Robot design tutorial

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Compact Disc players

Modems surveyed

Receiving satellite broadcasts

Kaycomp interfacing
## DELTEK PC

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(For use on Cables or Cables Graphics Cards)

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(Also available in 125K or 256K formats)

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**Digital control desk**

New's computer-controlled all-digital sound mixing desk has been incorporated into a BBC outside broadcast vehicle. Manufactured by New Electronic 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 New and forms the heart of the new console. All its functions are assignable and it has been ergonomically designed after extensive field trials with operational staff. A large number of experimental features have been included in the design particularly the flexibility of configuration, fibre-optic communication for remote use, and digital processing and mixing routing. The desk has four different configurations built in to it, available at switch-on, or 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 recallable. The faders can be singled out, 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 out.

The desk is based on 16-bit 4-6 and a 4-64 converters, but at various points the dynamic range capacity varies. The fader channel is ringed within an 18-bit "window" by the use of a system whereby the channel fader also affects the input gain. The main mixing signals are 32-bits wide to allow headroom for summing and extremes of equalization. The signal is reduced to 16-bits before the output stage. A maximum of 128 mixed signals can be produced unless processing is required beforehand for the control of specific groups, the mixes are not formed at all until the final output stage.

Processing racks are mounted permanently in the o.b. trailer and the complete desk is taken out and back linked to the processor by up to 180m of optical fibre. The trailer has an expandable side to incorporate an acoustically treated listening control room with stereo loudspeakers, v.d.s. for the Neve system, a tv monitor and additional loudspeakers. A separate area contains two Mitsubishi stereo digital tape recorders with provision for two further analogue recorders and a digital multi-track machine. Neve have sold digital signal processing (DSP) desks to CTS Studios in Wembley, and for disc mastering, to Tape One Studios. A fourth is going to the British Library National Sound Archives and a fifth to WDR in Cologne. "The application and know-how incorporated into the desks puts Neve and Britain some years ahead of anyone else in the field" says Laci Nester-Steele, Neve's m.d. "We intend to ensure that Britain keeps this lead."

**Computers could bridge class barriers**

Educational computers are now being used to a growing extent in schools. At the Great London Community Broadcasting Centre, after being vandalised by burglars at the Greater London Council's welfare benefits office, this Husky Hunter computer retained all its software. The i.e. display was smashed, the main p.c. board levered out with a screwdriver, the inside sprayed with 'silver' paint, and the computer appears to have been jumped on several times. Yet its stored program and data were found still intact, with the insulation still undamaged through the communications port. The central processor and operating system were also found to be fully operable.

**Home-designed fault tracer wins prize**

Emie Huggins with the Mole locator, which can accurately pinpoint faults in telephone cables and save money by reducing the number of holes to be dug. The invention is estimated by BT to save them up to £10 million a year, of which they give Mr.Huggins £2000 and a silver salver as first prize in their New Ideas competition. Huggins at 50 is a BT engineer and developed the Mole in his spare time at home.

**In brief...**

Field tests for transmitting data in addition to the normal sound transmission of LBC in London have been designed to show whether either or both of two different auxiliary data systems, and unlike a form of teletext, will interfere with normal reception of broadcasts. Early results from the IBA investigation have shown that few listeners noticed the presence of the data signals and this small number of reports received are to be thoroughly investigated.

One of the systems on trial is the Radio Scanning System endorsed by the BRI which is intended to provide listeners with channel identification, automatic receiver switching and other facilities, as soon as the necessary decoders become available for domestic or mobile receivers. The other service could provide information to specific interest groups on a subscription scheme.

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

The Institute of Acoustics has developed a video course to enable student in remote centres to study for their diplomas in acoustics and noise control. The scheme is based on material recorded on 35 video tapes and incorporate written assignments together with the associated exams. The student undertakes a set of exams at each of the examinations as those studying conventionally.

**More time please**

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

"We are asking the Home Secretary to extend the deadline for application for licences to the first of December and to increase the number of frequencies allocated to the new experiment. We have over 200 members nationwide, yet areas as large as Scotland are virtually excluded" says Ricky McCarthy of Brighton's Afro-Caribbean Radio Project says "Ethnic broadcasters are disadvantaged both by the number of experimental stations permitted and by the limits on transmission areas. We want to be able to reach more than a minority of a minority."

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

**Acorn takes a risc**

A 32-bit super-fast processing chip developed over the last two years has been sampled by Acorn Computers since last April. Called A1530 for `Acorn risc machine`, it has used as a second processor for the BBC Micro, but according to Acorn this is purely for software development and evaluation. While they expect to produce a computer incorporating this chip, Acorn say that they are interested in selling it to independent manufacturers. RISC (reduced instruction set computer) architecture was developed in the USA but has not yet been implemented by anyone else. The Risc processor is very fast because it incorporates a simple instruction decoder. ARM has many system as well as sub-divided into five groups. It operates at 3.3 million instructions per second and is used as a BBC second processor is said to perform at standard benchmarks over ten times as fast as the BME PC AT 16-bit technical computer. The RISC code twice as fast as a VAX 11/ 780 microcomputer.

**In brief...**

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No fault liability

As a result of Parliament recently amending the carriage of cars, the UK is committed to introducing tougher consumer protection legislation within the next three years. For the first time the UK will impose "strict liability" on manufacturers. This implies that, for example, manufacturers of radio and television products could be sued by users under the "no fault" liability already enforced in some countries should the product prove defective and cause damage or injury. While manufacturers could put the burden of proof forward the decision that they had taken all reasonable steps to prevent such defects, having regard to the current state of the art, the assurance of good will be this argument will be very difficult from the existing situation in the UK. Moreover, if the damage or injury is not sustained by the person who actually bought the goods, it is up to the user to prove "negligence".

Consumer protection thus means that the user is no longer protected by the argument that "the goods were of the merchantable quality and reasonably well suited for the purpose for which they are sold". In order to prevent the actual purchaser to sue for breach of contract but does not extend to third parties.

Developments

Hughes Aircraft have developed an h.f. frequency-hopping system - "short term anti-jam (STAJ)" which is a control system for existing standard tactical radio communications systems.

West Germany is to begin to transmit video programme signals (VPS) signals in a series of broadcasting machines automatically to record wanted television programmes without dependence on the use of transmission, based on telemetry codes.

The Microwave & Microwaves Laboratories have developed an experimental system which uses a single chip as a single secure channel. The system is able to transmit video signals in the radiofrequency interference (RFI) band, which is possible because of the system's wideband capabilities. The system is being developed for various applications including in the broadcasting of video signals, and is expected to be used in the near future.

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COMMUNICATIONS COMMENTARY

28MHz opens

Sunday, November 27 is the 50th anniversary of the first American broadcast of a television program. A large number of amateurs have been busy on 28MHz in the decade following 1935.

November 27, 1935 was the first time that a broadcast of a television program was transmitted over a television channel. In 1935, the BBC started broadcasting the first television program in the UK, and the US had its first television broadcast in December 1936. The transmission was made possible by the invention of the cathode ray tube (CRT) by John Logie Baird in 1926 and the development of the first television receiver by the English engineer E. H. L. Reed in 1929.

In brief

The next Amateur Radio Show is being held on December 2, 1985 and May 12, 1986. The Show is organized by the Amateur Radio Association and is known as the "Amateur Radio Show". It is an annual event that features the latest in amateur radio and related equipment, as well as seminars and workshops. The Show has been running for over 50 years and is a major event in the amateur radio world.
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From submarine to satellite

Communication with submarines has always presented a major challenge to naval communications. Radio signals at normal m.f., h.f., and v.h.f. frequencies cannot penetrate seawater to any useful depth. However, the energy absorbed by seawater decreases at lower frequencies. British submarines currently receive transmissions at v.h.f. from Rugby (GBR) or Criggion (GBG) in Wales. At these frequencies bandwidth and data rate present problems. Naval equipment uses four-channel minimum-shift keying to allow the simultaneous transmission of four 50 baud teletypewriter channels on one carrier. Even at v.h.f. penetration of the sea water is not very deep. Extra low frequencies in the range 30m to 3khz are needed if penetration is to be sufficient to allow the submarine to remain at a safe depth while receiving radio signals.

The Admiralty recently announced that it was looking at using Scotland to build an e.f.i. station. At e.f.i. antennas are lengths are measured in miles: two e.f.i. installations currently being installed in Wisconsin and Michigan have antennas 27 and 56 miles long! For the Scottish e.f.i. station, the Admiralty is proposing to use a 12-mile long antenna mounted on four metre poles. At 100Hz wavelength is 3.04km. Classical ray theory wave propagation is no longer valid at these low frequencies. Even antennas measured in miles represent only a fraction of a wavelength at e.f.i. Global coverage can be achieved at e.f.i. with only a few tenths of a watt 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 has 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 shows a number of different h.f. drive transmitters to feed into a common wideband 'power-bank'. The equipment, Marconi's XSS, has been selected by the US navy for use on its new Vasp class (LHD) 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. drive transmitter, the H2542, covering 15kHz to 30MHz and which is a development of Marconi's family of fixed station h.f. equipments, originally launched in the mid-70's as Marconi Fast Tune (MFT). Today's MFT-R version consists of an h.f. drive, and 10kW amplifiers, and the new receiver. The H2542 has a 1Hz read-out and can be used for c.w., a.m., f.s.k., s.s.b. and i.a.b.

Marconi also launched a naval marine transceiver called Swordfish designed to meet the v.h.f./u.h.f. communications requirements of smaller naval vessels and military vessels. Swordfish covers 30 to 40MHz in the three ranges 30 to 40MHz in the three ranges 30-48MHz, 108-175MHz and 265-400MHz and has an output of 100W on f.m./a.m. and 90W on a.m. Optional modules include continuous watch keeping facilities on the 121.5 and 243MHz distress frequencies. Typical naval installations couple several transceivers together into one antenna, and to avoid interference from one set to another the transmitter's spurious noise output has to be very low. Marconi claim that the transmitter output at just 1MHz away from the 100W carrier is 15dB down on the main carrier.

Satcoms

The launch of the UK's new defence satellite, Skynet 4, by the Shuttle in the summer of 1985 will mean that the UK will no longer need to rely entirely on US and NATO satellites for its satellite defence communications. Skynet 4 will be carrying s.s.b. transponders for the full 500MHz of the military satcom bands at 7.25-7.75GHz (downlink) and 7.9-8.4GHz (uplink) as well as u.h.f. and e.h.f. facilities. To investigate propagation at around 45GHz there will be an e.h.f. up-link facility on Skynet 4 which will be cross-strapped to 7GHz for the down link.

The UK's previous defence communications satellite (Skynet 2) recently celebrated its tenth birthday in service. Skynet 3 was cancelled by the government of the day before completion. Skynet 4 will consist of three satellites, all three of which will be in orbit. Early Skynets had only 50MHz of transponder bandwidth, but Skynet 4 will access 135, 85, 65 and 60MHz wide segments in the 7.8GHz band for use as earth cover, wide beam, narrow beam and spot beam applications respectively. There will also be a s.s.b. facility at 250-260MHz (up-link) and 305-315MHz (down-link).

by Nigel Cawthorne

MEL introduced their new ultra-compact h.f./v.h.f. tactical transceiver, the UK/PRC 319. The basic unit measures only 30 by 20 by 11cm and contains a 90W transceiver covering h.f. and up to 40MHz in the low v.h.f. range.
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PREAMPLIFIER DESIGN

I would like to accept the challenge offered by Mr Self (WW, October 1985) on the question of distortion in electronic capacitors. Both tantalum electrolytic and ceramic capacitors can be measured directly with a Sound Technology or equivalent distortion analyser. The only important factor to consider is scaling the RC time constant (R being an external load resistor) to be near the measurement frequency within an order of magnitude. If one considers warping frequencies below 10 Hz, many designs can be compromised poorly chosen time constants and component selection.

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

Generally the remainder will lie between 0.18 and 6%, depending upon capacitor construction, dielectric, the presence or absence of e.g., bias, pulse width, loading and other factors. This residual is not leveling dependent, so any reasonable pulse amplitude between 0.5 and 15V can be used. Alternatively, one can use pink noise or music as a source.

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

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

John Carl

California USA

(Letter received in April 1984 - Ed.)

References

I would like to thank Mr Self for the details provided for the Sound Technology unit he uses for distortion tests, and for the well-reasoned letter in April 1985 WW. For the sake of all, it is probably not worthwhile arguing about commonality anyway — you either believe in 'good' connectors or you don't. In this regard, I notice that the telephone supply I have appears to be full of gold flashed contacts and recent electronic watt-hour reference standards used in the calibration of electricity meters use silver instead of gold in order to prevent connectors from becoming loose, and that is what caused me to respond to the original article and led to the current letter writing saga. However, seeing that this epic has stimulated someone of Mr Carl's stature to examine the subject in detail, then all of us will have been served.

W.B.M. Armstrong

Ampstade

N.S. Canada

BEEF CUTS

A reader in the September issue of Wireless World on BBC plans to save money was interested but not, I admit, entirely relevant to your readers.

I understand that the bulk of the cuts to be made in BBC
WIRELESS!
Mr John Beud (Letters Department) was delighted to find how very good his radio circuit was. Although I cannot claim its length of experience, I have had much pleasure from fantastic wireless for some thirty years, starting with my first Marconi-soldered old-style receivers. Perhaps we should all start the Campaign for Sound Quality, or perhaps, instead of some editorial fodder for the more technical reader, I could add a strong plea for those of us not yet converted, not yet to be forgotten. I have long had a growing suspicion that the move towards total semiconductor electronics has involved a compromise in the fundamentals of wireless, as well as in the fundamentals of semiconductor theory. Sealing was and string are out of fashion now, but it is salutary to remind ourselves of the many great discoveries and discoveries associated with this apparatus, where the apparatus rather than the reader becomes evident.

RELATIVITY and NOSTALGIA
Since I have been a tinkerer by nature, I think I should respond best i.e. I can to the question about relativity, but the letter from George Lewin stirs some ancient memories. While still at school I was given a stack of back numbers of Wireless World (long ago disposed of), so I should be interested to know when it first appeared. Probably a quarter of a century since my student days, I am somewhat confused in the case of the great man in his day, who was probably in 1915 when his book on Electro dynamics was published, but I do not think he would have been interested in relativity; he disliked theses and vacuum tube circuits. The theoretical tacho oscillator was run at 900 volts because, so it would be, if someone thought 1000 volts would be dangerous! Various writers of relativity theory have been experimental. I increased my interest to readers.
When I wished to obtain a model of an R388/URR receiver of 1952 vintage I naturally turned to specialists first. The last time I saw this type of receiver, it would let me work just about satisfactorily of little delay. I bought 690 volts, and I have only found about 1100 volts for people who know what he would have made of the present solid-state technology. The technology isn't what the designer wants, but it works. I hope it helps those who are interested in readers. If I was spending £2 in 1955 on a small crystal receiver, £388 my disappointment amost flowers. I am interested in experimental. If I have a point, it is to make what I am asking for clear.

RELATIVITY
Having noted the parties of many readers on the topic of relativity, it appears that they do, in the case of the great man in his day, who was probably in 1915 when his book on Electro dynamics was published, but I do not think he would have been interested in relativity; he disliked theses and vacuum tube circuits. The theoretical tacho oscillator was run at 900 volts because, so it would be, if someone thought 1000 volts would be dangerous! Various writers of relativity theory have been experimental. I increased my interest to readers. If I was spending £2 in 1955 on a small crystal receiver, £388 my disappointment amost flowers. I am interested in experimental. If I have a point, it is to make what I am asking for clear.

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One notices how many contributors to Mr. Carg’s enquiries into the existence, or otherwise, of electric ‘current’, have been folk steeped in lineal electromagnetic theory. And who as such have been able to clearly distinguish between R pure and simple, and the R-i+j aspect of practical transmission system.

The question which has been lodged in the writer’s mind, existence of the R pure case, as far as I can see it, is: ‘What is the behaviour of a line of subject to a temperature superconduction conditions’? always supposed that a real applied e.m.p. is sans either R or R-i+j. One imagines the value of such a problem would be equal to that of free space, but what of phase angle considerations.

First go to Mr Carg please.

Ozzy Dog
Hurstpont
Hassocks
Weste Sussex

LIGHT, DISTANCE AND TIME

I have no doubt added to your magazine’s no doubt lengthy correspondence on special relationships. Alan Jones (Sept. 1985) calls for a reply. Wad I wholeheartedly agree with Mr Jones’s sentiments concerning some of the basic errors present in ‘standard’ relativistic theory, and feel he should be congratulated on correctly dealing with most of them, there are a few points that he omitted, notably the flaw in Einstein’s second postulate.

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

The velocity of light in a vacuum, given direction, as opposed to its speed, as Einstein measured it, and it is probably a basic law that it never can, cannot be altered by any back and forward experiments performed at the end of the last century to determine the correctness of the anisotropic behavior.

The two opposing velocities that could only give an average of the two opposed velocities that would be a constant whatever the relative motion of the ether, which can be used to equate energy with length, yields new equations of motion for the regions where the abbreviated E = mc² is no longer accurate enough, and allows for the expansion of space by radiated energy

The other fatal flaw is as Mr Jones neatly says in Einstein’s use of Cartesian geometry to formulate his equations. Using a polar system more suited to coping with observations made from a given point and discarding his incorrect use of the Lorentz transformation (which relies on a fixed velocity of light), the result is a simpler equation for the time-dilution effect, which has that it does moving towards the observer run fast, clocks moving away run more slowly, and that those that are “stationary” or moving at constant velocity an observer stay in sync... exactly the same result that you would obtain using temporal perspective. The Doppler-Fresnel effect is a common sense tool to calculate the “apparent”, and “non-relativistic” effect in moving objects. E. Hurst
Iverloch
Middlesex

CAUSALITY

Although somewhat belated (February 1985) issue of EWW this is an acceptance of a challenge made in that issue...

... if there are readers of this journal who can see a way around the strongly held view that “the necessary connection” exists only in the human mind, (News Commentary, p.6) this issue concerned the existence or non-existence of necessary connection between physical events in nature such as a force-e.m.f. and a current flowing in an armi.

The recent view of Hume-Ayer etc is that there is no such a link between separate events and that these constant conjunction of such discrete events is a physiological.”

A concrete example of a necessary connection between e.m.f. and 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 this first form modern 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 as i.e. c.m.f.-photons-electrons motion. And this is where the reply of 01 in terms of mathematical laws is crucial.

It is a historical fact that the extreme empiricism of Hume-Ayer etc is limited both in its reliance on common experience and especially on the logic of ordinary language. Here and there where that school made its greatest error re scientific law. It assumes with Aristotle that laws are of the form, ‘If A, then B’ or equivalently ‘All A’s are B’, the generalizations of logic.

But as Galileo pointed out and Newton expected, nature follows and laws of mathematics and not the sterile tautologies of philosophy. In the language of mathematics as applied to nature one finds that necessarily not found in more tautologies, and which binds events into a set of necessary relations. It is only when the philosophers of tautology go to work on the notion of natural necessity with their a priori model that this is the realisation of an irreverent conjunction of events, on the one hand, and a series of empty tautology on the other hand. This is the fatal 1894 that makes so much of modern philosophy of science into an empty justification of a happy relativism of languages systems.

G. Giordano
M.R.
Ontario
Canada

Letters

Letters for publication are always welcome, but the Editor prefers a handwritten letter. I try not to edit original letters, but sometimes they are far too long, therefore cut and the writers upset. Please keep your letters short.

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Satellite receiver design

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

Antenna sighting

The boresight of the antenna must point directly towards the satellite and a line of sight to it must exist. The space between the earth's surface and the satellite must be occupied by the atmosphere. The height of the satellite is in the order of 25 miles. A cable or wire antenna will have no boresight. A typical example of a practical case is taken as an inflated figure calculated from the equation: 

\[ T = T_0 + (F - 1)T_{\text{in}} \]

where \( T \) is the antenna temperature, \( F \) is the noise figure and \( T_{\text{in}} \) is the reference temperature of 290K. A practical antenna temperature of 100 degrees Kelvin requires a noise figure of 4dB or 2.5 times, giving a value of 0.95. This and the adjacent antenna losses are high enough to necessitate a further noise figure reduction of 10dB or 10.5 degrees Kelvin.

Indoor unit

Shown in skeleton form in Fig.2, the indoor unit consists of a second i.f. amplifier and mixer, a surface wave filter, a down converter, a carrier to noise ratio detector, and an audio amplifier. The carrier to noise ratio detector is a balanced mixer and a tuned band-pass filter, which operates on a source of a few kHz. The output of the mixer is provided to the audio amplifier, which is a half-wave rectifier and a tuned band-pass filter. The output of the audio amplifier is provided to the television receiver.

A common problem with the indoor unit is the low noise figure of the carrier to noise ratio detector. The noise figure of the carrier to noise ratio detector is the third i.f. amplifier, which operates on a source of a few kHz. The output of the second i.f. amplifier is provided to the audio amplifier, which is a half-wave rectifier and a tuned band-pass filter. The output of the audio amplifier is provided to the television receiver.

Maximum signal power

The maximum signal power is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The maximum signal power is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The maximum signal power is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The maximum signal power is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier.

Noise performance

The noise performance of the indoor unit is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The noise performance of the indoor unit is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The noise performance of the indoor unit is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier. The noise performance of the indoor unit is limited to 112dBw, which corresponds to a signal level of 2600 mV at the input of the audio amplifier.
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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. 2, appear similar but in these forms are of no use for audio because of practical limitations. In (c) the binary input is about to have a major overflow, and all of the low-order currents are flowing. In (d) the binary input has increased by one, and the current consists only of the least significant bit to an accuracy of rather better than one i.e. b. In this simple four-bit example, the necessary m.s.b. accuracy is better than one part in 16 (2^4), but for a 16-bit system this becomes one part in 65,536 or about 0.00125%. The 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 (c) requires a clock for the counter which allows it to count up to two times the sampling rate. This will be more than 2^2 times the sampling rate. However, in a 16-bit device, the clock rate (must be 2^16 times the sampling rate, which for CD this would be 2.9 GHz. Clearly some refinement 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 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 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 currents of 1:1:2:1:2:1:1, 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 b.s.b. linearity, and subsequently in 16-bit devices.

Dual integrators

The integrator approach is preferred by Sony, and the solution adopted is to have two current sources operating simultaneously, with a ratio of precisely 256:1. Clearly if the larger current flows for one clock period, the effect will be the same as if the smaller current source operated for 256 clock periods. Thus the least-significant eight bits of the input sample control the larger control. The clock frequency now only needs to be in exess of 2^8 times the sampling rate, or about 11MHz. As the output is a ramp, the clock must run faster than this to leave time during the sample period for the analogue vol
The only problem with any foundation occurs if the two outputs are converted to mono by means of analog adders; this results in a h.f. roll-off. With this exception, other factors have a much greater bearing on subjective sound quality than the use of multiplexed d.c.s.

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-like function falling to zero at the sampling rate. This gives a loss of about 4dB at the Nyquist limit.

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

Oversampling

One approach to improving the phase linearity of converters is to use oversampling, which means using a sampling rate greatly in excess of that required.

by Nyquist. This results in a spectrum shown in Fig. 7. As there is now a large separation between baseband and sidebands, the reconstruction filter need only have a gentle roll-off and phase linearity will be improved.

Over sampling by factors of two and four is used in CD players. It is necessary to provide an increased sample rate using samples from the disc as input. The samples being between must be computed. The method is a digital simulation of the process of analogue reconstruction. The difference is that in the digital domain, the impulse response can be made arbitrarily close to the theoretically perfect.

The 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-like function falling to zero at the sampling rate. This gives a loss of about 4dB at the Nyquist limit.

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Oversampling

One approach to improving the phase linearity of converters is to use oversampling, which means using a sampling rate greatly in excess of that required.
The oversampling system used allows the use of 14-bit data, provided that the resolution in wordlength is done in an optimum fashion. This is not implicit in the definition of oversampling, and an additional mechanism is necessary to obtain these results. Simple truncation of a sample stream is the same as if the original audio had been quantized into fewer levels. For every bit knot, a given level of quantizing distortion will be reached at a level 6.02dB higher. Sample truncation, then, will not allow us to obtain the results predicted by information theory. The round off mechanism used with oversampling spreads the harmonic distortion due to truncation over the entire oversampling spectrum, thus distortion power within the baseband is only a fraction of the total. The fraction is in fact the reciprocal of the oversampling factor. For example, X4 oversampling allows two bits to be neglected, which potentially raises the level of harmonics by 12dB; the round-off system spreads these harmonics over a spectrum four times as great, thus the distortion within the baseband is reduced by a factor of four, or 12dB.

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

An example is given of a X4 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 undoubtedly 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 Phillips takes advantage of the aperture effect by using zero-order hold on the d.a.c. Ripple in the stop band is due to truncation of coefficients. (Diagram courtesy of Phillips Technical Review).

References

Fig. 7. In this X4 oversampling system, the large separation between baseband and sidebands allows a gentle roll-off reconstruction filter to be used.

Fig. 8(b). In X4 oversampling, for each set of input samples, four phases of coefficients are necessary, each of which produces one of the oversampled values.

Fig. 8(c). Practical implementation of digital filter. Shift register at the top provides access to several samples simultaneously. Multipliers produce contributions from each sample according to the coefficients. In X4 oversampling, there will be four coefficient phases and four output values before data at top shifts one place. Lateral data shift gives rise to name of transversal filter.

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

Fig. 10. By adding the error by truncation to the next value, the resolution of the lost bits is maintained in the duty cycle of the output. Here, truncation of 011 by two bits, would give continuous zeros, but the system repeats 0111,0111, which after filtering will produce a level of three quarters of a bit.
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 capacitance, and this led him to reassess Faraday's idea of the propagation of transverse electromagnetic waves.3 So the concepts of electric charge and magnetic energy preceded the concept of a transverse electromagnetic wave4, and it is generally agreed that Maxwell's theory is not primarily that the t.e.m. wave follows from the prior postulation of charge and current1,2.

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

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

Kip says that the energy dissipated in a resistor is proportional to the change in the electric current. However, this is not true in general, as energy is also dissipated in magnetic fields. For example, if a current flows in a magnetic field, the magnetic field will change, and energy is dissipated in the change of the magnetic field. This is known as the energy dissipation in magnetic materials.

Consider a plank of wood tapering to a point at the front, traveling at velocity v. The aspect ratio of the wood's cross section is z. Height and width at any point are

\[ \frac{h}{w} = \frac{z}{v} \]

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

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

Again from first principles, we can write

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

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

\[ \frac{\partial w}{\partial t} = \frac{z}{v} \frac{\partial w}{\partial t} \]

Cat's equations of motion for a tapering wooden plank:

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

Equations 2 and 4 we define as Cat's Equations of Motion for a wooden plank. Note that they hold true for any type of taper, and even for a straight portion of the plank, when both sides of the equations are equal to zero. The plank, we postulate that the temperature T is proportional to the density of the wood ρ, so that T/ρ = const.

Cat's equations 2 and 4 now become

\[ \frac{\partial w}{\partial t} = \frac{z}{v} \frac{\partial w}{\partial t} \]

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 extant versions of Maxwell's Equations for a vacuum.

\[ \frac{\partial E}{\partial t} = \frac{\partial B}{\partial t} \]

\[ \frac{\partial B}{\partial t} = \frac{\partial E}{\partial t} \]

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 text books (ref. 2):

\[ \frac{\partial E}{\partial t} = -\frac{\partial D}{\partial t} \]

\[ \frac{\partial B}{\partial t} = \frac{\partial H}{\partial t} \]

only imposed limitation is that h must be proportional to w. The velocity of the plank is the change of height with forward distance to the change of height at a point, with time, so from first principles, we can write

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

Cat's equations of motion for a thick warm plank

We postulate that a thick plank of wood travels forward with velocity v. At every point within the plank, we have

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

Only for explanation of the minus sign, see ref. 7.

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

\[ \frac{\partial h}{\partial t} = \frac{z}{v} \frac{\partial h}{\partial t} \]

By Ivor Catt
MAXWELL'S EQUATIONS

The hidden message in Maxwell's

In general, Maxwell's Equations
to a head-spinning brew, see
listed above. Other versions tend
to contain a mixture of integrals,
divs, curts, and much more, lead-
to a head-spinning brew, see
for instance refs 1,13. (For the
inscrutable Ultimate, see panel
.

Two questions arise:
do Maxwell's Equations con-	ain any information at all
about the nature of electromagne-
tism?

why do academics and practi-
tioners generally believe that
Maxwell's Equations are use-
ful?

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

Returning to equation 1, this is
only valid if the constant in the
equation equals the velocity of
propagation. When we then mix
the two together and w to produce
the hybrid equations 3 and 4, they
only remain true if w and
are always in fixed proportion z. So
we find that Maxwell's Equations
9 and 10 are only true if at
every point in space Z is propo-
tional to Il, and also if the velocity of
electromagnetism has the fixed value
. So the only information about electromagnetism contained in
the apparently sophisticated equa-
tions 9 and 10 is about the two
ruling constants in electromagne-
tism: the velocity c and
. I and E, every point is in
fixed proportion Z. The remain-
ing constant of electromagnetism is
howsRobert.

We have to conclude, with
respect to the fact that Maxwell
and his contemporaries do not say a
thing, disappearing plank of
wood isn't worth saying.

Now move on to the second
question, "Why do academics and
practitioners generally believe
that Maxwell's Equations are
useful?" The answer to this
question, derived from the pre-
cise discussion, is extraordinary.
We have already seen that
and c are the only items of
information hidden in Maxwell's
Equations. We resolve the para-
dox by pointing out that
is not a concept or a subset of
the whole of the fraternities called
modern physics:

The only way they can use such
a necessary constant is their work
is by taking on board with it all
the meaningless rubbish in digital
engineering. One is not in a
position to look at the evolution of
telecommunication, nor to
modern physics. Since there
no one has pointed out any case
where it is not important in the lit-
tration. It follows that
The only purpose served by
Maxwell's administration is to
derive the constant
is not available as a concept to
the practitioners.

If they lacked another source
for it, could also be accessed
via Maxwell's Equations, with instruc-
tions to some extent available
via other routes, although uni-
versity lecturers remain mystified
and vague about the velocity of
a t.e.m. wave. Curiously, they are
much more sure that the velocity
of light equals the constant c.

Did Maxwell lodge with his
bank managers, as is usually
assumed to his mathematical大脑。Maxwell's
Equations, with instructions to
open and publish a centenary later?
Did he bank lose the envelope?
Should we say to the postman, as
he sits laughing, or perhaps
"A fate like burning down your house to get

References
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3. p. 3, 41. Eq quoted made as say
ing that another means to
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CIRCLE 59 FOR FURTHER DETAILS.
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 2kByte cross ram with battery backup using addresses from zero to 7FF.

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

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

Communication between these aspects relies on a set of global variables in the 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.

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

When power is applied, the 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 t.i.L processor. The volume registers are all zeroed and all voxcons are set to default values giving a simple reed organ type sound, i.e. a triangle wave, about a -1.0V and all other features off.

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

- scan keyboard, turning on or off notes that have changed since the last scan,
- send values to the d-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 computers.

Three 185 five-pin DIn sockets are fitted to the instrument - 'Midi-in', 'Midi-out' and 'Midi-through'. Data is transmitted on pins four (positive) and five (negative) at 10mA current loop to drive opto-isolators at the receiving end. Cables used are shielded twisted pairs with the shield connected to pin two at both ends; this pin is only earthed at the transmitting end. The connector chassis is not connected and pins one and three are unused.

Data is transmitted serially at 31.25 kbaud. Each bit of the word is sent sequentially with a stop bit at the end. Data is transmitted in four bits using a Manchester code. If a number greater than 32 (00h) is transmitted, then the instrument will play that note as though the keyboard were continued to the right, provided that at least 15 bits are still within the instrument's pitch range. The actual highest value will depend on how the keyboard is currently transposed.

One restriction on Digipoly is that the Midi 'out' socket cannot be used at the same instant as the 'io' socket. This is because data is serialized and deserialized in software and not using a UART (universal asynchronous receiver transmits). I.e., the only problem is that there is a useful loop test involving connecting the 'out' and 'in' sockets of the same instrument will not work.

Midi output

If transmit-on mode is selected on the front panel, 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. Command messages that may be transmitted are (9h, 90h) which notifies any device on channel a that key 90h has been pressed on the Midi. Third, (8h, 40h) which notifies any device on the channel that key 40h has just been released, (Da 90h v) used to adjust sound-generating parameters of other instruments (and 91 04) sent as a continuous stream of double bytes on the Midi 'out' socket.

In the third command, adjustable parameter, the parameter to be modified, is p., 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 lights.

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

BUT 2 , port 7 is a bit-mapped image of buttons 19-32. All of these buttons are push-to-make and produce a zero when pressed.

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

STATUS, Port 9, is a read-only port with bit flag as follows. Bit seven, reflecting output of the oscillator into the arpeggio (TBASE), and is available to clock a sequencer which could be added as a software extension. Bit 6 is one if voltage from the rotary control potentiometer on the front panel is higher than that of the control d-a converter. In conjunction with CONTDAC, this bit allows analogue-to-digital conversion under software control so that the 8086 can read the knob position. Bit 2 is zero if the sustain foot switch is depressed. Bit 1 is one if the clavier key index by the value last recorded written to CONTDAC is currently held down. This controls the state of the Midi in serial-data line.

INFLUTE, port 11, when written to causes the voltage of the d-a output to be stored on a sample-and-hold capacitor. There are five of these capacitors. Writing number zero to four has the following effects.

- Code 000 sets the track oscillator frequency. The track oscillator produces a waveform for tremolo and vibrato and can be varied from about 0.2 to 10kHz.
- Code 001, tremolo depth varies the coupling of the track oscillator to the master clock to change the degree of vibrato in the sound by frequency modulation.
- Code 010, tremolo depth varies the coupling of the track oscillator to the multiply input of the main audio d-a converter. This changes the amount of tremolo in the sound by amplitude modification.
- Code 011, fine pitch, varies the steady frequency of the master clock to the Midi processor and so pitches the whole instrument.
- Code 100 sets the TBASE oscillator frequency over a range of about 0.2 to 10kHz.

HOSTREG, port 12, has its most significant bit inverted and connected directly to the Midi out socket at the back of the keyboard for communication with other instruments and computers.

Other bits in this port address regions of the t.i.L processor main memory. Values correspond directly to values 41 in the microcode instruction set.

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

DATAX, port 14, is used for writing data to the t.i.L processor. Values are up set in HOSTREG and INDEX, then the first data written is written to the port for passing to the t.i.L processor when it next executes a HOST instruction. Completion of the last operation can be detected by the 8086 using a handshake on its test input.

The 8086 has a WAIT instruction which causes the processor to wait until the test input goes low; it is normally advisable to execute a WAIT instruction before updating ports 12 to 14.
parameter, the main control knob is enabled and any change in its setting causes the adjust parameter command to be retransmitted with a new value of vv. Value vv ranges from zero to 127. In the final command, used as a hardware diagnostic aid, the two byte transmission is repeated about once every 400µs.

Midi input

Any data received on the Midi 'in' socket will be retransmitted on the 'through' socket. If the data is one of the following commands, it will also be interpreted by Digipoly. Since the keyboard has no touch-sensitivity software, the third byte of these commands need not be present for correct operation. Normally, the command will be interpreted as soon as the first two bytes are received. Commands are ( 9a kk 40 ), write on command, which plays a Digipoly note exactly as if a key had been pressed, ( 6a 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 70 00 ) for turning all notes off and ( FF ) for repeating the power-on reset sequence.

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

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

The L.T.I. 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 Groveley Way, Cramm- moor, Rawsham, Hampshire SO5 9XK. A 50 page listing of the 8088 source program is C3 and a 40 track disc for the BBC microcomputer holding source, object and related files is £4 (single density). Programmed 2764eproms containing the 8088 object code and a bipolar prom containing the L.T.I. processor code are £0.50 and £4 respectively. Please include £1 for UK postage and make cheques payable to D.J. Greene. Brave masters can obtain a copy of the hexadecimal listing by sending a large stamped addressed envelope and a cheque for £1.50 to our editorial offices. Please make this cheque payable to Business Press International.

Digipoly's main board. The L.T.I. processor is in the upper left area. Microcode prop, op-code latch, op-code decoder, 100ns register memory and the two a.Us are in the top row of L.e.s. Analogue circuits to the lower right include the output low-pass filter, vibrato and tremolo (note the glass encapsulated thermistors) sections and the d-to-a converter influence sample and hold circuits. To the right is a small perpendicular board holding the 10MHz master clock and at the left, a 4-pin keyboard socket and two 26-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.
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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.

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

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

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

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

Fig. 2. Being intended for working over a large area, the x, y-axes are supported at each end and slide on rails mounted above the work area. Figure 3 is a cylindrical coordinate robot similar to the rectangular coordinate configuration except that the x-axis linear movement is replaced by a rotary axis. This gives the robot a much wider working envelope but at the price of increased complexity in determining the tool position in world coordinates and the control of the axes for straight line motion.

The working envelope is usually a partial cylinder or wing or pipe-work generally presents a full 360° of rotation. Cylindrical coordinate robots are widely used for pick-and-place operations such as taking a finished component out of a press and placing it on a conveyer belt. If the belt is running parallel to the front of the press then the rotary axis will be moving through about 180°. A rectangular coordinate robot is unable to pick up a component in front of it and then transfer it to behind itself. The turret or spherical coordinate robot is like the cylindrical robot but with the linear x-axis replaced by a rotary joint—see Fig. 4. This permits vertical movement of the nozzle. They are usually used for a centre column taller than the movement required. When moving large loads there would be a huge tilting force on a tall column resulting in very heavy engineering being required. With the turret the gripper can be lifted well above the main body of the machine although it is unusual to have lifting capability of more than about 30° above horizontal. Their main application is the relocation of very heavy components such as engine castings and the like.

With their two rotary axes and one linear axis the working envelope of a turret robot is that of a partial spherical shell. Generally, a hydraulic system is necessary for providing the power to the axes of these robots. The most versatile configuration is that of the articulated or jointed arm robot, Fig. 5. This has similar features to the human arms. Axis alpha corresponds to the shoulder, and axis beta to the elbow and axis theta to the wrist. The versatility, however, results in a complicated relationship between axes angles and world coordinates, and it is often most practical to program such robots by teaching them on-site by leading the arm through the required positions using human eyesight as the means of establishing that the gripper or tool is in the correct location. Data corresponding to these axes coordinates which resulted in that final positioning is 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, by manipulation of a model of the robot, called a simulator. This last technique is parti-
lead to tilting of the component leading to jamming. Like gantry robots, scarf operate mostly on the horizontal plane with simple vertical movements and find most use for pick-and-place work and assembly operations where more versatility is not required. To simplify their application, the work is usually mechanically coupled to the waist with a pair of belts to keep the angle of the waist, with respect to the workpiece, constant irrespective of articulation of the arm except when specifically programmed to rotate.

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

Robotic categories are further sub-divided according to their control system which may be electronic or non-servo. The scarf control system is one where a sensor measures the position of the driven axis and uses it to modify the drive to that axis. Position sensors include potentiometers, linear variable differential transformers, resolver and optical devices such as shaft encoders. The power to the axis is dependent on the difference between the measured position and the desired position. It therefore follows that the axis will be at rest unless there is some interference between measured and desired position and the desired position will depend on the data or signal which defines the desired position.

In a non-servo robot the rest position is set by fixed stops. The axis is driven continuously and simply stalls when the stop is reached. This technique is widely used on pneumatic robots where the cylinder receives a continuous supply of air at one of the ends.Whilst automatic end-stops can be fitted to an axis, the movements of the robot will remain very simple and such machines is incorrect to refer to as an engineer, non-servo, and non-servo robot is unlikely to lose the title of the robot. The Japanese do not distinguish between servo units as robots, so the title 'robot' is bound to appear in sales literature. Rather than being involved in a losing battle regarding the nomenclature of the non-ambiguous titles of 'servo-controlled robot' and 'non-servo robot'.

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

The energy source for non-servo robots is generally pneumatic, using air compressed to between six and eight bar (a bar is 14.5 bar or 0.1 MPa) applied via solenoid-operated valves to a cylinder from which energy transfer is via the piston rod. The force from the cylinder is proportional to the area of the piston rod (less the area of the piston rod on double-acting cylinders). Double-acting cylinders are useful in applications where the piston must be moved in either direction, whilst single-acting ones rely on springs or gravity to return the piston. Hydraulic power could also be used for non-servo robots, but generally they normally handle only small loads the high energy capability of a hydraulic system is of little use.

Hydraulic systems are, however, more expensive than the larger servo-controlled robots. With working pressures up to 250 bar huge forces will be generated in the cylinders which are of similar size, but heavier, compared to those used for pneumatics. Hydraulic literally means 'using water' and the earliest hydraulic systems used water extensively. The new private telecommunications company, Mercury is now installing fibre optic cables to the wide network of ducts under London through which until only a few years ago The London Hydraulic Company was supplying high pressure hydraulic power to the telecommunication industry and for raising hotel lifts. Many hydraulic systems however now use mineral oil or water/oil emulsions, which amount to about 5% of the oil. The problem with water is that is it is not a very good lubricant, limiting the speed at which a piston can move without overheating of the piston seal at the point of contact with the cylinder wall.

A recent development in hydraulics called the rolling diaphragm (Fig. 8) has solved the problem of friction and hence runners pure water a suitable fluid for use in servo-controlled hydraulic systems. Hydraulics is unaffected by the rolling diaphragm and becomes suitable for use in clean environments as required for food handling, radioactive isolation, or laboratory work where spills of hydraulic oil would be unacceptable.

A conventional hydraulic seal is a ring of a resilient material such as rubber, rubber impregnated fabric or P.T.F.E. This fits into a groove around the piston and has a diameter slightly larger than that of the cylinder. Inside the cylinder, the ring compresses and the resilience causes it to firmly fill the gap between the piston groove and the cylinder wall. It is this necessary resilience which holds the seal/cylinder contact points under pressure during the friction.

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

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

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

Both stepper and servo motors, which may be either d.c. or a.c. are suitable for driving robots. Stepper motors have an even number of windings of which at any one time 1/2 have current passing through. The fixed magnetic flux holds the motor shaft stationary until a different combination of windings is switched. The shaft moves in a different position. On sequentially switching between the windings the shaft will step through a constant angle for each switching transition.

Servo motors are widely used in machine tools, such as the slide of a lathe where there is only moderate acceleration and deceleration, the response is much much faster than stepper motor on articulated arm robots on which the rapid change of position and loading can cause steps to be missed. Steps are minor when inserting the static load and only a static control is sufficient to ensure a smooth transition from one position to the next.

Electronics & Wireless World November 1985

Fig. 4. Diaphragm is clamped between two parts of cylinder and attached to the piston forming totally leakproof yet fully adjustable workpiece.

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

Fig. 6. Parthograph on an articulated arm robot enables the arm to maintain its position and remain perpendicular to the work station when the shoulder axis is moved, could

ECLECTRONICS & WIRELESS WORLD NOVEMBER 1985
Bob Coates describes the circuit of Kaycamp a 6800 microprocessor board with G64-bus option that can be built for £100.

Kaycamp is a low cost computer board using a 6800 micr0processor with 16-bit data bus. It is designed for use either as an evaluation-internal tool or as the processor board of a larger system, connecting to a wider array of readily available peripheral cards through its G64 bus. This second article describes the circuit.

Address decoding is performed by a three-to-eight-line decoder, IC2 of Fig.1 (below). The least significant address lines A15-A12 are decoded, splitting the 16M byte memory map into eight 2Mbyte blocks. For output select eprom, ram, 68681 dual universal asynchronous receiver/ transmitter (dutri), 68220 parallel interface/terminal (p.i.t.) and the G64 bus.

None of these five devices actually requires a 2Mbyte address space; the dual only needs 32 bytes. As a result, each device is repeatedly addressed throughout its 2Mbyte block — addressing for the dual is repeated 65,536 times! This may seem a waste of addressing space but for a small system such as Kaycamp it allows adequate memory capacity while greatly simplifying address decoding. Figure two shows the memory map.

EPROM and ram outputs are further gated with the upper and lower data strobe drives, LUDS and LDS, by IC5 for defining upper and lower-byte eproms and rams. The three enable inputs of IC5 also qualify the output strobes.

Address strobe AS allows an output valid delay only when a valid address appears on the address bus. To ensure that the output is valid only when the date bus carries valid data, the two data strobes are combined in IC5.

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

Finally, IC2 pin six inhibits output data during an interrupt acknowledge edge cycle during which the processor asserts A12 high. Without the inhibit signal, in the case of user vectored interrupts output seven would be selected to cause reading of the G64 bus at the time of the interrupting device placing its vector on the data bus.

Data acknowledge

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

Peripheral devices in the 68000 family have DTACK open drain outputs which are directly connected to the processor DTACK input along with a pull-up resistor. 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 different configurations for each type of device and the delay is selectable so it may be to the optimum required for each type of device on the board.

To keep things simple on Kaycamp, the chip select signals are direct outputs from DTACK which means that no wait states are inserted and the memories must be fast enough to allow this.

EPROM and ram select outputs of IC5 are enabled in IC5 at pin eight and then inverted by the open-collector inverter IC5 at pin zero, pulling DTACK low if either select output goes low.

Outputs one, three and six of IC5 are not used. If the processor tries to access a vacant part of the memory map no DTACK signal will be generated and so the processor will insert wait states automatically. Setting is necessary to recover the situation.

One output from each device does result in DTACK being generated in 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. Any synchronous transfer then takes place, no acknowledge being required. Output pin seven of IC5 going low pulls the 68000 VPA input low through IC5 pin eight.

Memories

In a 6800 bus system, byte-wide eeproms and rams are used in pairs. Memory IC5 is the lower-byte eeprom, IC6 the lower-byte ram, IC7 the upper-byte ram.

Lower byte device data buses connect to the processor D0-D7 lines and upper-byte device to the D8-D15 lines. Address pins connect to the processor address output ports but as there is no A0 output, A0 is connected to the 05000 memory address. Lower byte pins 23 and 26 go to link one and are also linked to the upper byte RAM.

Chip enable (CE) pins of each device driven from the appropriate output of IC5. Output enable (OE) pins connect to the read/write line, inverted at IC5.
Fig. 1. Full circuit of Kaycomp with G64 bus interface and both 08000 peripheral ICs connected. All these components fit on a double Eurocard sized board included in the kit described last month.
pin 10 so that the output buffers are disabled during write cycles. The read/write signal is memories is the processor read/write output gated with the add pass strobe.

G64 bus interface

Circuits IC4b—buffer on-board signals to the G64 bus, which can support a wide range of peripheral cards. The G64 bus specification allows a portion of the memory map (nominally 162byte) to be dedicated to peripheral cards, leaving the rest of the memory map being available for memory. An area which is accessed by a particular card is determined by either "valid memory address" or "valid peripheral address" being asserted low. These names are not to be confused with the 68000 pins of the same name.

To avoid confusion I will call them G64-VMA and G64-VP.

As Rycamp is not designed to use the G64 bus for memory expansion, the G64-VMA line is pulled high by resistor R3.

The G64-VPA memory block is only 162byte long so only address lines A0—A6 are needed. Once again the lack of an A7 line means that the G64 address lines are driven by the next higher 8000 address line and the block is considered 2byte wide in size.

Although 64 has 16 data bits, the processor uses only eight bits and no IC6, IC7, IC8, IC9, IC10, IC11, or IC12 to the external bus. As a result, only odd address lines are driven by any memory when accessing the G64-VMA block, as a rule, a processor may drive two odd addresses, or even addresses, which is the same as to say that the 8000 in which a vector address is fetched from memory. Two interrupt pins, I2P and I3P are connected to G64 VMA and I2Q lines. The third, I3P, is connected to the external interrupt output and may be optionally connected to the interrupt outputs of the peripheral interrupt controller IC11, IRQ and TIM5.

When the processor recognizes an interrupt on one of these standard hardware interrupts, it generates an interrupt acknowledge signal. A function code of all of these appears on the I2P or I3P outputs which causes pin six of IC6, to go high. This signal is inverted by open-collector buffer IC3, pin 2 to give a low level I2C signal during this cycle. When pin six is low, the output level is also high indicating that this is not the interrupt acknowledge signal. IC3 pin 11 and IC3 pin 10 are pulled to the G64-VMA VPA low. The same occurs when forcing a synchronization signal.

If IC6s are taken low during an interrupt acknowledge cycle, the processor's interrupt controller interprets this as a request for an auto-vector interrupt and sends a synchronous bus cycle. It responds by also taking VMA, which is why VMA is disabled if IACK is asserted. VMA and VMA serving dual purposes. Thus an interrupt signal which is also used to disable IACK (G64-VPB) generates an auto-vector interrupt signal. But two interrupt I2P, (a 68000 peripheral) does not cause IACK to go low and so generates a request for an auto-vector interrupt.

There are two types of interrupt defined in a later article. One in which the processor which accesses the G64-VMA line, IC4b, pin 10 takes IC4b 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 selecting the relevant G64-bus peripheral. The result is that, although the VPA is qualified by IC2, output pin six of IC2 chip, which is the VMA or IC4b is high, it is not an interrupt acknowledge cycle. However, the level of the auto-vectored interrupt acknowledge cycle also asserts VMA. The reason for this is to allow this gating of signals will become clear later when the interrupt handling discussion.

As mentioned last month, there are two types of interrupt and 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 8000 in which a vector address is fetched from memory.

Two interrupt pins, I2P and I3P are connected to G64 VMA and I2Q lines. The third, I3P, is connected to the external interrupt output and may be optionally connected to the two interrupt outputs of the peripheral interrupt controller IC11, IRQ and TIM5. The device generates a clean signal which should be the case unless the device is not used or the environment is electrically noisy.

The kit printed circuit board which is used to connect the IC4s to the G64 bus has a clock/calendar plus additional output flags and I/O. Mass storage devices. Backplanes, FMU and battery packs. Drive boards offering power output, signal conditioning and externally gated outputs. Memory card channels for low power, timing, sound or VTS. The new Cavendish Automation 7000 CPU is one of a complete range of Eurocards providing comprehensive interface control to G64. Support includes eight bus decoding, Display Down Control boards, Decoder boards, providing further address line decoding, watchdog, real time clock/calendar and external output chips and O/M. Mass storage devices. Backplanes, FMUs and battery packs. Drive boards offering power output, signal conditioning and externally gated outputs.

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Software for the unit described in September) is intended to run on the microprocessor. A complete listing of the software program and program description is available for those with a particular interest. This text however considers the general arrangement of the loop-type program being used.

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

**Table 1. I interloc labels.**

<table>
<thead>
<tr>
<th>Port A Page 09</th>
<th>Bit 0</th>
<th>Bit 1</th>
<th>Bit 2</th>
<th>Bit 3</th>
<th>Bit 4</th>
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<td>LANMT</td>
<td>PARX</td>
<td>BOSMT</td>
<td>HORT</td>
<td>ALMNT</td>
<td>FDOOR</td>
<td>KITSEN</td>
<td>KITCON</td>
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<td>STALGT</td>
<td>STALG0</td>
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<td>STALG0</td>
<td>STALG0</td>
<td>STALG0</td>
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<td>STALG0</td>
</tr>
<tr>
<td>Bit 2 Hall light</td>
<td>HALGT</td>
<td>HALG0</td>
<td>HALG0</td>
<td>HALG0</td>
<td>HALG0</td>
<td>HALG0</td>
<td>HALG0</td>
<td>HALG0</td>
</tr>
<tr>
<td>Bit 3 Kitchen light</td>
<td>KITLG0</td>
<td>KITLGT</td>
<td>KITLGT</td>
<td>KITLGT</td>
<td>KITLGT</td>
<td>KITLGT</td>
<td>KITLGT</td>
<td>KITLGT</td>
</tr>
<tr>
<td>Bit 4 Outside light</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
<td>OUTLG0</td>
</tr>
</tbody>
</table>

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 interconnection frequencies. These are various other subroutines that are required from time to time to supplement the main loop. The image is intended as a system diagnostic aid and will therefore hardly ever be used.

If a scan is to be performed then a display driven routine is available which can convert a number into the correct 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 up the loop if the editor has been called. Location `edit' 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 register and the rapid testing of the details of program. The editor will automatically cancel when its timer reaches zero, or it may be cancelled immediately by pressing key 6.

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

A keyboard input may be permitted 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 night only mode is required and a negative number if there is no person in the house. If an alarm condition is detected in mode 5, the routine `alarm', which is responsible for sounding an alarm when the premises are empty. The alarm is cancelled immediately with delay and reset of the alarm clock 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. After the call no longer valid, the outside alarm is activated along with the internal tone and the flashing lights. After several minutes, the alarm is cancelled and deactivated for a few seconds before retesting in mode 3.

Tests for simulate and silent entry are also made in mode 3. If the location `simul' is not zero then the routine `simul' is required. `Simul' performs its operation when `simul' (simulate timer) reaches the next value held in the data table `simul'. The addresses for the table starts at zero-page 80 hex and can continue to page one if this simplifies the required. The last item of data in `simul' must be 00 so that the routine is cancelled when this is reached. To set or clear a bit, it is simply necessary to set up the required bit address on the addres bus and the job is done. Reading individual bits is also possible from either of the set or clear addresses. The bit value is placed in the most significant bit position on the data bus so that it may be tested from the negative flag. Table 1 contains a list of the peripheral addresses and their label used in an assembly listing. At the start of the main program the registers are cleared, tables and constants set, stack initialized and port directions set. Mode 3 is set and the alarm temporarily deactivated.

Pulse is sent to the auto reset circuit at the start of the main loop. The peripheral data is then read by the `data' subroutine. This routine reads all the input port bits and deposits the data in registers in zero page.

In this particular implementation the ultrasonic detector is averaged to reduce the possibility of false calls. Registers containing the frequency at which the detector is read and the average value which is reached is also used. The value is averaged over about 50 seconds, and the stairs and kitchen lights turned off. Silent entry can be achieved with time to turn off the alarm in the prescribed manner.

When the alarm is set in mode 2, outside bedroom doors are locked first, if the door is not activated before any other, the alarm will be de-activated for about five minutes. The stairs and kitchen lights are turned on during deactiva-

Software for the Interloc: intelligent alarm and partial control of the electrical installation.
When the number is read 'OK' is level and auto reset prevention.

key presses. The routine lights
light) subroutine, which is
this will reduce the possibility of
Each key function is described
in the users literature.
Key calls the 'over' (overlight) subroutine, which is
responsibl for turning on any
light at keyboard request.
'Overed' uses the 'wait' subroutine for time intervals between
key presses. The routine lights
NO on the display, asking for
the number of light required.
When the number is read OK is
sent to the display before the rou-
tine ends. Timing of lights turned
on by 'overed' may be edited through
a register 'overed' (timer
constant for light extensions).
The lost 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 inc-
crements take place when a regis-
ter 'tine1' becomes zero. Regis-
ters time1, 2 and 3 are used to set
the main timing of the program,
in turn are set by zero page
constants 'main1' 'main1' and 'main3' which can be edited if cor-
rections are to be made. These
constants are used for flexibility, any
increase in the constants will
cause all timed events to be
quickier, and a decrease will make them slower. Most of the timers
that are incremented are two-byte
timers which gives an approximate
value for byte two of 256 x 6
or about 1 day in the system
described.
The only subroutine not dis-
cussed is 'wait', which is a delay
routine used by parts of the program. It also sends
pulses to the auto-reset circuit
since it may be used for long
delays. 'Wait' is 0.077 seconds
long which makes it useful to call
before verifying contact calls.
This subroutine is not called
when the loop is simply running
free without any diversions.

Summary
The unit described represents a
working system that has proven
to be both reliable and pleasant in
use. The final system has been
working for over two years, but
the unit has been working in test
form for over 12 months before
this. Automatic to get use, 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, regis-
ters may be included like 'olset',
to allow this option. It would sim-
ply be necessary to keep a record of
the calling contact and time
between calls to recognise the
faulty position. This position
could be masked from the alarm
routine.

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

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

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

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

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

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ELECTRONICS & WIRELESS WORLD NOVEMBER 1985

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EWW

CIRCLE 64 FOR FURTHER DETAILS.
Why stereophonic images broaden

As an image moves away from stage centre its width increases for frequencies up to 300 Hz, 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 wavefront from a given sound scene in an exact form over a region in space occupied by the head of a listener. The use of two spatially separated loudspeakers imposes restrictions on the ability of stereophony to reconstruct the correct acoustic field so that a sharp image can be perceived. Such a system can provide a well-defined image for a centrally located listener mainly at low frequencies, depending on the geometrical displacement of the speakers relative to the listener. It has been observed previously that images tend to broaden as they are displaced along the stage width. The problem 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 toward generating well-defined stereophonic images.

What causes image broadening?

The answer to this question can be found by considering stereophony as a wavefront reconstruction. The wavefront reconstruction of looking at sound source not limited in angle and encompasses the case of a general sound source which could completely surround a listener.

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

Thus the residual obtained by removing the plane-wave component of the wavefront from the reconstructed field reveals the contributions present due to other auxiliary sources in space.

The main image is defined by the plane-wave component and the auxiliary sources create the impression of spreading of the main source. This is broadening.

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

$$F(x) = \text{Re}[F(x)] + \text{Im}[F(x)] = \text{Re}[\text{exp}(i2\pi f x)]$$

where $R$ and $L$ are the amplitudes of right and left channels respectively and $k = 2\pi f$. Ignoring the complex image wave term, as it carries no directional information, leaves

$$F(x) = 2\text{Re}[	ext{cos}(\text{Im}(x))] + (R - L) \exp(-i2\pi f x)$$

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

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

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

$$F(x) = 2\text{Re}[	ext{cos}(\text{Im}(x))]$$

To decompose $F(x)$ into its harmonic components, $F(x)$ can be defined as a repetitive function $F(x) = \sum_{n=1}^{\infty} a_n \cos(n\pi x)$, so that the Fourier series expansion can be applied, where $a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} F(x) \cos(n\pi x) dx$ is a comb function with period $2\pi$, equal to the head width $H$.

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

For $-\frac{X}{2} \leq x \leq \frac{X}{2}$, the series expansion of $F(x)$ is

$$2\text{Re}[\text{Asin}(x)] = \frac{2}{\pi} \sum_{n=1}^{\infty} a_n \cos(n\pi x)$$

Where $A = (\pi^2 / 8) \text{Im}(x)$, a (integer values of $A$ lead to simple solutions). The constant term of this equation decreases as frequency increases. The harmonic components that are responsible for image broadening will increase in value as frequency rises.

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

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

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

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

General approach for finding image width factor

The use of equation 3, to determine IFW 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 $R \neq L$. The derivation of such an expression is cumbersome and unnecessary.

A simple and convenient approach is by software. The computer simulation involves generating the wavefront $F(x)$ over a region of $X_0 \times 2X_0$.

The use of two spatially-separated loudspeakers results in the image position being expressed as an image displacement from centre stage. This is in agreement with equation 3 which suggests that the image width factor is given by

$$\text{IFW} = \frac{\text{width of image}}{\text{width of wavefront}}$$

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

$$\text{IFW} = \frac{\text{width of image}}{\text{width of wavefront}}$$

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

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

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

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

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

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

Fig. 1 Stereophonic system geometry ($W = 2.3m$, $H = 2.0m$).
broader on-axis images with increases in frequency.

Listening tests
Practical tests have been carried out to validate the theoretical predictions made above. The tests involved subjectively determining image width using the geometric arrangement in Fig. 1. The tests were carried out in an anechoic chamber with reverberation time of less than 0.25 seconds for all frequencies down to 125 Hz. The signal used was a 10-cycle band limited pink noise produced by a random noise generator in conjunction with a band-pass filter set (Bessel & Kaiser type 1400 and 1430). Each loudspeaker cabinet housed a single 8" full range unit produced by Goodmans Loudspeakers Ltd. Ten subjects took part in the tests.

The subject, occupying a central position, was asked to maintain a fixed head position and look directly toward the stage, centre. The listeners were then told to state the location of the image and its width using the dimensions on a bar placed along the stage width. The tests were carried out using 250, 500, 1250 Hz, as centre frequencies of the J-0.5 wave.

A practical results of image width versus image position in terms of stage width as shown in Figs 2a, 3a, and 4b. Comparison between theoretical and practical results shows good agreement. The practical curves in Figs 2 to 4 for the central frequency of 2500 Hz shows that image width increases as image is displaced away from stage centre. This is in good agreement with theoretical predictions in Fig. 2a. Fig. 3b. 500 Hz, shows an almost constant image width. This compares very well with the theoretical results in Fig. 5a. At high frequencies, 1250 Hz, Figs 4a and b, both practical and theoretical results show that image width decreases as the image moves away from stage centre.

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

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

An array of speakers is generally regarded as an excellent form of stereoaphonic sound reproduction. However, the cost and inconvenience of having many speakers makes this approach uninviting. Quite a lot of methods of improving image quality have been proposed while retaining the conventional two speakers systems. While these methods may help to improve the accuracy of localization and naturalness of stereoaphonic images, they do not solve the fundamental problem of image broadening. The use of video cassettes, with the potential for storing many audio channels may help reduce the cost of having an array of speakers and thus facilitate the use of such a system which is the only real way of solving the problem of image broadening, or indeed of overcoming the general problem of fidelity and usable listening area in stereoaphonic sound reproduction.
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ELECTRONICS & WIRELESS WORLD NOVEMBER 1985
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 margin' and 'noise immunity'. Noise voltage margins were usually given as a requirement but allowed impedance levels were not always so readily supplied by those proposing the new schemes. A correspondent recently re-activated the discussion in comparing the relative merits of t.t. and c-mos logic. This triggered me into writing this paper, as I have been doing for some years, and deal with a subject that I know, as far as I am aware, have 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 radio engineer's bus - on his way to work - vacuum-tube voltage amplifiers, with their attendant distortion, were all the rage in the design of telephone Repeaters. Later a wealth of 'elise mathematical knowledge was built up, notably by Nyquist and by Reilly, on the 'stability' of amplifiers using these devices having a feedback arrangement. Unfortunately, a basic difficulty arising in practice is that many feedback problems are not directly solved by using a single, isolated feedback schematic form and associated elementary assumptions encountered at the outset. The feedback amplifier is, quite often, the bipolar transistor, for many years the basic amplifying device, has an incremental input resistance which is in most applications just not big enough to be regarded as infinite. The problem then, for those intending to use practical devices in proposed designs, is how to interpret the Nyquist criterion in its simplified received form.

"Logic gates" by T. Berisford, "Electronics and Wireless World" March 1984, p.32

"Breaking the loop - Nyquist revisited"

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

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 not work β are assumed to be unilateral, non-interactive blocks. Then signal flow is from left-to-right only, in A, which is presumed to have an infinite input impedance and zero output impedances. Similarly, signal flow is right-to-left only in β, which is assumed to have zero output impedance. From the above, taking the note of arrow directions, \( v_i = v_f = v_1 = \left(1 - \beta \right)v_i \) and so

\[ A \left(1 - \beta \right) = \frac{v_i}{v_i} = A \left(1 + \beta \right) \]

In this simple derivation we have used a convention popular with electronics engineers, that the signal fed back is added algebraically to the input signal in the input circuit. There is no attempt yet to define a polarity of feedback. This approach contrasts with the different but equally acceptable convention adopted by control engineers who, being interested in error-actuated systems, assume the feedback signal intentionally to be subtracted from the input signal in some mixing process in the input circuit. The difference in the two conventions leads to a +/- sign for \( A \beta \) in the control approach. I shall adhere to the electronics' approach. \[ A \left(1 - \beta \right) = 1 \] the feedback degenerative or 'negative', i.e. the magnitude of the overall gain is less than that obtained with the amplifier alone. The benefits gained constitute the well-known list of 'gains': important among these for electronics engineers is the denominational property of A with respect to tolerances and changes in A resulting from environmental variations, such as temperature. (The mutual conductance of a bipolar transistor changes about 0.3% per deg.C)

The price to be paid for the benefits arises because factors A and β are

\[ A \left(1 - \beta \right) = \left| A \right| \left(1 - \beta \right) \]

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The price to be paid for the benefits arises because factors A and β are

\[ A \left(1 - \beta \right) = \left| A \right| \left(1 - \beta \right) \]
Fig. 5. Loop gain for the circuit in Fig. 4c is obtained by opening up the loop but maintaining the impedance levels shown.

![Fig. 5](image)

nyquist revisited

![Fig. 6](image)

A practical non-inverting op amp scheme for investigation of stability, analyzed in Figs. 7 & 8.

![Fig. 7](image)

Equivalent circuit of Fig. 6 for straightforward circuit analysis.

ELECTRONICS & WIRELESS WORLD NOVEMBER 1985
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\[ t_1 = \frac{m}{N + 1} \]

where 1 \( m \leq 10 \) is the harmonic number and 1 \( N \leq 256 \) is the programmed counter module. For the second time

\[ t_2 = \frac{m}{N + 1} \cdot \frac{m}{N + 1} \]

As \( f_o = \frac{f}{m} \) is a function of the p.L.

\[ f_o = \frac{N + 1}{N + 1} \cdot \frac{N + 1}{N + 1} \]

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

Kamil Kraus

Czechoslovakia

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

Supply insensitive current source

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

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

The basic circuit gives

\[ I_o = \frac{V_o - V_{in}}{R_o} \]

Feedback connection of Tr3 and Tr4 to force Tr1 to pass a collector current effectively equal to \( I_o \) if small base currents are ignored.

Corresponding \( V_{in} \) causes an emitter current in Tr3. \( V_{in} \) is thermal voltage

\[ V_{in} = \text{BTDC} \]

approximately \( V_{in} \), which is also the value for output current \( I_1 \) if small base currents are again ignored.

Sensitivity factor \( S \) defines dependence of \( I_1 \) on \( V \) thus,

\[ V_{in} = (S/I_1) \cdot V \]

constant, \( T \) is absolute temperature and \( q \) is electronic charge magnitude.

\[ V = 25 \text{mV at room temperature and } V_{in} = 2.25 \text{mV typically, } S \approx 0.04. \text{ Thus a 10% change in } V \text{ produces a change in } I_1 \text{ of about 0.4%.} \]

Transistor Tr5 and diode string Tr6 together with their bias resistor R8 give a cascaded output stage.

Low-frequency incremental output resistance \( r_o \) is

\[ r_o = 8 \times 10^5 \text{ (ohms)} \]

In this, 6 is the common emitter direct-current gain of Tr5. Using \( I_1 \) in place of \( I_1 \) in a further cascaded stage, employing p-n-p transistors virtually eliminates the effects of power supply variations.

Selection of semiconductor devices is uncritical but a convenient low-cost choice is ZX2000 for the transistors (Ferranti) and 11418 for the diodes. Choosing \( V^* \) as 5V and \( R_2 \) as 3.3k allows \( V_{in} = 1 \text{mA and } V_{in} = 3 \text{mV. Thus if } V_{in} = 5 \text{mV and } R_2 = 1 \text{ is a } 5 \text{002 potentiometer the setting } I_1 \text{ is } 1 \text{mA. A value of } 3.3 \text{k} \text{ is convenient for } R_2. \text{ Taking } 8-100, \text{ the incremental output resistance can be expected to exceed } 10 \text{MQ.} \]

B.L. Hart

Leigh-on-Sea

Essex

CIRCUIT SHOWS FURTHER DETAILS.

**CIRCUIT SHOWN FURTHER DETAILS.**

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**CIRCUIT SHOWN FURTHER DETAILS.**
RS232 data recording

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

Incoming serial data is limited to ±7V and fed to the recorder head, giving full saturation of the tape. On playback, only flux changes give any tape head output, so a differentiated version of the original signal is available. This is amplified through IC2 whose response is tailored to minimize noise pickup, and fed to a bistable circuit IC3 to regenerate the original waveform.

Threshold levels of the bistable circuit may be varied to suit the tape head by changing the 4kΩ feedback resistor. Output of IC3 is buffered to give suitable levels and the buffer output is given some protection by a 330Ω resistor.

Since the state of IC3 will be indeterminate on power up, and could change with such events as motor switching, a push switch is included to keep the IC in its reset state until the play button is pressed. For the prototype, I found a pair of normally-closed contacts on the cassette unit but a microswitch could easily be added.

K.A. Cooper
Suffolk

Cable-core identifier

With the aid of an ohmmeter, this simple tool speeds up identification of cores within a cable. The meter must be 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 B multimeter.

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

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

H.T. Wyne
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 supply, and -5V for serial interfaces, LEDs, etc. Its major feature is that the diodes D1 and D2, which alternately charge capacitors C1 and C2 on both halves of the d.c. cycle, thus forming a full-wave rectifying system. Diodes D1 and D2, and capacitors C1 and C2 form simple half-wave rectifiers which are acceptable in view of the usual lower current requirement for +12V and +5V supplies.

H. Sa
Universidade de Coimbra
Portugal
When engine speed falls below 1200 rev/min, the solenoid of idle fuel supply when engine switches this solenoid to shut off idle fuel supply when engine speed rises above 1800rev/min. Above this speed, most of the fuel is supplied by the main jet so engine performance is not affected.

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

**Voltage-controlled frequency divider**

As part of a low-frequency digital waveform generator, this voltage-controlled frequency source provides output pulses synchronized with an external circuit. Normal Q-to-D connection around a D-type bistable i.e. is replaced by a time delay consisting of the current mirror $T_{Rg}$ and capacitor $C_{C}$. Current through $T_{Rg}$, controlled by variable external voltage $V_{C}$, is mirrored in $T_{Rg}$ and varies charging time of the capacitor. When $Q$ goes high, $T_{Rg}$ resets the circuit by discharging the capacitor, hence a sync pulse with a period equal to that of the clock is provided followed by a continuously variable delay determined by $V_{C}$.

R. Lowman
Milton Berwyn
Buckinghamshire

**Greater efficiency in power converters**

In a single-ended power converter, a resonant circuit is formed by the combination of transformer internal capacitance $C_{T}$ 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$_{y}$ allows energy recovery. Less snubbing is needed as there is less energy circulating.

Richard Aston
Sutton Survey

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---

**Circuit Ideas**

**Fuel saver**

While a car is decelerating, its engine does not require fuel. On many modern cars, the carburettor has a solenoid that stops idle fuel supply when the ignition is turned off to prevent "running on". The circuit shown switches this solenoid to shut off idle fuel supply when engine speed falls below 1200rev/min. Above this speed, most of the fuel is supplied by the main jet so engine performance is not affected.

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

R. Lowman
Milton Berwyn
Buckinghamshire

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**Humidity control**

There is a diode missing at the left-hand side of this circuit published in the October issue. This diode replaces the link between the junction of R and the 7-50 resistor and the positive rail. The diode cathode connects to the positive rail.
**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 considerable time saving of about 300 bits per second, a speed which was fast by comparison with the上世纪.

And the transmission standards have changed little in wide-spread use for public-access systems. Today, compact 300 bits/second modems can be bought by home computer users for the price of a few cassette tapes. So, too, can 1200/75 bits/second versions which give access to videophone systems such as British Telecom’s Pres.

The buyer now has a very large range of low-speed modems to choose from, though the introduction of special purpose modems has been slow to the hardware differences between one model and another are sometimes slight. However, some include special additional features, such as multiple standard operation, automatic-answer and data-rate selection, automatic-dialling and diagnostics.

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

<table>
<thead>
<tr>
<th>Table 1: CCITT modem standards for the public switched telephone network and for private lease-lines.</th>
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<td>CCITT</td>
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<td>V.23</td>
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<td>V.37 ter</td>
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<td>V.39</td>
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**Modems**

This microprocessor-based low-speed modem covers speeds of up to 1200 bits/s. Special features include an auto-dialler and a speed conversion buffer for access to viewed from terminals (such as the IBM p.c.) which can be used and receive at different rates.

**Wireless World**

**EDITORIAL FEATURES 1986**

The next editorial features to D and D to A converters will appear in the January 1986 issue for more details regarding advertising:

Contact Bob Nibbs
01-661 3130

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**Electronics & Wireless World November 1985**

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- CCITT V.23 1200/75 B/D duplex (Vidox/Video/Viewdata Host)
- USA BELL STANDARD
- Bell 103 ORI. 300 B/D duplex
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Duplex operation at 9600 baud over a two-wire telephone line is possible using a modem such as this one, the DM4682X 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 personal computer user. Its automatic error-correction copes with the momentary breaks in communication caused by radio fading and by switching action in the cellular network.

**MODEMS**

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**MODEMS**
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 £20 to make (E&WW, May-July and December 1984; the p.c.b is still available). A series by Martin Allard describing a personal electronic mail system for the constructor began in the August issue. And a microprocessor-based multi-standard terminal unit was described by John Walker in October’s issue.

Telephone lines

Telephone circuits come in three basic forms:

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

A simple 300 b/s/4 V.21 modem is still sufficient for many purposes; this direct-connect model is by Answercall.

Bits and bauds

In the V.21 and V.23 modes data is carried by a pair of simple audible tones; one travelling in each 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.

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 per second, since it takes ten bits or so to send each letter.

With more advanced modulation methods, it is possible to increase the number of bits represented by each symbol in the transmission medium. For example: with phase-shift keying, four possible phase shifts can be used to denote 11, 10, 01 and 00. Each symbol then carries two bits, giving data transfer at 600 bits/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.

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

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

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Eeprom programmer software

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

by Norman Sargent

These additions to my program published on page 45 of the July issue of IEE Publications: A Radio and Television Servicing Series, 1985-86 are as follows: the on-off feature is added for developing and manipulating data in memory.

In the software, on returning to the program after editing memory, the eeprom list menu is entered and the default disc drive is then reset to the Eeprom menu. With these changes, the program returns to command mode with the selected eeprom list menu.

After editing memory, key 0 is used to return to the program immediately. This function key, and any others that you may want to define for use during memory editing, is defined in line 130. If you need to define several keys, this line could be replaced by a procedure.

The function is disabled by line 150 and is enabled by the memory editing command to prevent spurious entries when the computer asks for input and you press the wrong user key.

To reset the programmer after it has locked up, which can happen for example when the break line is pressed, the command is issued and no error is fitted, a simple momentary push-to-make switch can be connected to the ground through a 1k resistor to pin 14 of IC, on the programmer. This will also remove any programming voltages on the slave socket to allow removal of the erpm.

There are no problems with reading and programming 9219 with 9419 processors, but note that bits in these devices are at zero when erased, and not 1 like a memory with an standard erpm.

The program detects this during an erase-verification command.

I have fitted sideways test to my computer and use Toolstar's T55 board to do a erase-verification command to the blocks of data around in memory.

This, in conjunction with the user-defined keys and these program modifications, allows speedy development of eeprom-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 to pin 20 of the 50 pin of the programmer.

Linear IC Equivalents and Pin Connections by Adrian Michaels: Bernstadt Radio (publishing) Ltd, 247 pages, £15 to £200, soft covers, £4.95. Lists the European, U.S. and Japanese ICs from a wide range of ICs. The tables are supplemented by 80 pages of self-convolution diagrams. From the same publisher, since the same price, comes a companion volume, Digital IC Equivalents and Pin Connections (490pp).

BSC Catalogue 1985. British Standards, soft covers 419 pages. Available by post from the Sales Department, BSC, Linford Wood, Milton Keynes, Buckinghamshire for non-members is £19. How to obtain specifications for just about every product or activity you can think of: from A-series paper to Zones of comfort in earth-moving machinery, from test-gauging lenses (BS5361) to ethylene glycol (BS5327). Of particular interest are the BS8000 series and the many other specifications relating to the electronics industry. An introductory section outlines the work of the BSI and lists centres in Britain and overseas where complete sets of British Standards are available for reference. A table lists corresponding IEC and BSI standards.


Micro-Prolog and Artificial Intelligence by A.A. Beck, Collins, 164 pages, soft covers, £9.95. Lists a range of microcomputer based expert systems applications, and explains the thought processes behind such systems.

Micro-Processors and electronic data handling by R. Stainer. Adam Hipser, 148 pages, price £12.95, hard cover, ISBN 071311959 (hard cover). Interested as an undergraduate-level text for physics or electrical engineering, this book is a well-written survey for electronics students. Chapters cover the design of microprocessor systems, and applications to a variety of electronic systems and their characteristics, with particular emphasis on activities and professional computer science and research. The book is written in a style that emphasizes the concept of electronic instrumentation, digital electronics and computer technology.

Within the BBC Microcomputer by Roger Cullis. Losco Ltd (P.O. Box 4, Corsham, Wiltshire, SN13 8BQ), wire bound, £11.95 plus £1.80 postage. Invaluable reference book for advanced programmers, giving much of the information on the Acorn as hoped could be hoped for, of a commented assembler listing: Sections cover your own module the 1,2 operating system, Basic 1 and 2, Hi-Basic for the 3022 processor, the 0,90 disc filing system, 3,34 Emac and others. For each version the author gives a general description, a plan of its zero-page and other work, a gazetteer explaining the function for each line of code and (most useful) a reference table showing the calling locations of jumps, subroutine calls and look-up.

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

Cost-effective Electronic Construction by John Watson, revised edition. Macmillan, 142 pages, soft covers, £5.95. This project's for the hobbyist and a further eighteen circuit ideas, all designed with a value-for-money in mind: among them is a automatic pot light, a feedback DSC controller, sensor strobe, temperature alarm, portable meter interface and a radio-controlled system. Each project is fully explained and, to help the beginner, detailed shopping lists are given at the back of the book.

Fundamental Fort by Richard Lyndall and Michael Benson. Personal Computer News Journal, Banbury, Oxford, 292 pages, soft covers, £8.95. In the first 30 pages is a complete set of lecture notes, introduction to computers, programming and Fort; then there is a look at the keyboards and layout of the language. Topics covered include string-handling and the use of disk. 36 apprentices to describe the syntax of Forts words to Pig-Forth, Forts-79 and For83 versions.


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Fed up with trying to locate suppliers and technical support for plug-in boards for the IBM-PC, Detek 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 our own experts as well as other users. Ranges to be stocked include Techmar, 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 special products. They already offer a similar service for the Saxony 500 Computer and can offer a complete package to the customer including monitors, printers etc.

D.C. converter on a card

This d.c. converter is the Rifa PKA which has an integral board and can provide 40W power. Mounted on a Eurocard by Campbell Collins, the user can add a bridge rectifier and a reservoir capacitor for a.c. input; a trimmer for output voltage adjustment and a protection indicator on the board. The Rifa converters use a very high frequency switching rate which gives them high efficiency, over 85% and an m.l.h.f. of over 200 years. The card produces 5V at 8A for an input of 45V. The outputs may be connected in parallel to provide more power. Campbell Collins Ltd, 159 High Street, Stevenage, Herts. E/W 217.

Lap-sized CP/M computer

Designed and built in the UK, Microco 600 is a little larger than a paperback book, yet incorporates 1256, or ram and 64K of read-only PROM. It's a version of Basic. It is battery driven, and can have an idiotic "CUTT" V21 full duplex modem fitted within its case. The 600 is run an HD68140 c-mos processor which uses a superfast of 280 instruction codes. Ram may be increased to 256 or 32K and the firmware includes the CVM operating system, Locomotive Basic interpreter, ram controller and an optional toolkit for software developers. The computer communicates through two RS232 ports to printers, bar-code readers or other serial device. The case can be easily extended during manufacture to include a built-in printer or other peripheral. The keyboard has the conventional qwerty layout, but it is smaller than on a typewriter. All 67 keys are reprogrammable to any function.

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An additional com and p.c.b.

- BBC Micro into a multitasking computer capable of running the OS-W386DOS system and high-speed, high resolution graphics. The Upgrade from Cumana includes 316K ram, double-density floppy disc controller, SIS interface for one or more hard discs, battery-backed real-time clock, and a comprehensive collection of software. The p.c.b. has 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 into the upgrade board.

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

The OS-9 system is similar to Unix in operation and is compatible with Unix at the C-shell-code level. However it has certain advantages over Unix, in that 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 real-time and monitoring applications. The hardware is packaged with OS-9, Stylograph word-processing system, Dynacnic electronic spreadsheet, Sculptor database, Interactive Basic 99 specifications and Hypercanvas Pascal-like structures, compilers for C and ISO-Pascal, and assembler and a graphics kernel that offers windowing facilities and multiple character sets. For about £7000. A similar board is available from the Cumana Ltd. The Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3BD. E/W 207.
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**Electronics & Wireless World November 1985**
NEW PRODUCTS

Swept functions up to 2MHz

Sine, square and triangular waveforms over a frequency range of 0.5Hz to 2MHz can be generated by the Emetrite 4416/2. The frequency can be selected by the front panel controls, an external direct voltage or through the general-purpose interface bus. Output levels are variable up to 10V peak-to-peak with or without voltage offset. In addition the generator enables the frequency to be swept up to 10000 Hz with sweep times variable from 30ms to 30s. Full control of the waveform selection, amplitude, frequency and offset is possible through the interface.

Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5SH, EWW 215

Technical computer

Designed and produced in the UK, the Technical Computer from Positron is specifically intended for engineering and scientific applications. It is based around two Motorola 6809E processors and operates under OS-9 and Basic 89 (see also item on Compaq's OS-9 Upgrade.)

The computer features multi-user access. Four X interfaces may be used for control and/or system design. Several background operations, such as printing, plotting and instrumentation control can be performed concurrently while the workstation continues to operate interactively. Real-time operation means that the system is fast enough to receive, process and respond to data from external sources. Basic 89 is an advanced, version of Basic which in many ways is similar to Cebol, importing many of the facilities from Pascal which enables programs to be modular, structured and capable of using a range of data structures. The system includes a text editor, run-time interpreter and a high-level interactive bug-hunter. The OS-9 operating system is high speed and offers multi-user software development through a range of access rights together with record locking within three structures directories. Each workstation has a c.r.t. display with 24 lines by 80 characters and a 25th line for the use of the operator or the display of status. It also has a graphics display of 640 by 40 dots and a drawing speed of 16milli seconds.

A graphics plotter provides hardcopy and a graphics tablet may be used for input. Positron Computers Ltd, Deacon Trimming Estate, Newton-le-Willows, Lancs WA12 9QX, EWW 215

Cellular phone

The first car telephone designed specifically for the UK cellular radio system is the claim of Philips for their M7000, inferring that other sets are adaptations from American or Scandinavian models. In addition to the facilities offered normally by such telephones - storage of frequently used numbers, on-hook dialling and security locking - this model also has number scrolling, re-dialling of the last 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. Modelling a digit can be corrected without having to start again. It is also possible to listen to the conversation over a separate loudspeaker while entering a number in the handset's scratchpad.

Darlington-in-line

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

Bright-light indicators

Alphanumeric characters, four in a row, can be viewed in sunlight says their manufacturers 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. At full set of characters may be displayed. The green version is suitable for viewing through pilots' night-vision goggles. Hewlett-Packard Ltd, Edkate House, Winnersh, Wokingham, Berks RG11 5DZ, EWW 212

Electronics & Wireless World November 1985

From Shure, a microphone system that mixes automatically.

Presenting a remarkable breakthrough from Shure — a microphone mixer and logic technology all contained in channel-appropriate integrated system of quite astonishingly simple operation. Each microphone has complete independence within the system, eliminating all associated sounds. Concern is pre-setting the individual volume levels. Its mixers (4- and 8-channel varieties) can easily be linked to control separate microphones. Which makes the mixers extremely ideal for conferences and symposiums through it performs excellently in churches, courthouses, teleconferencing, broadcasting. And asynchronous logic terminals provide unparalleled flexibility for including.

AMS 30, outside a low-cost 120-channel receiver and continuously analysing an environment as each channel adapts itself autonomously as audio conditions change. In fact, the AMS Automatic Microphone System is so simple to use that an operator's only concern is pre-setting the individual volume levels. Its mixers (4- and 8-channel varieties) can easily be linked to control separate microphones. Which makes the mixers extremely ideal for conferences and symposiums through it performs excellently in churches, courthouses, teleconferencing, broadcasting. And asynchronous logic terminals provide unparalleled flexibility for including.

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**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-code commonly used, mathematically complex routines, and can concentrate on problem solving rather than on writing, testing and documenting codes for difficult algorithms. Subroutines in the library can be called from programs written in either Fortran or C. The software has been developed by Quantitative Technology.

**Data aquisition module**
Remote monitoring and control of any electrically operated machinery is possible with the Sciterra Brain. 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 1WV. EWW 218

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

**Eurocard controller**
An adaptable new single Eurocard computer that may be programmed in Basic, Fortran or Assembler lends itself to industrial instrumentation and control. The Essex Chameleon is based on Rockwell's 6501A 2MHz single-chip computer and features 2 x 16-bit counter inputs, 54 parallel input/output lines, full duplex serial channel to RS232/422 (RS212, four 29pin memory sockets with a total capacity of expandable 64K bytes ram/eprom with 8K of ram fitted as standard, and full compatibility with the Essex range of cards. Essex Electronics Centre, Wivenhoe Park, Colchester, Essex CO4 3SU. EWW 220

**Printer buffer**
A range of printer buffers are available that can free your computer from waiting while documents are being printed. The series from PMCL include many options of memory size and whether serial or parallel (or both) interfacing is required. Versions are available to fit inside Epson and IBM printers and free-standing models can be used with any printer. These last-mentioned models also include additional features such as the ability to pause between single pages or produce multiple copies. The range starts at £75 for an 8K buffer that will plug inside an Epson printer with either serial or parallel interfacing. Top of the range is a 256K free-standing model that includes both parallel and serial links for £370. Kits are available to upgrade the chosen buffer for future expansion. PMCL Ltd, Royal Mills, Esher, Surrey. EWW 206

**E.c.l. and t.t.l. share same gate array**
An 1800-gate bipolar gate array from AMD features input/output interfaces that can be configured for mixed emitter-coupled and transistor/collector logic operation. The AmMPA1850 incorporates the same set of internal macrocells that are used in Motorola's MCA-1 library along with additional property functions developed by AMD. The advantage of the combined e.c.l. and t.t.l. is that it may be used for high speed applications such as video graphics and disc storage systems. The device is available in a variety of packages from 28 to 120 pins. AMD offers an 8-week turn around from receipt of the customer's net list to delivery of the first samples. They use a development system that combines a logic simulator with test program generator, automatic placement and routing, and an electrical design rule checker. Designs can be completed from a logic net list, a finished layout or any intermediate stage. Advanced Micro Devices (UK) Ltd, Goldsworth Road, Woking, Surrey GU21 1UT. EWW 205

**Frequency meter for the pocket**
Enclosed in the unmistakable case of a Thandar instrument, bequeathed to them by Sinclair Radionics, is their new frequency meter which can count between 20Hz and 200MHz with a 0.1Hz resolution. It features a sensitivity of 10mV, a timebase accuracy of 2μs.p.m. and an 8-digit display. It is powered by internal batteries and low power is indicated by the simultaneous lighting of all the decimal points. Optional accessories include prescalers, a.c.

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**Precision thermostirs**
Two families of disc-shaped thermostirs are available from Iksa. The Everterm range have specific resistance values between 10-1 and 105Ωcm. The families are divided between the UN2 which are of 10.5mm diameter with a maximum dissipation of 1W and the UN3 range measures 5.5mm in diameter with half the power dissipation of the others. Both families are available with resistance tolerances of 5, 10 or 50% with the UN2 range varying from 8.2Ω to 33Ω, while the UN3 ranges from 33Ω to 100Ω. The devices are suitable for use in temperature control and measurement, remote control of liquid levels and flow rates, time delay relays, and voltage stabilization. Iksa Ltd, Redlands, Coulston, Surrey CR7 2HT. EWW 409

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Applications are invited for the above position in the Department's Electronics Workshop. The position involves the construction, repair and calibration of electronic and microprocessor based equipment. Applicants should have completed a suitable training, and have a minimum of a further 4 years of experience. Minimum qualifications required are ONC, TEC or equivalent. Salary (under review) on the University Technicians scale Grade 5 (£1,201 to £1,944 per annum). Further details may be obtained from the Head of the Controller, Department of Engineering Science, University of Oxford, Parks Road, Oxford OX1 3PJ, to whom applications should be sent together with a Curriculum Vitae and names and addresses of two referees.

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**HARRINGAY HEALTH AUTHORITY**
**NORTH MIDDLSEX HOSPITAL**

**MEDICAL PHYSICS TECHNICIAN III/IV**

To assist in the provision of an electronic maintenance service for Harringay Health Authority, including equipment maintenance for Interim Care Ward.

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Qualifications: ONC (or equivalent).

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Further information from Mr D Bailey 01-587 9017 ext 678

Applications forms and job description available from the Personnel Department, North Middlesex Hospital, Whittington Way, Alexandra, N12 4QX, or telephone 0877-3971 ext 791.

Closing Date: 30th October, 1985.

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**CIVIL AVIATION COLLEGE (GULF STATES)**

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**AVIATION ELECTRONICS INSTRUCTOR**

1. University degree in electronics or electrical engineering or equivalent.
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3. Minimum ten (10) years teaching experience in an ICAO approved training centre.
4. Salary and allowance up to us dollars 3460 per month.

Applications to: The Principal, Civil Aviation College (Gulf States) P.O. Box 4999, Doha, Qatar.

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require Technicians

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Please telephone Miss Jane Rickett for an application form and further information on 01-633 6513.

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We are interested in applicants with a flair for communicating in writing but particularly those who can make manuals more effective and interesting. Founded by a sound understanding of either hardware or software. The range of our work is wide, so those with flexibility, imagination and team spirit are most welcome.

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Applicants with BTEC ONC or equivalent and at least 4 years relevant training and experience are eligible for posts at the ENGINEERING TECHNICIAN level for which a structured training programme is provided.

**INTERESTED?** Then for further details contact the address below, quoting Ref.: 7/6623/83.

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Idaho | £89 | £71 | Printer Card. Parallel Port | DELTEK
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