giving curve (i) indicates that IAB +1 for \( Q = \beta = 0 \) and would be insensitive as an amplifier.

An alternative, and frequently more convenient, graphical method of examining stability is to use 'bode plots', which represent \( |A(j\omega)| \) in dB and \( \angle A(j\omega) \) versus log \( \omega \). The Nyquist criterion then requires that the bode plot \( |A(j\omega)| = 0 \pm 90^\circ \) does not encircle the point \( (0, -1) \). The bode equivalent of curve (i) of Fig. 3 is represented by the pair of plots in Figs. 3(b) and 3(c).

In Fig. 3(b), for convenience, only that part of the phase characteristic near \( \omega = 0 \) is shown. Clearly \( |A(j\omega)| \) when \( \omega \to 0^+ \) is the system unstable.

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 b are still considered unilateral and \( Z_0 \) has a finite input impedance \( Z_0 \) and \( Z_1 \) has a finite output impedance (not shown). \( Z_0 \) has a source impedance \( Z_0 \). 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 exist before the cut was made. The circuit for calculations of loop gain \( V_{OUT}/V_{IN} \) is that shown in Fig. 5. In investigating 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. Further, output feedback is rarely applied as shown in Fig. 4. Take a more realistic circuit, like Fig. 6, which shows an op-amp non-inverting stage. To keep the algebra simple, consider the op-amp to have an incremental input resistance \( r_{in} \) and a high gain which makes the differential voltage gain \( A(j\omega) = \infty \). Feedback components \( (R_1, R_2) \) are resistive and the d.c. source resistance is \( r_s \).

First, let's examine 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 now correct the same result (assuming the stability of the system) by both approaches. Fig. 7 is an equivalent version of Fig. 6. We have nearly used Thévenin's Theorem on the feedback network \( r_s \) as \( \infty \) in parallel with \( r_s \). It is easily shown (see appendix) that

\[
\frac{v_o}{v_i} = \frac{-A(j\omega)R_2}{1 + A(j\omega)R_2/r_s} \quad \text{(iii)}
\]

where \( A(j\omega) = \infty \), \( r_s \), and \( R_2 \) are all real. For non-oscillatory behaviour \( R_2 < \infty \) when \( v_o = 0 \). This suggests the generalization of the power condition as follows:

A 'sufficient condition for the avoidance of self-sustained oscillations in a single stage non-linear amplifier is that the signal loop-power-gain is less than unity.'

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

Fig. 8. Here drawn version of circuit of Fig. 6 opened up by making a 'cut' at the inverting input terminal. Resistor \( r_s \) is not connected to the inverting input terminal, and the feedback network, in zero.'

The '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 energy loss per cycle of oscillations.

An attraction of the proposed formulation of the condition for oscillation avoidance is that it is a simple 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 load effects are taken care of in the formulation of the loop-gain function.

Appendix

(a) From Fig. 7, by inspection, \( v_o = A(j\omega)(r_s/R_s)\phi_1(t) \).

Manipulating this gives \( |L(j\omega)| = \left|\frac{A(j\omega)}{1 + A(j\omega)(r_s/R_s)}\right| \).

(b) From Fig. 8, by inspection, \( v_o = A(j\omega)(r_s/R_s)\phi_1(t) \).

Simplifying, \( |L(j\omega)| = \left|\frac{A(j\omega)}{1 + A(j\omega)(r_s/R_s)}\right| \).

Fig. 9. Redrawn version of circuit of Fig. 6 opened up by making a 'cut' at the inverting input terminal. Resistor \( r_s \) is not connected to the inverting input terminal, and the feedback network, in zero.'

The '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.)

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8K dynamic ram inside ZX81

This modification extends memory of a ZX81 from 1K to 88Kbyte without using an external memory pack. Existing memory chips — usually two 2114s — are replaced by an 8K by 88 bit dynamic ram, the Imms IMS26350 as follows:

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 ±5V 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 IC1 whose response is tailored to minimize noise pickup, and fed to a bistable circuit IC2 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 IC1 is buffered to give suitable levels and the buffer output is given some protection by a 330Ω resistor.

Since the state of IC1 will be indeterminate on power up, and could change with such events as motor switching, a push switch is included to keep the tape winding in place until the play button is pressed. For the prototype, I found a pair of normally-opened contacts on the cassette unit that would be easily 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. Telephones 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 MP5442 high voltage transformer is turned on. The Darlington-connected TX3200 transistors are turned off, the relay is energised, and its contacts remain open.

During a call, line voltage falls to much less than 37V so the MP5442 transistor is turned off, the TX3200 transformer is on, the relay is energised, and its contacts are closed. These contacts connect to a 2.5mm jack plug fitted to the recorder remote-control input.

Speech from the telephone is fed through a 100µF capacitor and step down audio transformers, such as type LF44, or L1700, 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 unplugging the circuit e.g. for rewinding and playing 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 copying, recordings over the telephone line. The voltage sensing circuit draws about 100µA, so the line voltage is not in use; current could be further reduced with different voltage-sensing arrangements. The grid of V1. A preset potentiometer may be connected by 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 core 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 metal lead is connected to any core at the other end and used as a reference. The black metal lead supplies a positive voltage when 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 red lead reads the value of the resistor in the core connected to the red 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.

K.H. 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-runs, etc. Its major feature is diodes D1 and D2 which alternately charge capacitor C2, on both halves of the a.c. cycle, thus forming a full-wave rectifying system. Diodes D1 and D2, and capacitors C2, C3 and 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 Câmbria
Portugal

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 A, B. The counter U/D input is low, the counter counts down. The LS169 is a synchronous device so changing any input has no effect until an active edge is received.

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

A.J. Crofts
Leamington Spa
Warwickshire

Electronics & Wireless World November 1985

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CIRCUIT IDEAS

Fuel saver
While a car is decelerating, its engine does not need to run. On many modern cars, the car’s computer communicates with the “extra” fuel supply when the ignition is turned off to prevent ‘running out’. The circuit shown switches this solenoid to shut off idle fuel supply when engine speed rises above 19000/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 19000/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

Greater efficiency in power converters
In a single-ended power converter, a resonant circuit is formed by the combination of transformer internal capacitance C2 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, effectively isolates drain-source capacitance from the transformer and raises the resonant frequency of the system, while D, allows energy recovery. Less snubbing is needed so there is less energy circulating.

Richard Aston
Sutton
Surrey

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 Q-to-d conversion around a D-type bistable i.e. is replaced by a time delay consisting of the current mirror Tr, and capacitor C. Current through Tr, controlled by variable external voltage V, is mirrored in Tr and varies charging time of the capacitor. When Q goes high, Tr 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, and R, H. R. Banton
Manchester

Humidity control
There is a diode missing at the left-hand side of this circuit. This diode replaces the link between the junction of R, and the 7.50 resistor and the positive rail. The diode connects to the positive rail.

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Electronics & Wireless World November 1985

Modems

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 cassette tapes. So, too, can 1200/75 bit/s versions which give access to video systems such as British Telecom's PresTel.

The buyer now has a very large range of low-speed modems to choose from, through the introduction of special-purpose modem I as has seen to it that the hardware differences between one model and another are sometimes quite small. However, some include special additional features, such as multi-standard operation, automatic caller identification 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 accepted as a sort of unoffical standard and so allow the use of a wide range of readily 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 current 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, g.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 transmits the user code word or 'mark' or 'space'. One 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

<table>
<thead>
<tr>
<th>CCITT</th>
<th>Date</th>
<th>Data Rate</th>
<th>Modulation Scheme</th>
<th>Circuit Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>V.21</td>
<td>1962</td>
<td>300 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
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<tr>
<td>V.22</td>
<td>1962</td>
<td>1200 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.23</td>
<td>1962</td>
<td>1200 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.24</td>
<td>1962</td>
<td>1200 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.25</td>
<td>1962</td>
<td>1200 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.26</td>
<td>1962</td>
<td>2400 bps</td>
<td>async/sync</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.27</td>
<td>1962</td>
<td>4800 bps</td>
<td>async/async</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.28</td>
<td>1962</td>
<td>9600 bps</td>
<td>async/async</td>
<td>1-wire 2-wire</td>
</tr>
<tr>
<td>V.33</td>
<td>1984</td>
<td>14400 bps</td>
<td>async/async</td>
<td>1-wire 2-wire</td>
</tr>
</tbody>
</table>

Key: 1 half duplex (i.e. each end sending in turn) 2 full duplex (i.e. both ends can send simultaneously)

www.americanradiohistory.com
Duplex operation at 9600 baud over a two-wire telephone line is possible using a modem such as this one, the DM492EX 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.

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.

CTIT recommendations
Transmission standards for modems are defined by the ETSI (European Telecommunications Standards Institute). Among these standards is the CCITT, a committee of the International Telecommunications Union. The organization has produced a series of recommendations, the V series, which deal with all aspects of sending over telephone lines. Those dealing with modem specifications are given in Table 1. In North America other standards are used, of which the 200 (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.

Modem software requirements
Without good communications software, the modem software in the Modem Management System is less than an expensive novelty. Computer software for controlling modems, varying greatly in price, quality, form and complex-

PC discussion list
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MODEMS

Wireless World modem: this low-speed two-wire modem, based on the Am7910 IC, covers the V.21, V.23 and corresponding Bell modes and costs around £70 to make (E6-55W, May-July and December 1984; the p.c.h. is still available). A series by Martin Allard describing a personal electronic mail system for the constructor began in the August issue. A microprocessor-based multi-standard terminal unit was described by John Walker in October’s issue.

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 JF, 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, Caiston Way, Watford Business Park, Watford WD1 8XD.

Bits and baulds

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 symbolize 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 bits/ s. This speed amounts to roughly 30 characters of text per second, since it takes ten bits or so to send each letter.

Built-in test facilities and software control are becoming increasingly common. The Hycanth modem from Telindus has a front-panel LCD 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 dual-line connection over the public network: a two-wire circuit at the subscriber’s end
- The two-wire lease-line, which may be equated 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 Answereall.

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.

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

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**Emprom programmer software**

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

by Norman Sargent

These additions to my program published on July 15 of the June issue will prove useful to readers developing and manipulating data in memory.

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

After editing memory, key 0 is used to return to the program instead of exiting to the emprom-list menu function key, and any other that you may want to define for use during memory editing, is defined in line 140. If you need to do other tasks while in edit mode, they could be replaced by a procedure.

The function is disabled by line 100 and reenabled by the memory editing command to permit 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, line 20 should be changed so a command is issued and no emprom is fitted, a simple momentary push-to-make switch can be connected from ground through a 180 resistor to pin 11 of IC on the programmer. This will also remove any programming voltages on the slave socket to allow removal of the emprom.

There are no problems with reading and programming S048 and S049 processors, but note that bits in these devices are at zero when erased, and not all as with a standard emprom.

The program detects this during an erase-verification command.

I have fitted sideways room to my computer and use Toolstar's 2MB 20-pin DIP socket to block digits of data around in memory.

This, in conjunction with the user-defined keys and these program modifications, allows speedy development of emprom-based programs.

Finally, I omitted to mention connection of the RTS signal to the RS232 lead in the original article. This should be wired from pin three of the microcomputer plug to pin 20 of the programming plug.

---

**Radio and Television Servicing. 1981-85 models, edited by R.N. Whitley. Macmillan, 322 pages, hard cover, £22.50. Service information on a wide range of recent models, including some portable stereo sets; brands include most major European and Far Eastern names.**

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**COOPERATIVE ELECTRONIC CONSTRUCTION BY JOHN WATSON, 1984, revised edition. Macmillan, 232 pages, 144 pages, soft cover, £5.95. Too many projects for the hobbyist and a far better circuit idea, all designed with value-for-money in mind: among them a miniature push button, a feedback drill controller, a tone control system, an alarm system and a complete studio interface.**

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**FUNDAMENTAL FORKS by Richard Elliott and Michael Benson. Personal Computer News Library, 260 pages, soft cover, £6.95. In the first few pages a revision of an introduction to computers, programming and Forth; then a complete look at the 'forked' guided tour of the language. Topics covered include string handling and file use.**

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IBM PC boards from one source
Fed up with trying to locate supplies and technical support for pub-in-bins 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 Technum, Conway, Hercules and Deltek's own range. As a major distributor they are able to stock some of the more unusual boards such as image processor and other specialized products. They may also offer a similar service for the Sanyo 550 Computer and can offer a complete package to the customer including monitors, printers etc. An introductory offer is that Deltek are discounting up to 20% off a wide range of products. Deltek PC Support Ltd, The High Street, Staplehurst, Kent TN12 0BH. Bmw 211

D.c. converter on a card
This d.c. converter is the Rifa P28A which has an integral heatsink and can provide 48W power. Mounted on a Eurocard by Cambridge Collins, the user can add a bridge rectifier and a reservoir capacitor for 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 them high efficiency, and at 80V and an m.t.k. of 2000. The card produces 5V at 5A for an input of 48V. The outputs may be connected in parallel to provide more power. Cambridge Collins Ltd, 16 High Street, Stevenage, Herts. EWW 211

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<th>PRICE</th>
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<tr>
<td>CE608</td>
<td>60W B2</td>
<td>£21.00 Bi-Polar</td>
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<td>CE1004</td>
<td>40W D2</td>
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<td>CE1098</td>
<td>100W B4</td>
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<td>CE1704</td>
<td>170W A2</td>
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<td>170W B2</td>
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<td>300W</td>
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<td>CPR</td>
<td>Stereo Preamplifier</td>
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<tr>
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<td>12V Supply</td>
<td>£16.00</td>
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BBC-68008
An additional ram 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 Cumians includes 516R 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 motherboard is transparent to the computer apart from the floppy disc controller, the calendar 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 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, Sylograph word-processing system, Dymac electronic spreadsheet, Sculptor database, interactive Basic 999, Operating System many Pascal-like structures, compilers for C and ISO-Pascal, assembler, and a graphics interface that allows windowing facilities and multiple character windows. All for about £700. A similar board is available for the Acorn, CMaana Ltd, The Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3RH. EWW 207
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Technical computer

Designed and produced in the UK, the Technical Computer from Postom is specifically intended for engineering and scientific applications. It is based around two Motorola 6809 microprocessors and operates under OS-9 and Basic 09 (see also item on Cunuma'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-sitter.

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 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 16 million dots/s.

A graphics plotter provides hard copy and a graphics tablet may be used for input. Postom Computers Ltd, Deacon Trading Estate, Newton-le-Willoby, Lincs 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-book dialling and security locking — this model also has number scrolling, redialling 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 conversation on 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

Darlington driver

Seven Darlington transistor pairs are housed in a 16-pin d.d.l. package from Steatite. The packages feature integral clamping diodes for use with inductive loads and bypass capacitors 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 Vcc of 2V. The maximum power dissipation is 0.52W. Versions are available for use with 12- & 24- volt circuits with operating voltages from 5 to 350V. Steatite Microelectronics Ltd, Hailgley House, Hailgley 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 good resolution is suitable for viewing through pilots' night-vision goggles. Hewlett-Packard Ltd, Edelate House, Wincanton, Wokingham, Berks RG11 5SD, EWW 212

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ELECTRONICS & WIRELESS WORLD NOVEMBER 1985

CIRCLE 103 FOR FURTHER DETAILS.
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 Quantative Technology specifically for Honeywell computers and can be implemented on the DPS8, 88 and 88E main-frame computers operating under COS 8. The programs have been hand-coded 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 ranging from Hewlett-Packard.</p>

U.h.f data link

Developed for telemetry in hydrographic surveying, SenTel has many applications in engineering and computing. It consists of a single-channel u.h.f. transmitter and receiver operating in the 450MHz band to provide simple 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 5000mW to comply with UK regulations, though alternative antennae and power boosters can be supplied for use elsewhere. Microkane, 1, The Holt, Hare Hatch, Upper Warre, Berks RG10 9TG.

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 6510A 2MHz single-chip computer and features 2 x 16 bit counter timers, 54 parallel input/output lines, full duplex serial channel to RS232/422/485 (RS232, four 28pin memory sockets with a total capacity of expandable 64K bytes RAM. The machine is fitted as standard, and full compatibility with the Essex range of cards. Essex Electronics Centre, Wivenhoe Park, Colchester, Essex CO4 3QJ. E220

EURO PRODUCTS

Frequency meter for the pocket

Enclosed in the unmistakable case of a Thandar instrument, this pocket-sized meter is down to 20Hz and features a sensitivity of 0.1mV/m. A battery longevity of 200 hours is indicated by the battery level indication of the meter. The unit is powered by 2AA batteries and is powered on and off by means of a simple switch at the rear of the meter. Available through Electronic Brokers Ltd, 140 Camden Street, London NWI 9PB. E211

Data acquisition module

Remote monitoring and control of any electrically operated machine 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 be 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. E218

High-speed maths chip

A world's first is claimed for the TRK e-mos multiplier/accumulator as it is manufactured using 1 micron internal architecture. The TMC2110 is organised as 16 by 16 bits and operates within a clock time of 100ns. Input data can be specified as two's complement or of unsigned magnitude, giving a full precision 32-bit product. Present results are accumulated into a 35-bit result. Features include: individually clocked flip-flop input and output registers to maximise 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 TRK device is available from HiTek Electronics Ltd, Beadle Trading Estate, Ditton Walk, Cambridge CB5 8QD. E224

Control timer

The use of a microprocessor and a non-volatile memory in Vellman's control timer enables the programming of 40 steps (with additional memory expandable up to 2000) 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. Vellman (UK) Ltd, PO Box 20, St. Leonard's-on-Sea, East Sussex TN37 7NL. E214

Precision thermistors

Two families of disc-shaped thermistors are available from Iskr. The thermistor range has specific resistance values between 10 kohms and 100Mkohms and is divided into two parts: the US3 range which measures 5.5mm in diameter with a maximum dissipation of 1W and the US3 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%, the US5 range varying from 2% to 350%, while the US3 range varies from 3% to 100%. The devices are suitable for use in temperature control and measurement, remote control of liquid levels and flow rates, time delay relays, voltage stabilization. Iskr Ltd, Redlands, Coulton, Surrey CR3 9HT. E209
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Further information available from the Personnel Department, North Middlesex Hospital, Stepping Way, Enfield

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Please call Charlie Kennedy, our Service Manager, on (078) 61619, or write with full details to Linda Burke, Personnel Department, Sony (UK) Limited, Selsdon Park, South Street, Selsdon, Middlesbrough TW18 4PF.

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If you can meet this challenge please contact either Brenda Edmunds or: READING (0734) 853041 or send your CV to: Brenda Edmunds, Digital, PO Box 121, Reading RG2 0TU.

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Send application to: Annette Lee, Personnel Officer, Olympus Optical Co.(UK) Ltd, 25-27 Wimpole Street, London W1M 8AE.

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Egham Hill, Egham, Surrey, TW20 9EX

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