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NEWS COMMENTARY

Radiodata to begin next year

From the autumn of next year, programme-labelling data will be carried by all BBC f.m. radio stations in England. The extra signals will make possible the development of push button radio sets with fully automatic tuning. This, the BBC hopes, will put an end to the increasing difficulty many listeners have in finding the stations they want.

In the initial phase, to begin in September 1987, the new Radio Data Signalling (RDS) transmissions will carry five items of information:

- a programme identification code, very frequently repeated, which uniquely identifies the transmitting station: this helps the receiver to find the service chosen by the user and to select the strongest signal.
- a programme service code, a label of up to eight characters which could be displayed on the receiver (e.g. "BBC YORK") or passed to a voice synthesiser.
- a list of alternative frequencies for the same service: with car radios, for example, this could speed up the retuning process on passing from one transmission area to another. Where networks are split between wavebands, the list could include l.f. and m.f. stations.
- 'other network' information to allow, say, automatic switching to another station when a traffic announcement is to be broadcast.
- clock time and date.

These features are cheap to implement, says the BBC, because they require no editorial input by the broadcaster.

But if RDS is a success with audiences, a range of other services could be added later. These might include a text block of up to 64 characters to carry programme details, phone-in numbers, news-flashes or even advertisements; identification codes for individual programmes; and a telex-like text channel for downloading programme fact-sheets or computer data.

The BBC’s RDS transmissions meet a specification laid down by the European Broadcasting Union after a decade of technical work and international discussion. And this month the system is expected to be adopted as a world standard by the CCIR.

The data stream, at 118.5 bit/s, is carried at 57 kHz with a deviation of 1.2 kHz of the main f.m. carrier. It can co-exist with mono or stereo programmes and with most existing subcarriers offered by broadcasters, although some 67 kHz systems in the USA would need to move to accommodate it. However, the MBS radio-paging system used in Sweden is now being changed to make it compatible with RDS.

Several European broadcasters are working on plans for RDS, although at present only Sweden is running a service — an experimental operation on one channel only. In Britain, the IBA carried out tests of RDS last year in the London area but has not yet decided to launch a service. No doubt the commercial broadcasters, as a loose federation of separate stations, have rather less to gain from automatic tuning than a national broadcaster who carries the same programme on many frequencies.

The cost of self-tuning RDS sets will depend on whether i.e. makers are prepared to commit themselves to the system. But the BBC says the prospects for its success are good: a recent survey found that over 70% of adult listeners would be prepared to spend an extra £15 on a basic £25 portable set if it could have RDS. And users of car radios are said to have found the idea of RDS especially attractive.

However, although several Japanese firms are said to be working on prototypes, there are no signs yet of a rush to launch RDS sets. And in Britain, Mullard tell us they have no plans at present to produce the necessary i.e.s.

Full details of the RDS format are given in an EBU document, “Specification of the radio data system: RDS for VHF/FM sound broadcasting”, technical publication 3244/E.

In brief

Up to 2 x 105 bytes of information can be stored on both sides of a 12 mm optical disc and 600 MB on a 4.75 in compact disc. Such discs are likely to have a similar impact on information technology as the microcomputer, according to a report from the US Technical Information Service. The report includes a detailed assessment of optical disc technology and is available in the UK from Microinfo Ltd, Alton, Hants.

Kef Electronics, makers of loudspeakers, are to have a new head of research in the person of Dr Richard Small, who has left his post as a senior lecturer in the University of Sydney. He is the author of Direct radiator electrodynamic loudspeaker systems, which has been reprinted four times and received a Silver Medal award from the AES.

ELECTRONICS & WIRELESS WORLD MAY 1986

www.americanradiohistory.com
Digital assistance for tv signals

Experiments at BBC’s Research Department have produced a system for transmitting analogue picture signals along with high data-rate digital signals carrying control or supplementary information about the picture. One application of this Digitally-assisted tv (DATV) could be to reduce the bandwidth of high-definition tv so that it can be accommodated within a single DSS channel, previously planned for 625-line tv services. DATV is a bandwidth compression technique intended for use with high quality tv signals. The digital control signals assist in the reconstruction of the picture without degradation. One example of the use of the digital component is to carry information about which parts of the picture are static and which are moving. It is possible to repeat the static information and only transmit the changing part of the picture. Such techniques are common in bandwidth-saving exercises, but the DATV experiments have shown that it is possible to apply them to HDTV with a bandwidth reduction by a factor of between two and four.

Another example is the reconstruction of a sequentially-scanned picture where, to save bandwidth in transmission, the signal has been converted from sequential to interlaced scanning. DATV can also be used to improve the performance of 625-line tv systems which have associated digital capacity, such as the MAC/packet family of transmission standards. However this use restricts the freedom to exploit the full potential of DATV compared with its use to facilitate the transmission of HDTV systems using more than 1000 lines.

Charles Sandbank, deputy director of research said: “DATV is a powerful technique for squeezing HDTV signals through the bottleneck of transmission channels, using the sort of technology that will be available in our homes in the 1990’s. I am confident that it will play an important role in establishing a European broadcasting strategy for HDTV.”

Light at the end of the tunnel?

The Council of the Electronic Components Industry Federation (ECIF) reported recently that their industry seems to be pulling out of the recession. Most sectors reported encouraging signs. In particular the semi-conductor manufacturers noticed an increase in demand; enquiries for application-specific I.C.s particularly were encouraging. The council thought that lead-times might soon lengthen but warned that another ‘boom and bust’ cycle was in nobody’s interest and if it were to be avoided, equipment manufacturers must recognise that the ‘supply tap’ cannot be turned on and off rapidly, and that ordering must be planned accordingly. The ECIF were seeking urgent talks on this with customer trade associations.

It was agreed that glimmers of light were appearing at the end of the tunnel, and the council concluded that overall prospects were for a significantly better 1986 than 1985.

After Alvey

The Information Technology (1986) Committee has been formed to look into ways of preserving and maintaining the momentum generated by the Alvey programme. Sir Austin Bide, chairman of British Leyland and former chairman of Glaxo is heading a committee drawn from the IT industry, IT users and academics. The new committee has been organized by Sir Robert Telford, chairman of the Alvey steering committee. A major task for the committee is to establish a proper balance between national and European efforts including the UK relationship with Esprit, Eureka and Race. The Committee is to report its findings by October 1st.

A good idea? Patent it!

All too often, says the Chartered Institute of Patent Agents, adequate safeguards are not taken to prevent ideas being poached by others, and many entrepreneurs come unstuck in the race to get their idea to the marketplace. The most common mistake is to tell others about the idea before asking for professional advice, only to find that as a result all hope of protection has then been lost.

Manufacturers are well aware of the legal wrangles which can follow discussions of purveyors of unprotected ideas and many will refuse to negotiate with inventors until the proper legal protection has been applied for.

To counter these problems the Institute has launched a campaign to help inventors and entrepreneurs bring their ideas safely into fruition. A working party of patent agents and financiers is looking into the whole area of invention, and the funding of projects in their early stages.

Patent agents believe they must promote a better understanding of the forms of legal protection available for new ideas and of the registration systems involved. They have issued free leaflets as introductory guides to patents, trade marks and registered trade marks, design registration and design copyright, and service marks for service businesses. Available from the Chartered Institute of Patent Agents, Staples Inn Buildings, London WC1V 7PZ.

WALLCHART OF FREQUENCY ALLOCATIONS

It is over ten years since the original frequency allocation wallchart was produced and it is, of course, well out of date. Many changes have taken place during that time and it has been clear for some time that a continuing demand had to be satisfied. In response to repeated requests for a new chart, we have produced a new version, which will be presented as a loose insert with the June issue, on sale on Wednesday, May 21.

Many schools, universities and commercial laboratories still have the original chart, and we expect a large demand for the new one. Readers may find it useful to place an advance order for the journal with their newsagents, or take out a subscription, to ensure that they do not miss this once-only opportunity.

ELECTRONICS & WIRELESS WORLD MAY 1986
Electron beam writing on GaAs

At its base in Towcester, Plessey 3-5 Group is installing a Cambridge Instruments EBMF 10.5 electron-beam tool. This will enable the consistent production writing of gate lengths down to 0.2µm on gallium arsenide metal semiconductor field-effect transistors (MESFETS). The first product to benefit from this ability will be a 40GHz MESFET currently under development. Direct writing of features on monolithic microwave ICs will also be possible.

The equipment allows the fabrication of fine geometries by a highly focussed beam of electrons to expose a specially formulated resist, thus reducing the size of the features compared with that previously possible with photolithographic techniques. Computer control provides a high degree of automation. Such short gate lengths will not only lead to higher frequency devices but also improve the signal/noise performance of current MESFETS at frequencies down to X-Band.

Microwave power devices will also benefit; large device structures can have total gate widths of several centimeters and gate lengths of 1µm. Such devices are used in phased-array radars and as solid-state replacements of travelling wave guide tubes.

Knowledge base for Esprit

A five-year project, funded by the European Esprit programme, is to be undertaken on research into knowledge-based systems. Such systems are a facet of 'artificial intelligence' research. They acquire knowledge from experts in a specific field; combine this with codes of practice and/or other rules and regulations, and then programme a computer to analyse and give a prognosis based on the acquired knowledge. One successful example has been used in medical diagnosis. The software required is intrinsically different from conventional programs. In order to apply it effectively in industry, a better understanding of the methods and techniques for building such systems is needed. Ways of applying the disciplines of software engineering in this new area need to be found. This could also reflect back by providing insights into writing more conventional software.

The work should be of interest to all researchers in providing a better understanding of the way such systems operate. It should also provide modes of operation, applying similar techniques to new areas and for increasingly complex applications. The work is to be led by STC.

Britain dominates the comms RACE

Yet another European acronym to go alongside Esprit and Eureka is Race; Research in Advanced Communications for Europe. The European Commission has announced details of contracts to be awarded and Geoffrey Pattie, IT minister, is very proud that: 'there are more British participants than there are from any other member state. Of the 192 participants, 52 are British. British enterprises are leaders in 14 of the 32 successful consortia and there is a British presence in 26. This shows that Britain is ready, willing and able to take a leading part in collaborative research in Europe, which is important both for Europe and for British companies.'

The aim of the Race programme is to establish a strong Community manufacturing industry in broadband communications and to accelerate the emergence of a viable and competitive Community market for telecommunications equipment into the next century.

IBA plans DBS service

The Independent Broadcasting Authority if proceeding with plans to persuade contractors to provide up to three directbroadcasting-by-satellite channels. This follows the bringing into action of sections 37 to 41 of the Cable and Broadcasting Act which provide for the contractors to make the financial and other arrangements for the provision of satellite transponders, subject to the specification of the IBA, which as broadcaster will be responsible for ensuring that the services are of high quality.

John Witney, IBA's director general, warmly welcomed the opportunity to provide additional services; "After much discussion as to how DBS could be introduced to the UK, we are enthusiastic at the prospect. We shall be proceeding with all speed while aiming to ensure that the firmest possible basis is laid." The service, if suitable contractors are found, could be broadcasting by 1990. It is likely to be funded by advertising and/or subscription.

In brief

We have received bitter complaints from manufacturers of modems who are frustrated by the red tape and delays in getting BATB approval for their equipment. Nazir Jessa of Watford Electronics points out the Catch-22 situation that he is caught in with Watfords Le Modem: "If I wait for approval before I put Le Modem on sale, I could find that the technology is out of date. Alternatively I could sell (am selling) the modem without approval and risk customer dissatisfaction."

According to Nazir the situation is made more ridiculous because the device is constructed from BT approved components and is actually being offered with a three-month free subscription to Micronet, partly owned by BT.

Similarly vociferous is Barry Krite of DataStar Systems, distributors of the Magic Modem: "BT's marketing policy supposes that modems without BATB approval are potentially dangerous, despite the fact that they themselves sell modems without approval. Until our modem is approved, customers such as government departments and schools, who are obliged to buy approved products, can't by the Magic Modem." Barry is even more frustrated with the knowledge that the modem has been successfully tested in the BT labs but is still awaiting official approval.

Ceefax, BBC's teletext service is now using six lines in the TV signal compared with the four in previous use. This speeds up the time it takes for the required page to come round. The improvement is the result of the new computer equipment which also increases the efficiency of the system by taking over some of the 'housekeeping' tasks from the contributing journalists. There has also been improvement in the subtitling service: it is now possible to transmit subtitles on both channels simultaneously. The teletext signals are now generated at the point of programme origin, bypassing the Ceefax computers.
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Order Code Target Processors Price

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- **Graphix Plus Card (Graphics Plus II)**
- **Hypercard**
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- **Paradise Multidisplay Card**
- **Quadrocard Card**
- **Simpalamics 54K**
- **Vis On Mosaic**
- **Grappler + Parallel**
- **Laser Hi-plus colour monitor**
- **Cluster Adapter IBM PC**
- **Cluster Cable Kit IBM PC**
- **Plan 2000 Network**
- **Emulex Disk**
- **Dacom Buzzbox Modem**

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**Price £**

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**Price £**

- Quickfile II: 40
- Apple Access: 11
- ASCII: 24
- The Dictionary: 12
- MailList Manager: 25
- PFS: 32
- PFS Graph: 30
- PFS Report: 30
- PFS Apple: 20
- Multifiler: 32
- Superlantis II: 49
- Think Tank II: 35
- Systematics financial applications: 50
- Systematics General Ledger: 50
- Systematics Purchase Ledger: 50
- Fort: 36
- Workbench: 40
- Exas I System Software: 80
- Viasat Manual: 10
- Video: 10
- Pascal: 10
- Drill: 20
- Bulkfile (Management info): 10
- Quickfile: 10

**SOFTWARE IBM**

**Price £**

- DMA 6201 + BUX - IBM: 110
- VDT Emulation: 10
- OPM 91: 10
- Cobol Compiler - IBM: 100
- APL Program: 30
- Microsoft BASIC Compiler: 136
- Microsoft Basic Compiler: 72
- Microsoft Basic Int/Ext: 68
- PFS File - IBM: 30
- PFS Graph - IBM: 40
- Cardbox - IBM: 40
- PC Blasto: 40
- D: Graph: 40
- PC Tutor Intro to DOS: 10
- System Build Budget: 10
- System Build CashFlow: 10
- System Build Multi Regress: 14
- System Build Mail Shop: 14
- System Build Project: 14
- System Build Sales F/Cast: 14
- EasyPhi: 16

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ELECTRONICS & WIRELESS WORLD MAY 1986
by J.D. Last, Ph.D., M.I.E.E. (GW3MZV)

New directions for marine d/f

Marine d/f is dying, long live marine d/f.

Although radio direction-finding is the oldest and simplest form of radio navigation, it is still the one installed on the greatest number of ships, and aeronautical radio-beacons outnumber all other radio navigation aids for aircraft. The technology of direction-finding, developed before the first World War, has been changing rapidly, the latest receivers employing microprocessor and data-processing techniques. In parallel with these developments in the technology, an inter-governmental radio conference held in Geneva in 1971 and 1972 agreed radical changes in the transmission formats of maritime radio-beacons. These open the door to the development of a new generation of receivers which promise to revolutionize radio direction-finding.

Alongside the most modern techniques, the earliest method of direction-finding — turning the aerial by hand until the signal received is at a minimum and then noting the direction in which the aerial is pointing — is still in widespread use. Automatic direction-finders employ a similar technique and a pointer shows the bearing of the transmitter relative to the heading of the ship, as in Fig. 1. From this relative bearing and the magnetic heading measured by a compass, the bearing of the radio-beacon is calculated and a line of position drawn through the location of the beacon on a chart. Two or more such lines of position should intersect at the receiver.

Maritime radio-beacons are simple, low-frequency, non-directional transmitters installed at coastal sites and on light-vessels. Figure 2 shows some of the beacons which serve the English Channel. The frequencies, power levels and transmission standards of the more than 500 beacons in Europe and North Africa are organized under an old intergovernmental agreement — the Paris Plan of 1951. The prime object of the Paris Plan was to minimize interference between radio-beacons, but in achieving this laudable aim the Plan has seriously inhibited the development of radio direction-finding. To see how this has happened — and how the new Geneva agreement has freed the logjam — we must look at the way the Paris plan attempted to squeeze a quart of beacons into a pint-pot of spectrum.

The marine radio-beacon frequency band, from 285 to 315kHz, is divided into just 14 channels, spaced 2300Hz apart (top of Fig. 3). However, so many beacons must share each channel that it is only possible to space co-channel groups sufficiently far apart to achieve about 14dB of the 30dB protection ratio on which the Plan is based.

The remaining 16dB of protection is obtained by amplitude modulating the signals of each group of beacons with a different audio tone, one of a set of tones between 354 and 1052Hz. The idea is for operators to measure bearings by turning their receiving ailerons until they hear a null in the tone of the wanted beacon, all interfering tones being carefully ignored — the 'audio null' method of direction-finding.

Beacons may be identified by the callsigns which they transmit in Morse code or by the unique combination of carrier frequency, tone and time-slot.

When the systems was designed, some 35 years ago, radio direction-finding was the principal radio navigation aid for ocean-going and coastal ships. Installation was made mandatory under the Safety of Life at Sea Convention for all ships of more than 1600 tons. The receivers on these 'Convention ships' must meet type-approval specifications based on the Paris Plan. But ironically, the great majority of these receivers are operated as...
automatic direction-finders, automatically seeking the null direction of the carrier signal — not the modulation — so the interference protection provided by the audio tones is lost. Moreover, these receivers are used much less frequently nowadays because the ships carry radar, Decca or satellite navigation systems which give more accurate fixes, automatically and continuously. So the people for whom the system was designed don’t often use it — and when they do they don’t use it as it was designed to be used!

Instead, the main customers of the radio-beacons are the pleasure-craft sailors — relatively rare birds in 1951 but found in large flocks now. They generally carry few other electronic navigation aids, so radio direction-finding — still the cheapest form of radio-navigation — is very important to them. It has been estimated that more than 70,000 d/f receivers were sold by UK manufacturers in the decade up to 1983, principally to pleasure-craft sailors.

Small-craft receivers don’t have to be type-approved nor conform to the Paris Plan. This has freed designers to be highly innovative in developing receivers for this large market, which demands ease of operation, low cost and high performance — preferably simultaneously!

For example, one popular receiver has only 10% of the volume, 0% of the weight, 4% of the cost and 0.14% of the power consumption of a Convention ship receiver! Though a few small craft receivers are cheap and nasty, at least one claims to meet the type-approval specification for convention ship receivers.

Many small-craft receivers are hand-held. They include a built-in ferrite-rod aerial, a meter or headphones to show the signal null as the receiver is rotated and a magnetic compass to measure the bearing of the beacon when the null has been found. A hand-held receiver appears deceptively simple; in fact it contains a frequency synthesizer for channel selection and a precise clock to identify the transmission time-slots, since the most users cannot read the Morse code identification.

The most sophisticated small-craft direction-finders are very advanced. Taking bearings under microprocessor control and storing the positions of beacons in memory, they calculate the ship’s position and display it as a latitude and longitude or even as a bearing to steer and distance to run to the next viewpoint.

But all these receivers, just like the Conventional ship ones, measure bearings using the carrier only and ignore the audio modulation. So they all dispense with the protection provided by the audio tones. This is one of several ways in which the radio-beacon system, which now looks very old-fashioned in concept, is out of step with its users (and their receivers). Other problems include a shortage of channels which is seriously inhibiting the development and improvement of the service, especially in areas of dense shipping movement. But, of course, the channels are few because the transmissions are wide — wide enough to accommodate the modulating tones which the users ignore!

The six-minute transmission sequence is also very unpopular. Navigators want frequently-updated position fixes with no ‘skew’ errors due to the movement of the ship in the intervals between taking the two or more bearings used to plot the fix; a ship travelling at 20 knots may sail a nautical mile in the interval between measurements on beacons in the same group. A few beacons generally low-powered ones — operate continuously at present; it would be desirable for all beacons to do so or to be in groups of three at the most.

The Paris Plan actually obstructs the development of the art. For example, although it is now possible to measure and record the bearing errors due to the ship’s structure and...
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Fig. 5. Under the new Plan, some radio-beacons will be in groups of three, although many will transmit continuously on individual frequencies. The Morse transmissions are retained and short data transmissions are introduced at one-minute intervals. New 'high-tech' direction-finders will use these to measure bearings and read the beacons' identities, locations and ranges.

to apply corrections automatically, the Paris Plan requires the errors to be plotted and corrections applied by the operator!

These criticisms of the present system — together with a call for much greater automation of receivers — have led to new radio-beacon transmission standards being agreed: in April 1982 the Geneva Plan of 1985 will replace the Paris Plan of 1951.

The new Geneva plan totally abandons the use of modulating tones. The resulting narrow-band transmissions can be spaced by only 500Hz, so creating 62 channels, in place of the previous 14, in a slightly expanded band (bottom of Fig. 3). Although these are sufficient channels to do away with the grouping of beacons and allow every beacon to operate continuously without mutual interference, some national administrations will continue to group many of their beacons. They argue that navigators find it more convenient to receive beacons in the same area on a common frequency. In no case, however, will there be more than three beacons to a group.

At first glance, the transmission sequence in Fig. 5 looks remarkably little altered: the long transmissions have been retained — though slightly shortened — for the use of hand-held receivers. The Morse code identification is still there too, but the carrier is keyed instead of the modulation. This means that receivers must have beat-frequency oscillators (b.f.o.s) but most already have them to receive certain (A1A) aeronautical radio-beacons.

In fact, the new transmissions are compatible with the old receivers, even though the channels have been packed so much more tightly together. Most small-craft receivers already have very narrow bandwidths, since they require only the carrier for direction-finding. The Geneva Plan protects the older Convention ship receivers which have wider passbands by not allocating adjacent channels to beacons in adjacent areas. So the existing receivers should take the changes in their stride and no-one is forced to buy a new receiver.

The 'revolution' is in the short transmissions, shown in Fig. 5, which are radiated at one-minute intervals and allow a new generation of 'high-tech', automatic, processor-controlled receivers to be developed. Beacons which are grouped in threes will each transmit rapidly in turn so that these high-tech receivers can take and store sets of bearings with negligible skew errors at one-minute intervals.

But the short transmissions contain provision for something more: the identity, latitude and longitude of the beacon transmitted in digital form. Using this information, together with the measured bearings, the receivers will compute the ship's position and show it in digital form or on a moving map display. The data transmissions will use narrow-band frequency-shifting keying — either conventional f.s.k. at 100 baud, +/-85Hz shift (similar to the marine telex system) or minimum shift keying (m.s.k.) at 40 baud. The choice between f.s.k. and m.s.k. will be made by a World Administrative Radio Conference in 1987.

Although these data transmissions are not essential to high-tech receivers, their great value is in providing rapid and immediate access to updated information. Navigators are supposed to note and record all changes of radio-beacon parameters — a tedious task. Because the data transmissions will make this process more certain — and safer — to several administrations, including the UK, are planning to introduce them as soon as the Geneva Plan comes into force.

The short transmissions with their data signals will lead to a major advance in radio direction-finding, but the possibilities start to get really interesting when one thinks of putting a processor into the tuning of the receiver — so creating a scanning receiver which can step through the beacon frequencies. When first switched on, the receiver would have no idea of its position. It would locate itself by scanning through the radio-beacon channels for a period of three minutes, building up a record of the strengths and signal-to-noise ratios of all the signals received. The strongest transmissions would then be identified either by receiving their data transmissions or by comparing the frequencies and time-slots of the transmissions with radio-beacon data stored in the receiver. The bearings of these beacons and the ship's heading would also be measured. Then, using all this data, the processor would calculate the ship's position, taking into account the bearings of two beacons but weighting the contributions of all nearby beacons in accordance with their signal-to-noise ratios.

The information about each beacon which is transmitted or stored will also contain its 'protected range' — the area within which the Geneva Plan ensures that its signal is at least 15dB stronger than that of any other beacon which shares its channel. This information will allow the processor to check that the ship is within the protected ranges of the beacons it uses to calculate its position.

Once the receiver has obtained an initial fix, it continues to track the vessel, displaying its position continuously. The simplest receivers would recalculate position coordinates

ELECTRONICS & WIRELESS WORLD MAY 1986

Acknowledgements
The author acknowledges the advice of Mr F.E.J. Holden of Trinity House Lighthouse Service and Mr W. Paterson of the Northern Lighthouse Board in the preparation of this article.

References
each time a bearing was measured. Cleverer receivers would use a Kaiman filter to model the dynamics of the ship, rapidly identifying and displaying the position estimates continuously on a moving map display. Position inputs from other navigation receivers could be combined to give an integrated navigation system.

So the new transmission standards make possible the direction-finding receivers which operate wholly automatically, providing the navigator with a continuous view of his position. No such receivers exist, of course, and it is sensible to question when—or even whether—they will be able to create. There is no technique that is not already known and understood or which is especially expensive—as ever in electronics, the greater the role of the processor, the lower the production cost. The most advanced direction-finders already compute positions automatically, using beacon data typed in by the operator who must also specify the beacons to be used. The new transmissions simply remove the restrictions on the further development of such receivers, providing automatic input of beacon data, automatic selection of beacons and easier identification.

If there is no technical obstacle to the development of these high-tech receivers, will their development be plain sailing? Pessimists would say not—pointing to the failing costs and ready availability of small-boat receivers for the hyperbolic navigation systems (several for Decca Navigator alone), the rapidly growing use of satellite receivers and the promise of NAVSTAR. "D/F?, they say, "is dead!"

But D/F has been a dying for years and, while doing so, mad-deningly continues to grow! There are now more radio-beacons and more receivers than ever before. It has been estimated by the International Association of Lighthouse Authorities (IALA) that throughout Europe, a quarter of a million people depend on direction-finding as their primary means of radio navigation, while some 57% of Convention ships report that they still use D/F.

Part of the reason is that, while Decca and LORAN-C are only available in parts of the world (not by any means in all of Europe), while present satellites give quite infrequent position fixes with significant errors due to the vessel’s movement and NAVSTAR is subject to delays and fiscal cut-backs, radio-beacons are available in both advanced and developing countries. They are operated in each state by local administrations, not by overseas government agencies or companies; their technology is simple and operating costs low.

One or two possible glimpses of the future have been given by the French: they have suggested that radio-beacons may not be used as much by now as metamorphosed into something new. For some years certain French radio-beacons have transmitted 'differential Omega' data. Omega is a world-wide, v.f., hyperbolic navigation aid. Because of periodical changes in the ionosphere, Omega receivers experience position errors which are substantially constant over large areas. So the errors measured at fixed stations on land are broadcast as ‘differential Omega corrections’ and used to correct the fixes of marine receivers in the same area. The US Coast Guard are likewise proposing to use radio-beacons to broadcast differential data to improve the accuracy of fixes made using the proposed NAVSTAR (GPS).

In addition, the French have developed and installed a hyperbolic radio navigation system — RANA — operating in the radio-beacon frequency band and IALA are studying the possibility of precisely synchronising the carriers of groups of beacons to form hyperbolic systems. These beacons could be used not only for good old-fashioned direction-finding but simultaneously for precise hyperbolic navigation to accuracies of a few metres!

Whether that will happen or not I do not know. But I suggest that the next few years will prove interesting and that, in its death throes, radio direction-finding will make far more waves than many suspect.

**FEEDBACK**

**BLACK BOXES**

The magic of amateur radio still exists and, in some ways, with greater power, despite the proliferation of black boxes. High equipment costs do present problems to newcomers to the hobby and to the image amateur radio presents to the public.

Outsiders look upon amateur radio as ‘more expensive CB’ and turn away. People generally are unimpressed with communications technology; crystal-clear colour TV coverage of cricket in Australia or the latest pictures from Uranus are taken for granted.

There is nothing wrong with radiation, but the use of black boxes, however expensive. Japanese equipment manufacturers release new models every year and people buy them. It must be fun being wealthy! As far back as I can remember, big powerful stations have existed in places such as Kilowatt Alley, but the casual listener is not to know how those stations are qualified for this expensive equipment. I know that many of them have started on the factory floor, worked their way up through all aspects of electronics development and manufacturing to retire as multi-national company directors. They are entitled to enjoy the amateur radio they can afford.

We have to accept that black boxes are and ever will be an established part of amateur radio. Thanks to new technology and producing technique, equipment now represents far greater value per pound earned than in the 1950s. But there is a very great deal that experienced amateurs can do to portray the existence of the low cost approach to our hobby.

These days, beginners come into amateur radio ‘backwards’, starting with v. or u.f. fm. with zero interference and no ‘need’ for internationally recognised operating procedures, then progress into h.f. and wonder why they hit them! The Black Box/Black Box causes problems in forcing one to start at v.h.f., where it is difficult to home brew gear, so one is compelled to buy. It might be better to have beginners introduced directly into h.f. where a valve oscillator/p.a. transmitter is within everyone’s reach.

In the reformative years experience short-wave listening are missing, so there is a great need for magazine articles, club lectures and shack visits, to fill the gaps in the amateur radio education process. Dealers need to advertise their black boxes in order to make a living; consequently magazines, including the RSGB Radcom, unavoidably present the expensive image that turns a lot of potential enthusiasts away from the hobby. So there is a need for as much exposure of e cheapo amateur radio as possible, such as construction information, QRP and SWLing.

Public interest can be roused. Try featuring Morse code communication in your club’s next appearance at the local hobbies exhibition or rally. You’ll be amazed how the public associates old up-down key technology with ‘sensible’ and responsible spectrometer c.w. decoder and v.d.u. make the interest even greater.

The future of amateur radio depends upon us making the most of black boxes and technical evolution vital interest in the basics of radio, communication and electronics.

Denzil S. Roden, G3KXF
Lancing
West Sussex

**YES MINISTER**

The letter from David Rudd of the Department of Transport (March 1986) well illustrates the capabilities of innovation and originality that our public servants have. The abdication of planned and responsible spectrum allocation in favour of the discredited monetarism of his current masters is a perfect though late demonstration of the supreme size of their purse! Do the “small latecomers” have bigger purses? If there are bad practices, stop them. In this regulation-ridden society I am sure that suitable regulations exist. If they too are out of date, I would be happy to offer my services, but to pretend that spectrum renting will solve abuses generated by management deficiencies is an arrogance.

Another arrogance is the pretense that the present secret practices of allocation would somehow be ended by the transfer of money. Is it not possible for administrators to display their competence in public? The dissemination of claptrap through the media of papers, lectures, letters etc. still leaves it as claptrap; it cannot be mistaken for a display that would bring any credit to the propagator.
I will always be indebted to the Department of Transport for defining “arcane” for me, but now they have no buses to run could they leave the spectrum alone? It may well need attention but surely not from them.

D. E. Kershaw
Marton
Blackpool
Lancashire

ELECTROLYTICS AND DISTORTION

I have read with interest, in February 1986 & WW, letters from White and Self, on the subject of electronic components and Mr Self’s subjective quality of audio amplifiers.

White seems to sit on the fence and invoke a whole host of variables along the record/replay chain to explain differences in the final sound quality. Self uses a very strange logic to ‘prove’, that because his and others’ tests on capacitors show only minor improvements from the ideal, then somehow they cannot affect sound quality. Self argues that the proponents of ‘better capacitors’ have dreamt up ‘new effects’, which Self argues cannot exist without ‘a theoretical mechanism for the operation of the effect that is logically consistent if not actually plausible’.

Does Mr Self genuinely believe that an implausible theoretical mechanism is of any value in furthering the present state of development of audio amplifiers? In the real world, a great many well liked and widely sold amplifiers, make extensive use of non-aluminium capacitors. Aluminium electrolytic capacitors are certainly the cheapest; hopefully manufacturers that use non-aluminium ones have a good reason for doing so.

Amplifier manufacturers tend to make more sales and therefore profit, when their amplifiers sound better than their competitors and I think Mr Self has given less credence to this fact and examine its implications.

Familiarity with a range of presently available amplifiers reveals that non-aluminium electrolytics are prevalent in very low level circuitry, in direct contradiction to Mr Self’s implausible depolarisation theory which predicts quasi-perfect behaviour from aluminium types at these tiny signal levels. I agree that these subjective observations should be confirmed by sensible tests and statistical analysis but I suggest that manufacturers have little to gain from this. It can be more properly explored in university research departments, if there are any left to do this work after current government cuts. Hopefully we may also see a capacitor model produced from measurements derived from low and high lamp levels, which will predict non-linearities of an audible proportion.

Mr Self knows of no mechanism whereby a microphone can be left intact and yet music ‘mangled’. There exists a phenomenon called phase distortion which can be of such a magnitude as to render a previously unidentifiable transmission over, for example, long unloading telephone lines. This is quite a serious distortion when one considers that speech, when infinitely clipped is still intelligible. Furthermore a linear low-pass filter, at say 100Hz, will not produce any harmonic distortion but can be said to modify music considerably.

From my present (unconfirmed) observations (a) aluminium electrolytics are the worst sounding capacitors commonly available and (b) by far-to-back aluminium electrolytics (which incidentally will not cyclically depolarise) are little, if any, better.

B. Powell
Common Elektrik
Stoke-on-Trent

VON NEUMANN

I was somewhat disappointed by the January article (p.6) “Von Neumann’s elephants.” There are several statements with which I would take issue. Computable Numbers is certainly a landmark paper in the history of numerical methods. However, modern computers did not start to appear until some years later.

The machine described in Turing’s paper does not have a Von Neumann architecture. The program quite clearly resides in the “head” in the form of “configurations”, which approximate to the routines being executed at any moment.

Furthermore (though I am open to correction on this) I believe that the machines on which Von Neumann actually worked did not have subroutine capability, being effectively large calculators. There is a case to be made for all modern computers being derived from the Babbage architecture and the machines designed and worked on by Turing and others after 1945. Turing’s major claim to fame, I submit, is the profoundly practical nature of his genius, and the fact that (unlike other mathematicians) he was prepared to teach himself the electronic engineering he needed to make his proposals concrete.

RISC computers are one thing, and the data-driven architectures alluded to in the article are quite another. The basis of the RISC principle is the building of fast machines by limiting the instruction set to instructions and addressing modes that can be accessed without going to a complex microcode, while providing a partly exposed microarchitecture that provides good hooks for complex operations. RISC machines typically employ numerous registers to speed context switching but this is not essential.

The Pyramid superminicomputer and the new Acorn ARM processor is an example of the type. The TMS32010 DSP uses RISC techniques to such effect that its execution speed is comparable with bit-slice designs. RISC machines do not avoid the Von Neumann bottleneck, however; in fact they may actually worsen it in one respect. Microcoded processors typically do not use the memory with great efficiency (in fact the old 6502/6809 designs leave the bus dead for half the memory cycle time). It is thus possible to have multiple processors sharing some set of utilities. A RISC machine with highly efficient bus utilisation cannot share the bus without having to wait for program and data.

I may suggest a slightly different analogy, the new generation of 32 bit c.p.u. resemble Rolls-Royces and the RISC processors resemble racing motorcycles. (The Intel 386, with an enormous array of bells and whistles, perhaps more closely resembles one of those Cadillacs modified for desert oil but this is getting rather silly.) I suspect choice is largely a matter of market forces or personal preference. The Transputer is apparently a way out of the bottleneck — it has serial links between processors to relieve the bus overhead problem — but consideration shows that some time must be consumed in interprocessor communication. No doubt Imonos have looked very hard at the trade off between parallel processing costs and sophisticated architecture and processor-to-processor messaging, but my own feeling is that the Transputer architecture has as its major virtue the ease of connecting transputer processors rather than the avoidance of bus limitations.

One of the worst bottlenecks in computing is the blocking store. The problem is that where users share a large data base, any modification made by one must reach all. Reductions in the cost of semiconductor memory do not necessarily help this problem since the ability to store very large amounts of data in ram transfers the bottlenecks from disc to ram without changing its nature. My own pessimistic conclusion is that it is the field of mass storage peripherals that we need a revolution — not in c.p.u.

Historically, peripherals have always been the performance limiters, especially when one considers total process time rather than c.p.u. execution time. Anybody who doubts this should reply honestly to one simple question; last time your driving licence was updated, how long did it take?

Martin Bacon
Taunton
Somerset

CLASS B OUTPUT

There would seem to be very few new circuits under the sun. A circuit similar is that described by Mr Nalty in ‘Circuit Ideas’ (February 1986) was previously published by Mr Edwins in Hi Fi News and Record Review, October 1971. This circuit differed only in detail from that submitted by Mr Nalty; in the Edwins circuit three diodes were used to generate the bias voltage.

Having one of these circuits some ten or twelve years ago, and used it ever since, I would state that the quality of sound it helps produce is significantly superior to the traditional class B circuit. When first built the circuit was extensively tested for distortion both at high and low signal levels. The only conclusion reached was that better measurement equipment was required, as it was discovered that what was being measured was the ‘distortion’ output of the oscillator. The equipment used was manufactured by Radford and was of a very high standard — type numbers have been forgotten.

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Ware
Hertfordshire

MATHS PUSHERS

I feel that Ivor Catt is aiming at the wrong target with his polemic, in recent issues, against mathematics and mathematicians. I would like to take one example, a topic which he has touched on several times over the years in WW: the use of Fourier series.

Mr Catt has held up to scorn the assertion of a certain FRS that “reality is made up of sine waves”, and has pointed out that Fourier expansions are no more than a computational tool, sometimes useful and sometimes not. It is mere fantasy to suppose that the description of a single square pulse as a continuous spectrum of sine waves has a better claim to reality than the pulse itself. Fantasy becomes absurdity when one contemplates
the action on such a pulse of a perfect low-pass filter (which is defined by what it does to sine waves): its output must begin before the leading edge of the pulse arrives.

All this is true. But is it the fault of mathematicians? Around ten years ago I was studying pure mathematics at Edinburgh University. I remember in the course on partial differential equations, the lecturer pointed out (as Mr Catt has done in your columns) that the most general solution of the wave equation:

\[ \frac{\partial^2 u}{\partial t^2} = \frac{1}{\rho^2} \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \]

is \( u = f(x + t) + g(x - t) \), for arbitrary (sufficiently differentiable) functions \( f \) and \( g \), and not, as is sometimes supposed, some complicated Fourier series. Who, then, are those people who believe that “reality is made of sine waves”? I went to the library of the university where I currently work, and looked at a random selection of books on physics on the mathematics shelves. All of them gave the general solution, and those books which treated Fourier expansions at all did so only at a much later point. Then I looked on the shelves for physics and engineering. Out of ten books, only two gave the correct general solution. The remainder all dove straight into separation of variables, superposition and Fourier transforms, and never mentioned the general solution at all. It seems that physicists and engineers do not suffer from too much mathematics, but too little, and too little understood.

Richard Kennaway
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ENERGY TRANSFER

There is no problem with electric current theory as questioned by Mr Faint (Letters, March 1986). The resistance of a wire is inversely proportional to cross-sectional area at zero frequency (d.c.). Without getting bogged down in EM theory (I, Shaw, Theory H and I,or Catt’s Theory C) it is broadly true to say that a time-varying EM field cannot exist inside a perfect conductor and that when it penetrates a conductor, but not perfect conductor, its magnitude drops off as the depth increases. A good analogy is that it is ‘seeping’ into the conductor, and the rate of seepage depends on the conductivity and the frequency.

The skin depth is a convenient measure of this rate of seepage. Since the drop off is exponential, it is useful to define the skin depth as the depth at which the magnitude of the field has dropped to 1/2 or \( \pi \) of its surface value. The current is not confined to a surface region as Mr Faint perhaps thinks, and the skin depth is not a magic depth below which current cannot penetrate.

At high frequencies, the skin depth is indeed small — a few micrometres at v.h.f., but even at 50Hz the skin depth is only about a centimetre. There is no point, then, in making power cables more than a few centimetres in diameter, as the central portion would not carry much current. I am led to believe that this is why the cables on overhead transmission lines are often bunched as a group of four small cables rather than one larger one.

David Gibson
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Dorset

MAXWELL’S EQUATIONS

Maxwell’s equations are merely more precise formulations of the following phenomena, verifiable by experiment:

1. Changes in the spatial distribution of an electric field are attributable to a magnetic field which changes as a function of time.
2. Changes in the spatial distribution of a magnetic field are attributable to an electric field which changes as a function of time.

Maxwell’s equations merely state the empirically observed phenomena described above in the “shorthand” notation of vector analysis, a particular branch of mathematics which lends itself very nicely to the expression of spatial and temporal changes in a symbolic form and thereby avoid that cumbersome and imprecise sentences written above.

In my opinion, Maxwell’s great contribution lies not in any inherent truth or mystical quality (not to mention “obvious truisms”) attributable to the equations themselves but in the manner in which it made possible the derivation of a unified theory that explained diverse phenomena manifested in Faraday’s experiments covering a broad field known today as electrostatics, electric circuit and network theory, the generation of constant and distributed parameter versions), skin effect, antennae, wave propagation, etc. from just two basic equations stating “obvious truisms”. As a matter of fact, Maxwell’s equations actually predicted the existence and behaviour of radio and microwaves since, at the time of their publication, these had not yet been discovered.

It seems that Maxwell’s equations are beautiful examples of the so-called scientific method, whereby a large and diverse group of natural phenomena observed experimentally can be explained within the framework of a unified theory, which is even capable of predicting future discoveries. Maxwell’s equations make statements of obvious truisms much like Euclid’s postulates from which a lot less obvious truisms were later derived, much to the surprise of everyone. However, Euclid’s postulates were not the last word in geometry, much as Maxwell’s equations were not the last word in electromagnetic theory.

Catt’s rather extertaining equations presented by him as a parody of those of Maxwell, might still turn out to be great truisms in science, should they somehow become recognized as a theoretical framework for a large group of phenomena observed empirically.

I would like to present a modest contribution of my own, most humbly called Shaw’s theorem. To conserve space, illustrations will be dispensed with. In a recent series of experiments I placed an apple on the table, and a few minutes later, another apple was also placed thereon. This experimental fact may be expressed in the following mindboggling mathematical jargon:

\[ a + 2a \]

This, of course, represents only an obvious truism, since it is only a symbolic expression of the facts observable in my experiment. (The astute reader might even predict, as an inevitable outcome of my revolutionary discovery, that if the symbol means a banana, the equation would still be valid! But let us assume a few discoveries to posterity... before Mr Catt would hastily remind us that the above equation does not teach us anything about fruit...)

It seems to be fashionable today to say that scientific theories are nothing but tautologies and obvious truisms, purposely obscure by mathematical jargon.

In defence of the mathematical jargon, I wish to say that motion and change in time and space are, if expressed in mathematical shorthand, notation, necessarily involve “a mixture of integrals, divs, curls” called “mathematical brew” by those who never understood their function as merely shorthand symbols, easily manipulated and visualized by means of simple rules even by first-year university students.

As to tautologies and obvious truisms, logical thinking is a process which needs to start from a set of first principles or axioms, accepted by everyone as being obvious truisms, unprovable and fundamental. Thus any sort of “truth” derived from a set of axioms can only be relative and confined with respect to the framework of the axioms from which it was derived. Change one of the axioms and you end up with an entirely different set of “truths”. (This actually happened to one of Euclid’s postulates which gave rise to a new kind of geometry.) In fact, you can invent any set of axioms you wish and derive any “truths” from them you wish. These, however, become scientific truths only whenever verified by experiments, providing that somehow they relate to our real world (another bad choice of words). In fact, Mr Catt’s funny equations teach us just that.

I. Shaw
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Republic of South Africa

XY PLOTER

In the excellent ‘X.Y. plotter update’ article in December 1984, author P.N.C. Hill, the formulae printed for the calculation of the best next step to take in the ‘plotting of a “straight line”’ (at the bottom of page 77) requires, on most computers the use of ‘floating point’ routines, which of course tend to be relatively slow and not directly amenable to translating into a machine code program.

A rework of the formulae is shown below: it now requires for its solution only the use of simple integer additions, and can be coded up with no great difficulty (my own Z80-based home-built plotter uses this method).

It is written in program form as the computer’s own screen can demonstrate the line draw.

10 INPUT “LINE FINISH POINT (X’); XF
20 INPUT “LINE FINISH POINT (Y’); YF
30 Z + XF
40 C = YF
50 F + 0
60 IF I = 1 THEN = A + A + YF: C = C + YF
70 IF F = 2 THEN D = D + XF: B + B + XF
80 IF ABS(A-B) < ABS(C-D) THEN 90: ELSE 100
90 Y = Y + 1: PLOT X, Y; F: 2:GOTO 60
100 Y = N + 1: PLOT X, Y; F: 1:GOTO 60

The program is shown only working in the first quadrant, lines 90 and 100 being altered to suit the matrix in use.

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ELECTRONICS & WIRELESS WORLD MAY 1986

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www.americanradiohistory.com
68000 board - 6

Bob Coates ends his description of the monitor software with details of some applications

To illustrate some of the techniques we have discussed, we will now look at some simple programming examples.

We shall touch briefly on accessing the duat and p.i.t. but these devices are very complex and it is beyond the scope of this series to deal with them in any depth. Interested users should therefore obtain the Motorola data manuals. These are fairly voluminous documents! The data manuals will be obtainable from Magenta Electronics, who are producing a package consisting of manuals for the processor and for the duat and p.i.t.

When using Kaycomp with only a terminal and no access to a 68000 assembler, it is feasible to assemble by hand but it is a somewhat laborious task. This problem will be solved by the introduction of the eprom-based assembler for the board.

Other recommended reading is '68000 Assembly Language Programming' by Kane, Hawkins and Leventhal, published by Osborne/McGraw-Hill. The necessary information to hand-assemble is available from this, the MC68000 User’s Manual and the MC68000 Programming Card from Motorola.

In the examples which follow, the listings were produced by an assembler which uses a different convention for denoting hex constants from Motorola’s, h ‘1F’ being equivalent to $1F etc. The assembler directives are also different, but should be self-explanatory.

The examples start at address 400400A, which is the lowest ram address that the user may use; 400000H to 4003FH are reserved for use by the monitor.

**Example 1**

A very simple example is sufficient to demonstrate the trace function and the use of breakpoints when running a program. Using the *MO* command, enter the object code, which is the second column of the listing, into memory at the address shown in column 1.

The first three lines of the program preset three of the processor’s registers, d0, d1 and a0, with 0, 0 and 100 respectively. The loop section of the program then adds 1 to d0, 10 to d1 and subtracts 2 from a0.

First try putting a breakpoint at address 40040A. Now run the program using GO 40040.

The registers should now be displayed with their preset values as the breakpoint has been hit.

Next set another breakpoint at 400412. This must be a different breakpoint number from the
previous one, as we shall continue from the previous break.

When we use the CN command, it looks to see which breakpoint was encountered and starts from there; so it must not be moved in the meantime. CN will restart the program, canceling the first breakpoint and displaying the registers again as it encounters the next one. Here we should see that the registers have been altered by the appropriate amount.

The operation may be seen more clearly if the trace function is used. Remove the breakpoint at 400412 by setting the address of that breakpoint to 0 using BR. Now start the program using TR.

Enter 400400 for both trace and program start. Registers should now be continuously displayed after each instruction is executed. Execution can be suspended by control-S.

Leave it running for a while and see what happens to d1. The add instruction on this register is byte-length only so it will be seen that when the count passes FF it wraps around to 00. The upper six digits always remain unchanged.

Example 2

Our second example illustrates monitor calls and how the 4080 column formatting may be used.

The lea instruction loads a0, with the address of the start of the string. Then pdatm is called with the two lines...

trap #11
data 0, pdatm

The word data is an assembler directive which means 'form a byte containing the value of 0 and pdatm'; pdatm is equated to 6, so the assembler inserts this value.

After printing the string, which is terminated by the null byte, the next trap instruction causes a return to the monitor.

Try first running this program with the column mode at 80, then at 40. You will see that in the 40-column mode an extra new line is inserted after the word 'is'. This is due to the data line h '8d', h '8a' which are the ASCII codes for carriage-return and line-feed with bit 7 set to 1. The description of pdatm explains the difference.

Example 3

The MC68230 peripheral interface/timer i.e. is not used by the monitor, so this example will check whether the device is working or not (if fitted).

The base address of the p.i.t. is h 'A00001' and the first line sets a0 to this value. All references to the p.i.t. are then made using the 'register indirect with offset' addressing mode. The three registers of the device we are going to access are equated to their offset from the base address of the device.

The next line sets up the mode of operation of the p.i.t. (refer to the manual) and line after sets the data direction register for port A of the 68230 to all eight lines as outputs.

Then the program enters a loop where the port A outputs are set alternately to 01010101 and 10101010 with a delay in between. This delay is about one second with a 10MHz clock and pro-rata for other clock frequencies. On
Example 4

Now on to the interrupts. The interrupt output of the duart goes to the processor IPL1 input, the one on the Kaycomp wired for user-vectored interrupts. Accesses to the duart are made in a similar manner as in example 3 using 'register indirect with offset' addressing.

First we use the interrupt vector number we are going to use, 64, is put into the interrupt vector register (i.v.r.) of the duart. This value is passed over the data bus during the interrupt acknowledge cycle to tell the processor which vector address to fetch. If the register is not set, it holds a default vector which points at the 'uninitialized interrupt vector'.

Later, try padding out this line with NOPs and see what happens, but operate 'reset' before running it.

Next in the program, the jmp.l instruction opcode and the address of the service routine are placed in the vector #64 ram block at h '400092'.

Finally, interrupts are enabled in the duart for characters received (refer to duart manual) and the processor's interrupt mask is set to level 1 — one lower than the level of the interrupt generated by IPL1.

The program then hangs up in a loop waiting for an interrupt.

This may seem a little pointless (in practice the processor would be off somewhere doing something useful), but it serves to demonstrate the principle.

An interrupt will be generated when a terminal key is pressed and processing will jump to vector #64 location where it will find the ram address h '400082'.

There it will execute the jmp.l h '4004EA' instruction which is the start of the exception processing routine. This first gets the character from the transmit/receive buffer register (trba) of the port A of the duart. The trap #11, 0009' call prints the two-character hex equivalent of the Ascii key; the next trap instruction adds a space after them.

The duart receiver is then reset and re-enabled, because the previous monitor calls (which were not designed to be used at the same time as duart interrupts) upset the receiver operation.

The 'return from exception' instruction then causes processing to return to the next instruction after where it left off, the 'hang-up' loop again, until the next interrupt.

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LOC OBJECT M STAT E LINE SOURCE LINE

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</table>

Example 5

This example shows one way of accessing a peripheral on the G64 bus.

The card I have chosen is the Syntel SYN-ADC2 which is an analogue i/o card having eight 12-bit analogue inputs and two 12-bit analogue outputs. It is unlikely that many readers will have this card, but I include the example to illustrate the principles of external bus access and handling auto-vectored interrupts.

The card must be configured as follows:

Address switches — all on (FFF80116, bottom of VPA).

J1: 1—3
J2: 1—2 and 3—4
J3: 1—2
J6: 2—4

An analogue output should be provided on P2, pin 15 (positive) and P2, any even pin (negative) for channel 0.

The G64-VPA range on the Kaycomp is FFF801 to FFFFFF; that is, the top 2K-bytes of the memory map. This is so that accesses to these absolute addresses may be made with a word-length address operand.

One of the above jumpers connects the interrupt output to the IRQ line of the G64 bus, which is in turn connected to IPL0, giving a level 1 interrupt. The a-to-d card generates an interrupt when a conversion is complete.

Channel zero is selected on the a-to-d card in the program after the jmp.l instruction has been set up in the autovector 1 ram space, as with the previous example.

The conversion is then started by writing (it does not matter what) to the a-to-d register.

The ADC2's interrupt output is then enabled and the processor's interrupt mask set to its lowest level, 0, to allow interrupts at level 1. It then hangs up and waits for the interrupt to
occur, which will be about 35μS later after the a-d has finished converting.

Processing than jumps via address 400016 to 'except'. Here, after clearing $d_{37}$, the 12-bit conversion value is obtained from the card and placed in $d_{36}$. The 12 bits are obtained by reading two consecutive addresses of the ADC2 card, the eight most significant bits from the first and the four least significant from the second.

However, because there is no $a_0$ line on the 68000, the processor $a_1$ output goes to $a_0$ on the G64 bus and so consecutive addresses appear at alternative addresses to the processor. So we need, in this case, to read FFF809 and FFF80B.

Here the move p (move peripheral) instruction comes to the rescue. It addresses alternate locations (odd or even), two or four depending upon the size attribute, word or long-word.

The read word is shifted right four bits to right-justify it as, through a peculiarity of this card, the data comes out left-justified.

The value read will be between 0 and FFF16 (4096) for an input range of 0 to ±10 volts. So next it is scaled to represent millivolts by multiplying by 1000 and dividing by 4095.

The divide instruction exits with the result in $d_{37}$ bits 0-15 being the integer result and bits 16-31 the remainder. We are not interested here in the remainder, so bits 16-31 are forced to zero.

This binary value is converted to b.c.d. and then displayed as eight decimal digits, being the result of the conversion in millivolts

SmartWatch real-time clock with ram

Building components into a socket gives a real-time clock and battery-backed ram that plugs into many modern microcomputers without hardware modifications.

With most computers, adding a real-time clock involves at least plugging in a separate p.c.b. Adding non-volatile ram can mean yet another p.c.b.

A computer real-time clock needs address decoding, a crystal, power-down switching and a battery. Unless expensive electrically-erasable proms are used, non-volatile ram also requires power-down switching and a battery. Normally add-on clock and non-volatile ram facilities constitute two separate p.c.b.s.

With SmartWatch however — the subject of our special offer on page 65 — the clock and all its associated circuits are built into an 8mm-high socket. What is more, the clock’s lithium battery and power-switching circuits also connect to the top of the socket so the 8K-by-8bit ram fitted becomes non-volatile and remains so for 10 years.

Timekeeping information includes hundredths of seconds, seconds, minutes, hour, day, date, month and year. At the end of the month, the date is automatically adjusted for months with fewer than 31 days, including correction for leap years. Whether the clock operates in 12-hour mode with a.m./p.m. indication or 24-hour mode is selected by software.

Manufacturer of SmartWatch, Dallas Semiconductor produces various 'sockets', some with a ram and battery but no clock and some with a clock but no ram back-up facility so that eproms can be fitted. Other products include electronic keys and tags, an add-on serial port, silicon delay lines and an 'intelligent battery'. These are all available through Joseph Electronics in the UK.

Accessing SmartWatch

Plugged into a computer 8K-by-8bit ram socket, the device appears in the memory map as a normal 8K-by-8bit memory. Only when a unique 64-bit data stream is sent to the socket does the clock respond. After this initialization stream, the next 64 bits written or read from the memory area go to or from the clock.

This method of accessing the clock means that only one byte of processor address space is needed, and only when the clock is addressed. With many operating systems, the clock will only need to be read once when the computer is switched on. From then on, timekeeping can often be taken over by the computer.

Any ram byte can be chosen for accessing the clock because the clock-access sequence through data-line zero depends only on states of the ram read, write, output enable and chip-enable lines, i.e. those lines indicated on the diagram. Address line transitions during this period are irrelevant as far as the clock is concerned but data is only transferred via data-bit zero. If need be, the one ram byte affected can be stored elsewhere temporarily while the clock is read.

Any read from the ram area sets the 64-bit code pointer in the clock circuit to its first location, which means that when the clock is to be accessed, a read operation normally precedes the string of initialization bits to be written. It also means that should the initialization sequence ever be interrupted by a read operation, the pointer will be set back to the first code bit.

Minimum and maximum signal levels on all lines controlling the clock are 2.2V logic high and 0.8V logic low. Lines not controlling the clock go straight through the socket to the c-mos ram.

In some ram sockets, mainly in 6502-based computers, the output-enable signal is active during memory writing, which means that SmartWatch cannot be used without hardware modification. Next month we'll show such a modification and a SmartWatch control program for the BBC microcomputer.

All pins on the SmartWatch socket except pins 20, 26 and 28 pass straight through to the c-mos static ram.
The real-time clock interface card which was described in last month’s article included a 2K eprom programmed with firmware to control the clock. The remaining 1K-bytes are free to hold code to provide a variety of other useful functions, such as the one described here.

The 6821 p.i.a. consists of two parallel ports A and B each with two control lines CA1, CA2, CB1, CB2 and is located at the absolute address C000 using 7421 gates and 7425 gates to decode the address bus. The R/W (read/write) and E (enable) pins are driven directly from the edge connector of the Apple. The reset pin, pin 34, is tied permanently high so that the chip can only be initialized under program control.

The eleven lines required to address the eprom are provided by the eight lines of port A programmed for output. For programming purposes the eprom is split into eight blocks each of 256 bytes.

These are accessed by latching the three highest address lines, A0 to A2, through a 7475 latch (Fig. 1). The block is obtained through the p.i.a. outputs, PA0 to PA7, which are latched by control line CA1 used as an output.

The latch-enables, which are active-high, are obtained by taking CA2 low-high-low-under program control.

Having latched the block address, the eight data lines of port A provide the low byte of the address to the eprom, A0 to A7, whilst CA1 is held low to disable the latch. The fourth bit of the latch allows PA7 to be used, in conjunction with a 7432 gate, to control the PCM/READ pin of the eprom; again, CA2 is

<table>
<thead>
<tr>
<th>OOP/DCN(O)</th>
<th>SLOWER</th>
<th>MIDDLE</th>
<th>GLOBAL</th>
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</tbody>
</table>

The second in a series of laboratory add-ons for the Apple and other 6502 computers

Answer some questions about the article or provide additional information.
Below: subroutines. For details, see April issue.

```
C800  41  64  6A  AC  40  9E  9C  40  Adj, @ . @
C808  A7  A8  B2  A4  A8  40  B2  88  ' . ( $ ( @
C810  88  DC  40  92  9C  40  9A  A0  \ . @ . @
C818  A4  9E  9A  74  48  60  60  $. th'''
C820  60  40  9C  9E  5E  84  B2  A8  ' @ . 2 ( 
C828  8A  A6  74  48  60  60  60  60  &th' ' ' ' 
C830  61  5C  9A  B0  92  A8  40  62  o \ 0. ( # b
C838  5C  86  9E  A0  B2  40  64  5C  \ ' 2 e d 
C840  84  AA  A4  9C  7E  BB  A4  8A  * S ' ' ' .
C848  A8  AA  A4  9C
```

These numbers refer to Apple II interface connections.

---

Fig. 1. This eprom programmer programs single-rail 2K devices suitable for holding user firmware in the Apple II.
The register selected to appear at the shared address is controlled by the status of bit 2 of the appropriate control register. If bit 2 is cleared the DDR is accessed; if set, the i/o register is selected.

The control register format is given in Table 1. Bits 7 and 6 are interrupt flag bits for the CA/B, CA/B control lines; the flag is set to logic 1 when the programmed transition occurs on the appropriate control line. If the interrupt is disabled the related irq line from the p.i.a. will not be taken low and the processor will not be interrupted. The flag bit will however be set; it is cleared by reading from or writing to the port.

In the same way, the CA/B control lines are programmed by switching bit 5; if bit 5 = 0, the line is an input. The CA/B lines operate only as inputs.

For input control lines, a further bit specifies which transition will set the irq flag bit. If the transition is to be 1 to 0, a zero must be written to the appropriate bit. The logic state written to the bit indicates the status of the line after the transition has occurred.

For CA/B, bit 1 is used to control the transition whilst bit 4 indicates the required transition on those CA/B lines configured as inputs. When the lines CA/B are configured for output, if bit 4 is set to 1 the status of the control line is determined by the status of bit 3; if bit 3 is set the line is high.

**Firmware**

The 6502 code is entered by Call (52294). The user then selects Exit, Read or Burn. Exit may be followed by Call (52526): Poke 249,0 : Call (52290) in order to read a rom. The user next enters the eprom start address, number of bytes and ram start address in hex notation.

In read mode, the program then copies the specified area of the eprom to ram and indicates whether the byte previously held in ram was the same, for verification. In programming mode, the program asks the user to insert the 25V connection and burns the code into the eprom, displaying the data as it does so.

**Self-programming**

With a few modifications, the code can be used to generate its own firmware. Enter the code into ram at $6800-$6FFF, then copy it, using the Basic program (table 4), into ram at $8000-$FFFF.

The program alters the high bytes of absolute addresses $C7, $CB, $CC, $CD and $CF to new values ($57, $5B, $5C, $5D and $5F). The eprom programmer may then be operated by calling the modified code with CALL (23532).

---

Table 1 (above): control register from of the 6821.

Below: this Basic program modifies the code generated by the main listing so that the software can program its own eprom.
COMMUNICATIONS COMMENTARY

JAM TODAY

Unless a solution to the problems of deliberate interference can be found at the second session of the World Administrative Radio Conference for the planning of the h.f. broadcasting bands, due to be held at Geneva from January 27 to March 13, 1987, little progress is likely to be achieved and the interference may well continue. The pessimistic view was expressed by Bert Gallon, chief engineer of BBC External Services, in a recent "Waveguide" broadcast.

At peak-listening times as much as 60 to 70 per cent of available spectrum is being badly affected by jamming. This affects listeners in countries far beyond those to which the jamming is directed.

The Russians are currently jamming, in an extremely sophisticated manner, the Russian-language programmes of the BBC, Voice of America, Deutsche Welle, Radio Free Europe, Radio Liberty, Radio Israel and Radio Peking. The only other country jamming BBC transmissions is Poland. China jams programmes from the USSR. With the narrow 5kHz channel spacing and the mixture of very high and medium power transmitters on h.f., the jamming spreads over more than the target channel and can cause problems as far away as South America and Australia.

The USSR has an elaborate and costly network of ground-wave jammers for urban areas of more than 100,000 population and powerful sky-wave jammers to blanket suburban and rural area. Over the years, they have learned a great deal about the technique of jamming, seldom wasting power on what they regard as "harmless" programming but switching on very quickly when an "objectionable" programme begins, following any sudden changes of frequency promptly and effectively.

Non-deliberate interference arises mostly from poor spectrum management and lack of experience in some countries. The h.f. broadcast spectrum is the least well regulated of any of the broadcasting allocations, and is seen by many governments primarily in terms of national prestige and propaganda.

The jamming problem, unfortunately, could easily spread to the microwave bands for satellites, with their increasing use for such purposes as the world-wide television exchanges already in operation by the United States Information Agency, and the future possibility of high-power direct-broadcast satellite systems targeted at East Bloc countries. There is a popular view that d.b.s. is impossible to jam. In fact this could be done all too easily by squinting signals at the receiver of the satellite transponder.

Although jamming is contrary to the radio regulations, it could be argued that a United Nations recommendations on space broadcasting states that this should not be targeted towards another country without the agreement of the country concerned. It would, for instance, be one thing for the Federal Republic of Germany to put out their own national programmes on a satellite whose footprint extended over the whole of East Germany and beyond, but quite a different matter if the satellite carried programmes expressly for that area. A majority of viewers in East Germany can, in fact, already receive West German television from terrestrial transmitters, and viewers who take advantage of this are no longer harassed by the authorities as they once were. But then East German tv can be viewed as far west as Hamburg and I am told is popular because of the spectacular State-subsidized films with, as the cinema used to proclaim, "a cast of thousands".

USA IN THE RED

For many years one has thought of the USA as the heart-land of radio communications and electronics, the large domestic market giving the economies of scale that made their products sellable in every country that could find the dollars to pay for them. Yet in 1985, the USA had a world-wide electronics deficit of an estimated $8600-million, almost 40 per cent more than in 1984. The main reason is the enormous deficit of about $17,500-million with Japan, much of it due to importing $11,700-million worth of consumer products from that country. Only in computers did the USA achieve a worldwide positive balance. Japan's NEC has taken over from Texas Instruments as the world's largest supplier of integrated circuits. One result has been the hardening of the yen/dollar exchange rate by about 25 per cent in recent months, with Japanese firms trying to hold their market shares in capital equipment by not raising prices to an equivalent degree. But already losing some of their consumer-market to Korean industry.

Space Outlook

The UK may or may not have a high-power d.b.s. system in operation by 1989 or 1990. We shall have to wait and see what response there is to the IBA advertisements. Meanwhile the provisional timetable for other European high-power and intermediate-power satellites is that the French TDF-1 and West German TV-SAT could be launched later this year, both providing up to four channels from orbital position 19° East with transponders putting out more than 200 watts of r.f. If all goes well TDF-1 should be receivable over much of the UK with small dishes, and may have an English-language service provided by Robert Maxwell, but it is by no means certain that there will not be further delays. The Japanese Yuri BS-2b (not receivable in Europe) was launched in February with three 100-watt transponders, but it will be some time before anyone can be sure that these will not suffer a similar fate to two of those on BS-2a. The "intermediate power" Luxembourg SES satellite being built by RCA is expected to be launched in 1987 with a capacity of 16 television channels. With 45 watts per channel and an e.i.r.p. of 50dBW it should be receivable over most of west Europe on dishes of about 0.9 to 1.2-metre diameter. It has an Ariane launch booked. The American geostationary launches following the Shuttle disaster

ELECTRONICS & WIRELESS WORLD MAY 1986

This time the plans include a satellite link from the base camp to the UK, plus the use of Racal 10-watt manpack sets and a 100-watt h.f. transmitter to maintain links with North America and Portishead Radio. The manpack sets have been tested down to temperatures as low as minus 45 degrees Centigrade. The team are using special lightweight (500 lb) sledges made by British Aerospace and designed to stay afloat should they fall through the ice with a full 600 lb load. They are seeking scientific information on atmospheric pollution and the structure of the ice shelf.
seems bound to increase the pressure to get on to Ariane. Papers presented at a recent IEE colloquium on "Operational experience in the use of the European communications satellites for television transmission" was concerned exclusively with the use of the Eutelsat F1 (13° E) and F2 (7° E). F1 carries a number of the services for European cable systems. F2 includes EBU news and programme exchanges and occasional use for satellite news gathering (SNG).

Most speakers agreed that the Eutelsat systems have been very successful but equally it is clear there have been a number of problems. The drop in performance of the transponders used for Sky Channel and the Belgian film channel has so far not seriously affected the services, but has shown an unexpectedly high rate of degradation on two of the Telefunken travelling wave tubes.

There is also a difficulty in making meaningful cost comparisons between satellite and terrestrial links due to fluctuating exchange rates and the use of Swiss Gold Francs on terrestrial links and European currency units (ecus) on the leased space segments. A major problem for SNG is the need for frequency co-ordination before a 14 GHz uplink can be used from a temporary site.

For equipment designers there is still the problem of the different transmission standards including deviation (bandwidth), pre-emphasis, audio, sub-carrier spacing, audio bandwidth plus the different colour encoding systems, etc. The outlook for a single European transmission standard is still unsettled, while a world transmission standard grows ever less likely. Latest contender to enter the h.d.tv stakes is a BBC concept called digitally assisted television (d.a.tv) that involves the transmission of analogue picture signals together with high data-rate digital signals carrying control or supplementary information about the picture and claimed to put an h.d.tv picture into home receivers, even when the bandwidth of the signal has been reduced.

**TVI TURN-ROUND**

What appears to be a major change in the official DTI approach to difficult cases of radio-frequency interference, following the phasing-out last year of free investigation by the Radio Investigation Service, was disclosed in a Parliamentary reply by Mr John Butcher, Secretary of State for Trade and Industry. The reply, combined with the belief that new licence regulations for amateurs are in the offing, is causing many rumours to circulate about future power restrictions.

Mr Butcher stated: "Problems can arise when high power radio transmissions are made in close proximity to radio and television sets, or indeed a range of electrical apparatus not designed to receive radio. Such problems can be exacerbated by equipment which is deficient in its ability to reject unwanted signals or in the case of radios and televisions which have an inadequate or defective aerial or no aerial at all. The problem is growing because more and more homes now contain a great range of electrical equipment; and high power transmitting equipment is now more widely available to the growing number of amateur radio licensees."

"Radio amateurs generally take a responsible attitude to the problems their transmissions cause. Equally, manufacturers are keen to produce equipment which has adequate immunity. Regrettably, a few amateurs and manufacturers do not have a responsible attitude; it is they who cause problems."

"My officials are currently discussing with BREMA and the RSGB the implications for them of the new standard for television immunity currently under discussion internationally and procedures for dealing with individual cases where interference is caused. I would like to see sensible immunity standards observed by all manufacturers and importers of radio receiving and radio sensitive equipment. Where possible and appropriate these will be enforced by order. Similarly, manufacturers and importers of radio and non-radio equipment should seek to ensure that their products do not cause interference to radio users. Orders exist for some types of equipment and where appropriate others will be made."

"Where it proves impossible to resolve individual problems and the affected apparatus has been brought up to a reasonable level of immunity, I intend to vary the terms under which the relevant amateurs are licensed; where necessary (and I hope it will not be necessary often) licences will be revoked."

"In this particular case (at Easteate, near Pinner) I will vary the powers which the amateur is licensed to use and restrict his use of certain bands. If this does not resolve the problem, I shall further review the position." While few amateurs would disagree with the DTI's analysis of the problem, many are extremely worried at the new threat of varying or revoking a licence where the transmitter is causing breakthrough and not harmonic interference. This reverses the procedure that has existed for many years. This has meant that an amateur causing breakthrough interference will not be prevented from operating within the terms of his licence except temporarily while the RIS team advise the viewer on a cure. Furthermore, only appliances intended to receive radio or television have been the concern of the D.T.I.

It is understood that British Standard BS905, intended to improve the immunity of tv receivers primarily against CB 27 MHz interference is being put aside in favour of the European specification. While this still help minimise the problem of breakthrough from low-power transmitters there may remain problems of breakthrough interference in close proximity to high-power transmitters unless the sets are fitted with additional filters as in the past. It seems likely that the DTI will wish to introduce regulations restricting the effective radiated power of amateur transmitters, particularly on microwave bands, where high-gain antennas can result in very high e.r.p. from relatively low-power transmitters.

**THERMIONICS**

The 50th anniversary of the introduction by RCA Radiotron of the 6L6 valve in 1936 has sparked off a good deal of nostalgia among radio amateurs who still recall with something approaching genuine affection the series of beam tetrodes that included the 6L8, 807 and 813 that filled so many transmitter sockets over many years. I wonder if solid state devices will come to be remembered in this way? How long before we are talking nostalgically of the 555 or even the OC171?

For many amateurs, the valve is still the easiest and surest way to obtain lots of r.f. watts. The 813 is still in demand for s.s.b. linear amplifiers, along with the modern high-pervenance valves that can be decidedly more temperamental unless carefully handled.

I note that the British Vintage Wireless Society is sponsoring a three-day, 15-lecture course on "Early Wireless — the thermionic age past and present" at Imperial College, London SW7, July 7 to 9. A snap for retired engineers and amateurs is that the fee, including lecture notes etc, is £85. Course organizer is Dr L.L. Freris, Electrical Engineering Department, Imperial College, London SW7 2BT.

Looking through the list of topics one wonders how many of the current generation of amateurs are familiar with such techniques as reflex, neutrodyne and superinductance. But the use of the valve in modern transmitters and hi-fi equipment is also to be covered. The possibility of a considerable return to thermionics as a protection against equipment damage from nuclear electromagnetic pulses is still on the cards, with the American Naval Research Laboratory claiming to be working on microminiature thermionic devices.

PAT HAWKER, G3VA

ELECTRONICS & WIRELESS WORLD MAY 1986

www.americanradiohistory.com
Quad switch as SR latch

A set/reset bistable latch can be configured from two sections of a 4016 or 4066 c-mos quad bilateral switch.

Two transmission gates are cross-coupled as shown. Closing S2 causes gate a to be non-conducting; point A is therefore high and so gate b conducts. Because gate b is conducting, point B is low, holding gate a open when S2 is released.

When Si is closed, gate b is open circuit, point B goes high and gate a conducts, making point A low and so holding gate b non-conducting. The truth table is shown.

If a known power-up condition is required, C1 may be added across Si to make sure that gate a is conducting and gate b is open circuit at switch on.

The remaining two transmission gates may be arranged as a one-pole two-way switch, a two-pole one-way switch or as two one-pole one-way switches, and may be driven by SR latch outputs at points A and B.

J. E. Noakes Camberley Surrey

Automatic power switch and headphone amplifier

I have used this battery-power switch and the headphone amplifier for about a year now with my Sony Walkman DD and Sennheiser HD-430 headphones. Amplification is needed as the Walkman has a 32Ω output and the headphones are 600Ω.

Audio is amplified by Tr1, rectified by D1 and charges C1 to switch on the mosfet Tr2. Resistor R2 determines delay between loss of audio and switch off, which is usually greater than 1min.

Value of R1 is determined by fitting a 2.2MΩ potentiometer in its place and adjusting it so that Vout is zero with no audio, rising to Vin within a few seconds when audio appears.

Power consumption is 5mA when switched on and about 130μA when off; if the unit is switched off for long periods, add a normal power switch.

Philip Bosma Enschede The Netherlands

* All capacitors except these are tantalum.

ELECTRONICS & WIRELESS WORLD MAY 1986
Line driver

In order to drive c-mos at a distance, an active pull-up is required.

Active current sinking is provided by a high-voltage t.t.l. 7406 inverter or 7407 buffer while the BC183L acts as a current source when the t.t.l. output goes high.

This circuit has been used to drive a c-mos input at 2MHz over 3m of twisted pair.

J. Shaw
Dunfermline
Fife

Inexpensive 150V regulator

Using a 100V complementary pair as a shunt regulator provides a solid-state alternative to neon stabilizers. Point X is held at 75V relative to either rail, providing 150V. At 100mA, amplification of the TIP41C/42C pair is greater than 100.

David Hoare
Leicester

Development interface

This Z80 Spectrum interface reads most single-rail eproms and reads and writes non-volatile rams and battery-backed eprom emulators such as the GR2716.

We use assembly language on the Spectrum for developing industrial control applications software. Code is assembled then transferred to an emulator using the interface.

To transfer eprom content to ram starting at C000,16:

```
ORG B000
LD BC,0800 ;1000 for
LD HL,C000 ;4K devices
LOOP1
IN A,(1F)
INC HL
LD A,B
OR C
JR NZ,LOOP2
RET
```

or to transfer contents from C000 onwards to an emulator,

```
ORG B030
LD BC,0800 ;1000 for
LD HL,C000 ;4K devices
LOOP2
LD A,(HL),A
INC HL
LD BC
LD A,B
OR C
JR NZ,LOOP2
RET
```

Supply switching linked to the zero-insertion force socket allows eproms to be inserted and removed while the computer is powered.

Hamid Mustafa
Sola ADC Lenses
Ireland
DATA GENERAL MINICOMPUTER PARTS AND SYSTEMS

Does your application need those multi-user megabytes but your budget stretch only to a PC? Or is your old DQ mini flat on its back? Need an upgrade? Second printer? Hardware support? As traders in commercial systems, we always have stock of older (and newer) equipment. We also deal in second-hand and surplus micro systems. Large SAE for current catalogue.

Sample stock: Eclipse 5130 (CS;601) 8-line mux, 40MB — £5600; D211 screen — £570; 6123 Micronova/CS100 streaming tape — £3400; CS10 C3, 4 line mux, 12.5 x 1; 2MB, console — £1500; NEC APC, colour, 10MB, Autocad, A1 plotter & digitiser — £4000; 3000 rpm drum printers — £400.

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ELECTRONICS & WIRELESS WORLD MAY 1986
by H. W. Gleaves

An introduction to 3D graphics

Principles for producing threedimensional images in perspective are discussed, with an implementation example in QL Basic.

Many personal computer users regard computer graphics — especially 'three dimensional' computer graphics — to be both complex and specialized. For these reasons many people avoid one of the most interesting and effective applications of a personal computer.

To fully understand the subject requires great effort and study; modern state-of-the-art computer graphics, is a highly developed subject, demanding the highest performance possible from computers.

Forming an introduction to the subject, this article demonstrates how a microcomputer graphics system for constructing object outlines is developed. These outlines, or 'wire frames', are in perspective and can be constructed in any position and orientation.

Superbasic on the Sinclair QL is used to show how the graphics system is implemented. Elementary algebra and trigonometry are used but you can skip over these and just use the programs without studying their internal workings if you wish.

Applications for such graphics software are up to you; one obvious use is games, but time taken to compute the images has to be taken into account. It would be interesting to see how the software presented here performs when written in assembly language or speeded up by some other method such as compilation.

Because we want to be able to view objects in the graphics system from any position and orientation, a description of the objects must be present. This description takes the form of a numerical model of objects in the artificial world, or environment.

Three-D artificial environment

Such a model constitutes what is termed a 'three dimensional artificial environment', or simply 3D a.e. Given a 3D a.e. and appropriate software, it is possible to produce perspective images of the environment from any position and orientation. The environment used in this system has an hierarchical structure as shown in Fig. 1.

Every object in the 3D a.e. is referred to as a body. Each body is referenced by its body number and constructed from a number of polygons. A cube for example has six polygons. Furthermore each polygon has a number of vertices.

Finally each vertex has three coordinates uniquely identifying its position in space.

Because our 3D a.e. takes this form, it means that all objects in the 3D a.e. must be constructed from plane, that is flat, polygons, but this is not a significant restriction.

Thus the 3D a.e. contains the description of real, material objects and does not relate to the viewer in any way. It is a generalized description of the objects to be viewed.

The 3D a.e. is a data-base, but is implemented in Superbasic as a number of arrays. Since the 3D a.e. only contains array references, integer arrays can be used to save memory and increase system speed.

The viewing process

Now comes the problem of constructing an image of the region of the 3D a.e. in view. Imagine that you are inside a TV camera that floats freely in the 3D a.e. and can be pointed in any
desired direction and in any orientation.

The imaginary camera itself has coordinates, $C_x, C_y, C_z$, as well as three orientation components, roll, pitch, and yaw. Parameters roll, pitch and yaw are three angles that uniquely specify the imaginary camera's direction, and are measured with respect to the camera's co-ordinate system.

There are thus two coordinate systems. The first describes all points in the 3D a.e. including camera position and the second is an identical coordinate system that is fixed with the camera, i.e. each point in the environment has two sets of coordinates, those relating to its position in the 3D a.e. and those relating to its position relative to the camera.

To compute the image seen by the camera, the position of all points in the environment relative to the camera needs to be known. These relative co-ordinates depend on the camera position and orientation in the 3D a.e. and can be calculated from the real coordinates.

The process of obtaining these coordinates is transformation — a mathematical term to describe the process of obtaining coordinates in one system given the coordinates in another system.

Transformation takes place in two stages in the program (to follow). In the first stage, translation, the second coordinate system is placed at the specified position, with a plane parallel to the original coordinate system. New co-ordinates of any point can then be found very simply, as Fig. 2a shows.

The second stage takes the previously found coordinates of a point and rotates the coordinate system through the specified angles. New coordinates of any point relative to the coordinate system can then be calculated as shown in Fig 2b.

A similar set of equations exists for three dimensions. Our imaginary camera can now be placed anywhere in the 3D a.e. pointed in any direction, and coordinates of any point in the 3D a.e. with respect to the camera can be calculated. Calculation takes place in two steps as described above.

Given the camera's position and orientation, six numbers in all, the position of any point in the 3D a.e. relative to the camera can be calculated. But this is only half the story. A two-dimensional picture still has to be constructed from the 3D data. This final stage of the 3D a.e. manipulation involves finding screen coordinates of a point given its 3D coordinates in space. This is simply another transformation process, Fig. 3.

Several types of transformation are available that allow a two dimensional image to be produced. This article is primarily concerned with a class of transformations known as perspective transformations. In a perspective transformation, a point in space known as the focal point is designated and a surface is introduced, in our case a plane surface, between the focal point and the scene to be viewed.

Projection takes place as follows. For every point in the 3D a.e. or portion of the environment being viewed, construct a straight line from that point to the focal point. The position on the screen that this line penetrates is the projection of the point in the 3D a.e. If this process is carried out for every point in the scene, and points on the screen joined in the same order that they are joined in the scene, then a perspective image will have been produced on the screen.

**Perspective transformation**

There is a simple mathematical relationship between the point's true coordinates and the coordinates of its projection. The equation relating this is derived with reference to Fig 3.

The diagram shows the simple geometrical relationship between the true and per-
Transformation.

[Diagram of coordinate systems with equations and explanations]

Table 1. Example coordinates.

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Fig. 2. Translation of (ij) coordinate system (a) and rotation of the (ij) coordinate system (b).

The diagram also shows that the camera is located at the origin of its own coordinate system. It is in relation to this system that all points in the 3D a.e. are specified, after the aforementioned transformations are carried out.

Now, x and y coordinates of a point projected onto a screen have to be determined, say x_1, y_1, z_1. From Fig. 3 you can see that a triangle is formed by F(x_1, y_1, z_1) and the z axis. It should also be evident that a triangle is formed by points F(x, y) and the origin.

Since both of these triangles form the same angle at F, they are similar triangles. This means that the ratio of any two sides, is the same for both triangles. So for the point x,y  
\[
\frac{y-y_1}{D+Z_1} = \frac{y_1}{D+Z_1}
\]

which means that  
\[
y = \frac{D+y_1}{D+Z_1} = \frac{y_1}{1+\frac{Z}{D}}
\]

A similar argument applies to the x coordinate of any point on the screen. So that you can see for a given point x,y,z in the 3D a.e., its projection, i,j is given by

\[
i = \frac{x}{1+\frac{Z}{D}}
\]

and

\[
j = \frac{y}{1+\frac{Z}{D}}
\]

This final transformation allows points to be plotted on the QL’s screen, and if the points are joined in accordance with the 3D a.e. data-base, a line or ‘wire frame’ image in perspective will be produced on the screen.

Software for wire-frame drawings

We are now in a position to examine some preliminary software for producing wire frame images of objects of any shape provided that they can be constructed from straight lines.

Program 1, to be shown in the next article, is modular which allows the important functions and procedures to be used in any program. The main role of this program is to allow objects to be set up in the 3D a.e. and to view those objects from desired position. When ‘viewing’, you should try to prevent the camera from turning its back on the scene, since this program does not make any attempt to prevent transformation of invisible points.

The first procedure, SETUP, allows a rudimentary method of defining the 3D a.e. data-base. The next major procedure, VIEW places the camera at the origin of the 3D a.e. The image from this position is then drawn, and the user prompted for camera commands.

Entering positive x, y and z values causes the camera to move right, up or forward respectively by the desired amount. Negative values will move the camera in the opposite sense.

If you imagine that you are sitting in your chair facing the QL screen, then the orientation commands are described as follows. Entering a negative value causes the camera to turn towards the right, up through the specified angle, entering a negative pitch value causes the camera to turn upwards through the specified angle and entering a negative roll value causes the camera to rotate along its axis of viewing in a clockwise direction through the specified angle. Positive values will turn the camera in the opposite direction.

If you adjust the orientation and not the position then it is as if the camera has not moved, but simply turned about its centre.

Octahedron example

To give you an idea of how the program works, try the octahedron example, firstly using the SETUP facility to describe the octahedron to the 3D a.e. data-base.

Because ‘wire frame’ images are used, it is not essential to describe every face of the body, i.e. you make a cube from just four wire frame squares, the two remaining faces appear automatically. This can be a great saving for many bodies, the octahedron being the case in point.

In fact only four faces of the octahedron need to be described to give a correct image. Try entering the following data, after first entering ERASE and SETUP. The octahedron has four polygons, 1, 2, 3 and 4. Polygon 1 has vertices 1, 4 and 5, polygon 2 has vertices 1, 2 and 3, polygon 3 has vertices 4, 3 and 6 and polygon 4 has vertices 5, 2 and 6.

Table one gives the x,y and z coordinates of each vertex. When you have finished describing the body, the program will end and tell you so. You should now enter VIEW.

Software for producing wire-frame images will be presented in the next section.
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Fibre Optics '86

If you don’t think fibre optics is for you this event should convince you otherwise.

The Fibre Optics '86 Exhibition, held in hall D of the Earls Court exhibition centre, is part of British Electronics Week consisting of four exhibitions taking place simultaneously at Earls Court and Olympia. It aims to bring together leading manufacturers of fibre optic components and systems to show their latest products to a "broadly based audience of engineers, managers and commercial staff", and includes lasers, local area networks and optical sensors. It is open from 28 April to 1 May in hall D of the Earls Court exhibition centre — a different venue from last year's Olympia — and a list of exhibitors accompanies our stand plan.

For about £100 a day an accompanying conference, held at the nearby London West Hotel 29 April to 1 May, discusses recent developments in fibre components and applications in both sensing and communications. If you are unable to attend you will be able to buy a set of conference papers after the event (only abstracts are available at the event from, strangely, publishers in the USA — SPIE*), and if you want copies of previous conference papers (all British) you'll have to buy them from America. To help newcomers get down to basics there are tutorial sessions on 'Basic fibre optics' (28 April), and 'Optical fibre sensor technology' (29 April), both of which cost around £100 but for companies wishing to acquire the basics quickly this is probably a cost-effective way. (There is also 'Business opportunities in fibre optics', which the brochure shows as a listing of applications, and 'Industrial applications of expert systems', which connection with fibre optics isn't at all clear.)

- K-Tech claim a typical loss of less than a decibel for all Diamond SA single-mode connectors, using 6/125µm fibre, including new types MMS40 to BT spec and MMS11 the first to be approved to DIN standard. Also new are optical attenuators for single to multimode and vice versa use with values from 2.5 to 30dB, and several tool sets. EWW 301 for further details.

- Kaptron, a new principal for Centronic Sales, specialise in fibre optic components and specialist test gear including Polytrope, an IBM PC-controlled automatic fibre alignment equipment. EWW 302 for further details.

- BICC Optical Components Unit at Prescot are to introduce a series of test equipment, the first of which is a stabilized light source for accurate on-site attenuation measurements. The emitter is a 1300nm edge-emitting i.e.d. whose output is chopped at 270Hz (the normal power meter frequency) but which can be externally modulated or operated c.w. We're told the price of £3,450 is about half that of its laser-based competition. EWW for further details.

- Fused couplers for fibre sizes of 62.5 and 85/125µm are now made by ADC Fiber Optics in addition to existing types for 50/125, 100/140µm graded-index and 100/140, 200/240µm step-index fibre. EWW 304 for further details.

- Belling and Lee Intec fibre components, modules and connectors are to be distributed by Circuit Distribution following an agreement signed at PO '86.

- Cossor's optical time domain reflectometers will be marketed in the USA by Wilcom Products, a subsidiary of communications co. Plantronics Inc.

New at Electro-Optics, Brighton

- As well as standard single mode optical fibres York Ventures and Special Products of Chandler's Ford make both ultralow and high birefringent fibres. The high birefringent type avoids polarization noise and signal fading in fibre gyrosopes and other interferometric sensors, for links to polarization-sensitive devices and for coherent communication. York's fibre has a beat length of less than 2mm; beat length is a measure of polarization holding ability. (Any phase difference between the two orthogonal modes gives rise to beats.) Ultra-low birefringence is useful in devices where the polarization plays an important role.

Data link modules typical of those currently available for point-to-point use and local area networks. This Plessey pair can operate up to 125Mbit/s in either NRZ or Manchester biphase encoding (50Mbit/s) at distances of up to 2km. IBM PC-controlled fibre optic alignment aid by Polytrope (Centronic sales).

* PO Box 10, Bellingham, Washington, 98227-0010, USA.
role for example in electric or magnetic sensors. In ordinary single-mode fibres birefringence is generally sensitive to temperature, pressure and vibration making calibration of polarization difficult. York's fibre, made by a preform spinning process patented at the University of Southampton, can have zero birefringence in nearly all situations; linear retardance is less than a degree, with no variation of polarization with temperature. EWW 305 for further details.

- Radial fibre optics connectors are now available through Norbain Electro-Optics, following a distribution agreement with the French manufacturer. Covered are the SMA style connectors for live sizes of p.c.s. multimode fibre, the new FMA types, and the very low loss Optaball range also suitable for monomode fibre. Emitting and photodiodes from RCA, TRW, Siemens, and EC&G's Vactec were newly shown at Brighton but a surprise announcement was the exclusive rental agreement with STC for its range for time domain reflectometers.

- Temporal disperser is the name Hamamatsu give to their 30GHz long wavelength optical oscilloscope. Based on a synchronized streak camera, it connects with a conventional camera — TV or still — and temporal analyser for real time operation together with other peripheral equipment to allow measurement of chromatic dispersion of single-mode fibres. The multidimensional detectors are able to record time, position or wavelength, and light intensity, and allow time-resolved spectroscopy up to a wavelength of 1.6µm. Observations of long wave phenomena have been impossible with conventional streak cameras because of the low efficiency of the photocathode in the range 1.3 to 1.6µm. The streak unit, type C1587, uses a synchronscan tube in which a sinusoidal sweep voltage applied to the tube's deflection plates is synchronized with repetitive light pulses, for example from a dye laser. Integration of streak images occurs on the phosphor screen or by direct recordout. Hakuto International. EWW 306 for further details.

- Gallium aluminium arsenide emitters and a p-i-n photodetector are newly available from Motorola distributors Gothic Crellon. Designated type MFOE3200 and 3201 and MFOD3100, the devices are housed in a new low-cost rugged plastics-capped package that fits standard device receptacles. The two emitters launch 10 and 20µW into 100µm fibre and are 850nm diodes with a bandwidth (60MHz) claimed to be higher than any other emitter in the price range. Enter EWW 307 for further details.

SMA-style connectors, often referred to as the 'industry standard' of connectors, are frequently used in data transfer applications. The range of Radial SMA types now available from Norbain, together with the Optaball range which have average losses as low as 0.35dB. New ceramic-terrule SMA types are added to the Optical Fibre Technologies range from Walmore, as are two new biconical types with ceramic capillary. Multimode version is field-installable using procedures for Dorrans Photonics connectors, with which they are mateable. Telecommunication systems usually use flat contact (FC) connectors such as Sicko's NTT type. Their latest development is the point contact (PC) type, bottom,

Stabilized modulated light source for attenuation measurement (BICC).
SENSITIVITY ANALYSIS
— WHAT IS IT AND WHAT CAN IT DO?

Whilst generally used for filter analysis, the sensitivity analysis is just as valid in many other branches of electronics.

Sensitivity analysis is a fairly simple mathematical technique that is most often used in electronics as an aid to help establish whether a particular active filter will perform to the required specification, and if so, what tolerance and temperature coefficient the components should have.

Though quite useful in this context, sensitivity analysis is a very useful technique that may be applied to many circuit problems and the results obtained are valuable to the circuit designer.

Definition
The informal (not absolutely precise) definition of the sensitivity function is

\[ S^Y_X = \frac{\Delta Y}{\Delta X} \]  

(1)

and it is the ratio of the normalized variation of parameter Y to the normalized variation of parameter X. If the variation \( \Delta X \) is infinitely small, then

\[ S^Y_X = \frac{X}{Y} \frac{\partial Y}{\partial X} \]  

(2)

Equation 2 is the formal definition. To illustrate the meaning of \( S^Y_X \) consider the following example.

Suppose X represents temperature, T, and Y represents a resistor value R, the value of which is inversely proportional to temperature, i.e. \( R = A/T \), where A is a constant. Then using equation 2 gives

\[ S^R_T = T^2 \frac{\partial (A/T)}{\partial T} = \frac{A}{T^2} \]  

(3)

Sensitivity values

Using the informal definition in (1), the fact that \( S^R_T = -1 \) means that if the temperature were to increase by 1% then the resistance would decrease by about 1%. As can be verified using equation 2, if the resistor happened to be inversely proportional to \( T^2 \) then the value of \( S^R_T = -4 \) and then the change of \( R \) would be four times as great.

Mathematical relationships
A very helpful relationship in simplifying calculations of sensitivity values is derived next.

Suppose Z is defined by the expression \( X = e^Z \) or \( Z = \ln X \).

Differentiating gives

\[ \frac{\partial X}{\partial Z} = e^Z \frac{\partial Z}{\partial \ln X} \]

or

\[ \frac{\partial X}{\partial \ln X} = e^Z \frac{\partial Z}{\partial \ln X} \]  

(3)

Similarly

\[ \frac{\partial Y}{\partial \ln X} = Y \]  

(4)

Rewriting equation 2 using 3 and 4

\[ S^Y_X = \frac{X}{Y} \frac{\partial Y}{\partial X} \frac{\partial X}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \frac{\partial \ln Y}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \frac{\partial \ln Y}{\partial \ln X} \]  

(5)

To illustrate the value of this formulation of \( S^Y_X \), consider the following example. Suppose \( Y = AX^p \), where \( A \) and \( P \) are not functions of \( X \), then from equation 5

\[ S^Y_X = S^{AX^P}_X = \frac{\partial \ln A}{\partial \ln X} \cdot \frac{\partial \ln X}{\partial \ln Y} \cdot \frac{\partial \ln Y}{\partial \ln X} \]

(6)

This is the proof of the first identity shown in the Appendix, and the others can be verified in a similar way. The identities ease the complexity of evaluating \( S^Y_X \) using the definition of (2).

Application to negative feedback systems
Negative feedback results in a lower overall system gain and closed-loop gain in much less sensitive to open-loop amplifier performance. This classical result can be simply shown by evaluating the sensitivity of the closed-loop gain to the open-loop gain. If we use the symbol \( A_F \) for the feedback gain and \( A \) for the open-loop gain with \( \beta \) for the feedback factor, then the standard relationship between these parameters is

\[ A_F = \frac{A}{1 + \beta A} \]  

(6)

Rewritten equation 2 using 3 and 4

\[ S^{AF}_X = \frac{A(1 + \beta A)}{1} \frac{\partial (1 + \beta A)}{\partial \ln A} \frac{\partial \ln A}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \frac{\partial \ln Y}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \frac{\partial \ln Y}{\partial \ln X} \]  

(6)

Or

\[ S^{AF}_X = \frac{A(1 + \beta A)}{1} \frac{\partial (1 + \beta A)}{\partial \ln A} \frac{\partial \ln A}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \frac{\partial \ln Y}{\partial \ln X} \frac{\partial \ln X}{\partial \ln Y} \]  

(6)
The closed-loop gain is almost the same as the inverse of the feedback network gain, provided that the open-loop gain is much larger than the closed-loop gain. This fact is clear from equation 6, and from equation 7 this makes

\[ S_{A_f} = \frac{A_f}{A}. \]

The table shows that the \( S_A \) values are reasonable with no sensitivity effects evident. In fact, they are all within the range -1 to +1. Other constraints permitting, if \( R_1 \) were set to equal \( R_2 \), then

\[ S_{A_f} = 0 = S_{R_1} \]

and

\[ S_{R_2} = \frac{1}{2} = S_{R_2}. \]

The sensitivity tabulation resulted in any values being five more it would be wise to consider discarding the circuit in favour of an alternative yielding lower sensitivity to component variation.

The second-order active band-pass filter shown above has the characteristics:

- centre frequency
  \[ f_0 = \frac{1}{2\pi R C} \]
- centre frequency gain
  \[ A_o = \frac{K}{4 - K} \]
- quality factor
  \[ Q = \frac{\sqrt{2}}{4 - K} \]

One of the poorest aspects of this particular circuit comes to light when evaluating the sensitivity of \( K \) to variations in amplification gain \( K \). It is relatively easy to show that

\[ S_{R_2} = 2\sqrt{2} - 1. \]

Clearly if \( Q \) is 10 say, this gives a value of \( S_{R_2} = 27 \).

This is intolerably high as a +1% change in \( K \) results in about 27% change in \( Q \). Having discovered this most disastrous feature for moderately high values of \( Q \), the designer would be well advised to abandon this circuit completely and seek a replacement to achieve the desired band-pass response.

### Appendix

#### Useful identities for sensitivity analysis

1. \( Y = AX^n \), where \( A \) and \( P \) are not functions of \( X \)
2. \( S_X = Y^\frac{n}{X} \)
3. \( S_X = -S_Y^\frac{1}{X} \)
4. \( S_X = S_Y^\frac{1}{X} - S_Y \)
5. \( S_X = \frac{-S_Y}{N} \)
6. \( S_X = Y_1 + Y_2 = \frac{Y_1 Y_2}{Y_1 + Y_2} \)

### Application to active filters

The circuit shown on Page 46 is of a second-order band-pass filter and from analysis the centre frequency \( f_0 \) the quality factor \( Q \), and the centre frequency gain \( A_o \), are given by the following expression:

\[ f_0 = \frac{1}{2\pi \sqrt{C_1 R_1 C_2 R_2}} \]
\[ A_o = \frac{C_1}{C (R_1 + R_2)} \]
\[ Q = \frac{1}{(R_1 + R_2) \sqrt{C_1 C_2}} \]

The closed-loop gain of a standard op-amp with non-inverting amplifier with closed-loop voltage gain of

\[ V_o = A_f(1 + R_2/R_1), \]

where \( R_2 \) and \( R_1 \) are the feedback resistors linking the output to the op-amp with the inverting input terminal and the inverting input terminal and earth respectively.

To establish the sensitivity of \( A_f \) to each of the resistors without much effort and no differentiation, use the identities shown in the Appendix:

\[ S_{R_2} = \left( \frac{A_f - 1}{A_f} \right) = S_{R_1}. \]

Clearly if \( A_f > 1 \) then the sensitivity values given in equation 8 approach unity in magnitude.

On the face of it none of these results are particularly surprising nor startling. However, if the values obtained were not small but yielded figures of 10 or more we might well be alarmed as this would suggest a large change of the circuit parameter \( Y \) as a result of a change in circuit component \( X \). This does occur if positive rather than negative feedback is used in a particular application.

### Introducing the S/58 bus

**Simpler communications between computers.**

The notoriously difficult art of getting computers and their peripherals to talk to one another is about to become a great deal easier, with the launch of the S/58 serial interface. After extensive preparatory work by Government bodies and British industry, a detailed specification of S/58 has just been published by the British Standards Institution.

The new arrangement is certain to receive a warm welcome from anyone who has to struggle with RS232 and its endless permutations of data format and electrical connections. For with S/58, incompatibility has been designed out.

All physical and electrical aspects of S/58 (it stands for serial, 5 volt, 8 pin) are defined in the published proposals: as far as the user is concerned, it is a 'plug and run' interface. There is only one kind of interconnecting cable and only one permissible signalling format and data rate.

But S/58 offers further benefits: in place of the costly 25-wire connector it is based on cheap, compact eight-pin DIN connectors. Logic levels are compatible with 5V c-mos i.c.s and are appropriate for portable and other low-power equipment.

Already, six manufacturers are using S/58 in their products and many more have said they will adopt it when it becomes a British Standard.

We hope to publish shortly an article giving full details of S/58. But in the meantime, the specification is available under the BSI reference number DD 153. BSI Sales Department, Linford Wood, Milton Keynes MK14 6LE.

---

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CIRCLE 40 FOR FURTHER DETAILS.

ELECTRONICS & WIRELESS WORLD MAY 1986
Timing by remote control

Contraction, testing and setting up of a versatile Z80 timer that uses coded r.f. bursts through the mains wiring

The author asks us to point out two alterations to the transmitter circuit on page 67, February issue: the preset potentiometer at Tr1 should have a 100kohm value, not 10k, and a 100nF capacitor, C10+, was omitted between the bases of Tr7 and Tr8. (One constructor found that a 100PF ceramic capacitor connected between Tr7 and Tr8 bases cured his 1MHz oscillation.) And in the receiver circuit, page 68, C1 should be returned to the neutral line, not to the earth line. Incidentally, two of IC6 gates had the wrong symbol: the type number is correct. The line that leaves the address bus at IC8a on page 65 is A2; the brightness control is a 47kohm logarithmic potentiometer; and on IC9 it is the inverting inputs that are grounded.

Electronics & Wireless World May 1986 by Peter Ferris
If all the appliances to be controlled are in the same room as the control unit the f.s.k. control unit can be dispensed with. Instead of IC<sub>1</sub>, this circuit provides a directly-connected signal to operate each opto-coupled switch. Tables below refer to the receiver circuit on page 68 of the February issue.

### Table 1

<table>
<thead>
<tr>
<th>Filter resistors (kΩ)</th>
<th>Frequency (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0k</td>
<td>531</td>
</tr>
<tr>
<td>3.3k</td>
<td>482</td>
</tr>
<tr>
<td>3.6k</td>
<td>442</td>
</tr>
<tr>
<td>3.9k</td>
<td>408</td>
</tr>
<tr>
<td>4.3k</td>
<td>370</td>
</tr>
<tr>
<td>4.7k</td>
<td>339</td>
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<tr>
<td>5.1k</td>
<td>312</td>
</tr>
<tr>
<td>5.6k</td>
<td>284</td>
</tr>
<tr>
<td>6.2k</td>
<td>257</td>
</tr>
<tr>
<td>6.8k</td>
<td>234</td>
</tr>
<tr>
<td>7.5k</td>
<td>212</td>
</tr>
<tr>
<td>8.2k</td>
<td>194</td>
</tr>
<tr>
<td>9.1k</td>
<td>175</td>
</tr>
<tr>
<td>10k</td>
<td>159</td>
</tr>
<tr>
<td>11k</td>
<td>145</td>
</tr>
<tr>
<td>12k</td>
<td>133</td>
</tr>
<tr>
<td>13k</td>
<td>122</td>
</tr>
<tr>
<td>15k</td>
<td>106</td>
</tr>
<tr>
<td>16k</td>
<td>99.5</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Channel</th>
<th>R319</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1k</td>
</tr>
<tr>
<td>2</td>
<td>22k</td>
</tr>
<tr>
<td>3</td>
<td>33k</td>
</tr>
<tr>
<td>4</td>
<td>43k</td>
</tr>
<tr>
<td>5</td>
<td>56k</td>
</tr>
<tr>
<td>6</td>
<td>68k</td>
</tr>
<tr>
<td>7</td>
<td>75k</td>
</tr>
</tbody>
</table>

The timing’s operating program occupies the first 2K bytes of the processor memory map, i.e. from 0000 to 07FF. If a 2732 or 2733A is used, the next 2K bytes, from 0800 to 0FFF, are available for additional functions.

### Fault-finding

The following is necessarily only a brief outline of the sort of problems most likely to be encountered in a system of this type. It is based on the assumptions that all the components have been correctly fitted, and that theeprom contains the published machine code.

If there is no 601Hz waveform on interboard connection 16, check for a clean 1MHz square-wave on in 6 of the processor chip. If it isn’t there, check the 2MHzwaveforms at the outputs of IC<sub>8</sub>. You may find only one of these waveforms present - an impossible situation at first glance. But what is really happening is that the oscilloscope probe is adding enough extra capacitance to make the circuit oscillate when it is applied to one of the outputs, but not the other. The solution is to fit a small capacitor (between 10 and 30pF) between the apparently working output and 0V.

If you have a 1MHz clock but still no 601Hz at point 16, the most likely culprit is the power-up reset circuit (C<sub>1</sub>, D<sub>1</sub>, R<sub>8</sub> and Tr<sub>1</sub>). Try momentarily shorting Tr<sub>1</sub> collector to 0V. If the 601Hz waveform appears, experiment with the values of C<sub>1</sub> and R<sub>8</sub>; the aim is to increase the length of the not-reset pulse, because it must remain low for some time after the clock oscillator has started up. As a last resort, wire a reset pushbutton across C<sub>1</sub>. The software can distinguish a reset from a power-up, so you won’t lose your stored timer settings if the button is pushed accidentally; though you will have to reset the clock.
Interrupt structure

Although there are only two sources of interrupts, namely the 20Hz and 601Hz c.t.c channels, the priority between them had to be carefully defined to meet the following requirements:

- To maintain a regular rate of multiplexing the display, which is essential to avoid visible flicker, the 601Hz channel must be allowed to interrupt any routine currently in progress — including its own keyboard service routines, which in some cases can take tens of milliseconds to run.

- To maintain accurate time-keeping, the 20Hz channel must be allowed to interrupt keyboard services; fortunately it need not interrupt the display multiplexing/keyboard scanning routine, which only takes about 30ms.

- When the clock minute increments, the 20Hz interrupt service routine (i.s.r.) has to search for, examine, and possibly act upon, all the active timer settings; a process which can take more than the 50 ms interval between interrupts. The 20Hz channel must therefore be able to interrupt its own service routine.

- The 601Hz i.s.r. cannot be allowed to enter a keyboard service routine if it has interrupted a 20Hz i.s.r because the 20Hz routine will be using the c.p.u. registers. (The original contents, needed for keyboard servicing, are saved on the stack at the start of the 20Hz routine and replaced at the end.)

The first three of these requirements are easily met by clearing the c.t.c. channel's interrupt flag and enabling further interrupts, (using the EI and RETI instructions), before entering a potentially time-consuming routine. The 20Hz i.s.r. takes care of the fourth requirement by manipulating the Key Enable status in ram location 80BE. This location is set to FF (key services disabled) before the 20Hz i.s.r. enables interrupts, and the original contents and related data at the end of the 20Hz i.s.r. along with the processor register contents.

Flowchart

Space does not permit publication of a fully commented assembly-language listing of the software. However, such a listing would only be of more use than the flowcharts to constructors who intend to modify the program, and such people are likely to have sufficient knowledge of 280 assembler and machine code to disassemble small blocks of code. To assist in this, each block in the flowcharts has alongside it the eprom address of the first instruction corresponding to the process written inside the block. The following paragraphs should also help.

Most accesses to the scratchpad area of ram are made using indexed addressing via the IX register; the first byte of the instruction is always DD, and the third byte is the displacement, which in this application is the same as the lower half of the ram address. For example, at eprom address 216 is the machine code DD 7E BB, which disassembles as LD A, (IX + BB). This loads the accumulator from ram address 80BB, whose function can be looked up in Table 3.

Testing for a keyboard row or for a particular key is done with bit test instructions, which are recognizable by the fact that the first byte is always CB. The meanings of the individual bits in registers C, D and E are given in Table 4.

If the existing code is moved around to make room for additional functions, remember that the seven-segment look-up table must remain on a 256-byte page boundary. Also, beware of relative jumps which go past your added code. The safest, if not the most elegant, way of adding code into the middle of a routine is to insert a Call instruction into the middle of the last three bytes (or more if necessary) to make up a complete instruction) before the place where you want to put the added code. The Call is to an address above the end of the existing program, and at that address should be the instructions replaced by the Call, followed by your additional code.

Table 3. Scratchpad ram allocations and setting storage format

<table>
<thead>
<tr>
<th>Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>8080</td>
<td>Password to distinguish</td>
</tr>
<tr>
<td>8081</td>
<td>Reset from power-up</td>
</tr>
<tr>
<td>8082</td>
<td>Interrupt vector for</td>
</tr>
<tr>
<td>8083</td>
<td>601Hz CTC channel</td>
</tr>
<tr>
<td>8084</td>
<td>Interrupt vector for</td>
</tr>
<tr>
<td>8085</td>
<td>20Hz CTC channel</td>
</tr>
<tr>
<td>8086</td>
<td>Interrupt vector for</td>
</tr>
<tr>
<td>8087</td>
<td>spare CTC channel</td>
</tr>
<tr>
<td>8088</td>
<td>Counter 2 (5 to 1Hz divider)</td>
</tr>
<tr>
<td>8089</td>
<td>Counter 1 (20 to 5Hz divider)</td>
</tr>
<tr>
<td>808A</td>
<td>Enable 1/2</td>
</tr>
<tr>
<td>808B</td>
<td>Not used</td>
</tr>
<tr>
<td>808C</td>
<td>Pointer 1</td>
</tr>
<tr>
<td>808D</td>
<td>Pointer 2</td>
</tr>
<tr>
<td>808E</td>
<td>Temp. store 1</td>
</tr>
<tr>
<td>808F</td>
<td>Temp. store 2</td>
</tr>
<tr>
<td>8090</td>
<td>Search store</td>
</tr>
<tr>
<td>8091</td>
<td>Not used</td>
</tr>
<tr>
<td>8092</td>
<td>Day (bits 6 to 0)</td>
</tr>
<tr>
<td>8093</td>
<td>Tens-of-hours</td>
</tr>
<tr>
<td>8094</td>
<td>Units-of-hours</td>
</tr>
<tr>
<td>8095</td>
<td>Tens-of-minutes</td>
</tr>
<tr>
<td>8096</td>
<td>Units-of-minutes</td>
</tr>
<tr>
<td>8097</td>
<td>Tens-of-seconds</td>
</tr>
<tr>
<td>8098</td>
<td>Units-of-seconds</td>
</tr>
<tr>
<td>8099</td>
<td>Not used</td>
</tr>
<tr>
<td>809A</td>
<td>Timer enables</td>
</tr>
<tr>
<td>809B</td>
<td>Output status</td>
</tr>
<tr>
<td>809C</td>
<td>Repeat transmission password</td>
</tr>
</tbody>
</table>

809E to 80AC are not used.

<table>
<thead>
<tr>
<th>Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>80AD</td>
<td>Today (bits 6 to 0)</td>
</tr>
<tr>
<td>80AE</td>
<td>Hours</td>
</tr>
<tr>
<td>80AF</td>
<td>Minutes b-c-d</td>
</tr>
<tr>
<td>80B0</td>
<td>Seconds</td>
</tr>
<tr>
<td>80B1</td>
<td>Active/suspended/cancelled</td>
</tr>
<tr>
<td>80B2</td>
<td>Repeat (bit 7) and days</td>
</tr>
<tr>
<td>80B3</td>
<td>Tens-of-hours</td>
</tr>
<tr>
<td>80B4</td>
<td>Units-of-hours</td>
</tr>
<tr>
<td>80B5</td>
<td>Tens of minutes (7-seg)</td>
</tr>
<tr>
<td>80B6</td>
<td>Units of minutes (7-seg)</td>
</tr>
<tr>
<td>80B7</td>
<td>Tens of hours</td>
</tr>
<tr>
<td>80B8</td>
<td>Units of hours</td>
</tr>
<tr>
<td>80B9</td>
<td>Tens of minutes (7-seg)</td>
</tr>
<tr>
<td>80BA</td>
<td>Units of minutes</td>
</tr>
<tr>
<td>80BB</td>
<td>Channels</td>
</tr>
<tr>
<td>80BC</td>
<td>Output status</td>
</tr>
<tr>
<td>80BD</td>
<td>Not used</td>
</tr>
<tr>
<td>80BE</td>
<td>00: keys enabled, FF: disabled</td>
</tr>
<tr>
<td>80BF</td>
<td>Keyboard debounce counter</td>
</tr>
</tbody>
</table>

Table 4. Calculating registers

<table>
<thead>
<tr>
<th>Code</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>80BE</td>
<td>00: keys enabled, FF: disabled</td>
</tr>
<tr>
<td>80BF</td>
<td>Keyboard debounce counter</td>
</tr>
</tbody>
</table>

Variations

A number of simple modifications may be made, either to reduce the cost of the system or to change its operation in some way. For example, if all the appliances to be controlled are in the same room as the control unit, a substantial cost saving may be achieved by dispensing with the f.s.k. remote control. Instead of IC13 on the processor board, the circuit opposite provides a directly-connected signal to operate each opto-coupled switch. It would even be possible to mount some or all of the switches inside the control unit, to save on boxes, and to connect the appliance
main leads to the control unit, either with standard mains plugs and sockets, or via "chocolate-block" connectors or barrier strips. But remember that the total current for all the appliances is then supplied from a single wall socket, and must therefore be limited to 13 amps.

Table 4, Flags

<table>
<thead>
<tr>
<th>Register C</th>
<th>Meaning of Flag (when at logic 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Seconds count is enabled</td>
</tr>
<tr>
<td>6</td>
<td>Minutes count is enabled</td>
</tr>
<tr>
<td>5</td>
<td>The CHECK the time is enabled</td>
</tr>
<tr>
<td>4</td>
<td>Non-control keys are enabled</td>
</tr>
<tr>
<td>3</td>
<td>Settings for a particular CHANNEL are being examined/ altered</td>
</tr>
<tr>
<td>2</td>
<td>Settings on a particular DAY are being examined/ altered</td>
</tr>
<tr>
<td>1</td>
<td>Repeat setting is being entered</td>
</tr>
<tr>
<td>0</td>
<td>A NEW setting is being entered</td>
</tr>
</tbody>
</table>

Flowchart

Copies of the flowchart annotated with eeprom addresses and too extensive to print here are available from the editorial office in return for a stamped and addressed envelope marked 'Remote timer'. Included is the hexadecimal listing, some notes on battery backup, components lists and p.c.b. hints.

Register D

<table>
<thead>
<tr>
<th>Bit</th>
<th>Pressed Key</th>
<th>Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Set clock</td>
<td>Repeat</td>
</tr>
<tr>
<td>6</td>
<td>Last step</td>
<td>Saturday</td>
</tr>
<tr>
<td>5</td>
<td>Next setting</td>
<td>Sunday</td>
</tr>
<tr>
<td>4</td>
<td>Down</td>
<td>Monday</td>
</tr>
<tr>
<td>3</td>
<td>Jp</td>
<td>Tuesday</td>
</tr>
<tr>
<td>2</td>
<td>Next step</td>
<td>Wednesday</td>
</tr>
<tr>
<td>1</td>
<td>Normal</td>
<td>Thursday</td>
</tr>
<tr>
<td>0</td>
<td>New setting</td>
<td>Friday</td>
</tr>
</tbody>
</table>

Register E

<table>
<thead>
<tr>
<th>Bit</th>
<th>Key Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Control</td>
</tr>
<tr>
<td>6</td>
<td>Days &amp; repeat</td>
</tr>
<tr>
<td>5</td>
<td>Timer enable/disable</td>
</tr>
<tr>
<td>4</td>
<td>Output on/off</td>
</tr>
<tr>
<td>3-0</td>
<td>Not used</td>
</tr>
</tbody>
</table>

Operation

To set the clock when power is first applied (the day leds should be flashing):
1. Set the day by pressing the appropriate key.
2. Press 'next step'. This makes the tens-of-hours digit flash; use the up and down keys to change it if required.
3. Use the next step up and down keys to step through and change the other three clock digits in the same way. 'Last step' can be used to correct a previous digit if a mistake is made.
4. With the right-hand digit flashing, press 'next step' or 'normal' on a time signal. The seconds start counting from zero at this point.

To correct the clock time:
1. Press 'set clock', which makes the seconds digits flash.
2a. If the clock is less than half a minute fast or slow, press 'normal' on a time signal. This sets the clock seconds to zero, and if the clock was slow, (i.e. if the displayed seconds were 30 or more) the clock time is incremented by one minute.
2b. If the clock is out by more than half a minute, press 'next step' repeatedly until stepping through days, hours and minutes, using the day keys or the up and down keys to correct whenever part of the display is flashing. The seconds count is not affected unless the units-of-minutes digit is altered; in which case the seconds are set to zero and will resume counting when 'next step' is pressed again. If the tens-of-minutes digit is altered, the minute will not increment when the seconds change from 59 to 00. The minutes count is re-enabled on returning to normal mode, which is done by pressing 'next step' while the units-of-minutes digit is flashing.
3. Enter a new timer setting:
1. Press 'new setting'. If the display shows 'full', there are already a hundred settings stored, and one must be cancelled to make room for the new one (see below). Normally, the active led flashes, and the on-time is set to 00:00. At this stage the up key may be used to change active to suspended if required.
2. Press 'next step', which makes the repeat led and all the day leds flash. Any combination of days may be selected; the day becomes last day, and one you pressed 'next step' to return to the clock display.
3. If 'normal' is pressed at any stage when no channels are selected, the setting is cancelled and in place becomes blank except for the cancelled led, the colon and any output leds which were already on. Press 'normal' again to return to the clock display, or press 'next setting' to start again.

To examine and alter stored settings:
1. Press 'next setting'. The repeat led and all the channel and day leds flash.
2. To examine all settings for a particular day or channel, or all repeated settings, press the corresponding key; to examine all stored settings regardless of content, press 'next setting' again. The first appropriate setting (if there is one) is displayed with active or suspended flashing. If the setting is not a repeated one, the last day also flashes. If there are no such settings stored, the display shows 'none'.
3. Use the 'up' and 'own' keys to rotate the active/suspended/cancelled status if required. 'Next step' may be used to step through the rest of the setting; whichever part is flashing may be altered. 'Next step' is ignored if the cancelled led is lit, as there is no point in altering a setting if you're going to cancel it. (a)
4a. If any stage in the above, 'next setting' may be used to display the next appropriate setting (if there is another one). If the previously displayed setting was left with no channels selected or with the cancelled led on, it is deleted from the setting ram. If there are no further stored settings appropriate to the group selected at '2' above, the display shows 'none' with a day, repeat or channel led lit to remind you which settings you were examining. If you were looking at all stored settings, all the channel leds are lit.
4b. Pressing 'normal' at any stage restores the clock display, unless the last setting to be displayed was left with no channels selected or with the cancelled led on. In those cases, the setting is deleted from the setting ram, and the display is blanked except for the cancelled led, the colon and any output leds which were already on. Press 'normal' again to restore the clock display; or press 'next setting' to return to step '2' above; or press 'new setting' to set up a new setting from scratch.
Measuring tape speed

A simple and accurate method of ensuring the correct tape speed

It is often important to ensure that the speed of a cassette recorder is reasonably close to its correct speed, either to ensure the correct pitch of music or the correct frequency of delayed data. One method of doing this is to use a standard-frequency tape and measure the output of the cassette recorder on a frequency meter. Having neither at my disposal, I devised a method which only requires a watch, a pair of vernier calipers and a cassette. Basically, the method consists of measuring the thickness of the tape and then measuring the time for a given number of revolutions of the cassette when playing the recorder or player. The cassette used should preferably be a C60 (although a C90 will do) it must be of screwed construction and the tape hubs should be clearly visible. (The latest range of Sony cassette players are particularly good for this purpose as the tape clamp provides a very easy reference when counting the hub revolutions.)

Measuring tape thickness

If your cassette recorder doesn’t have a counter, this will be the most laborious part of the process. Run the cassette from start to finish and count the total number of revolutions of the take-up hub. Most cassette recorders, however, have a counter driven from the take-up hub, and this makes the process much easier.

First, the ratio of the hub revolutions to the counter is found by noting the change in counter reading for 20 revolutions of the take-up hub and then dividing this change into 20, i.e. read the number of revolutions on the counter from one end to the other and then note the change in the counter reading. The number of revolutions of tape (including the lengths) is the change in counter reading.

With the cassette wound to one end, unscrew the cassette and measure the diameter of the empty hub (h) and the diameter of the full spool (f) using the vernier calipers. The total thickness of the tape on the full spool is (f-h)/2, and if the number of revolutions is nT, then the thickness of the tape, t = (f-h)/2nT.

It is wise to do all of your calculations in one set of units, preferably millimetres, so if your calipers measure in inches don’t forget to convert the measurements to millimetres first. Tape thicknesses, typically, 18 µm (0.018mm) for C50 cassettes and 12µm (0.012mm) for C90s.

Tape speed

If the counter on the recorder uses the hub instead of the take-up hub then see Method 2 (later). Having reassembled the cassette, rewind it to the start. Either by direct counting or using the recorder’s counter, count the number of revolutions of the hub for, say, 5 minutes (using a watch or stop watch). Do not time the first few revolutions, since this will lead to starting errors, but do note the exact number of revolutions n1 at which you start to time. After timing for a duration d seconds (the longer the better) note the number of revolutions n2. If you are using the recorder’s counter don’t forget the conversion factor k. The tape speed is,

\[ s = \pi \left( n_2 - n_1 \right) \left[ \frac{h + (2nT + 2 - n_2 - n_1)k}{d} \right] \text{ mm/s} \]

and, since the correct speed of cassette recorders is 47.625 mm/s (1.51 p.s.) the speed error is

\[ e = \left( s - 47.625 \right) \% \text{ of 47.625} \]

These calculations can easily be carried out with the aid of a scientific calculator, but for those who need to carry out the calculation many times (for example, when adjusting the speed of a recorder or player) a short computer program is included at the end of this article. Although written for the Spectrum, it can easily be adapted for any other computer. The tolerance permissible for professional recorders is ±0.5% and for domestic recorders ±2%.

Method 2. If the counter is driven from the feed spool instead of the take-up spool then the same basic timings are made, but the equations are

Tape speed

\[ s = \pi \left( n_2 - n_1 \right) \left[ \frac{h + (2nT + 2 - n_2 - n_1)k}{d} \right] \text{ mm/s} \]

Making a speed test tape

Having determined the speed of a recorder, it is now possible, with the aid of an audio signal generator and a frequency meter, to make a standard speed tape. Using the frequency meter, set the signal generator frequency to 1kHz (X100+e) and then record several minutes of this signal. When replayed on any machine the speed error will be indicated on a frequency meter, the tens of Hertz indicating units of percentage error and units of Hertz indicating tenths of one percent error. For maximum stability of the test tape a C60 (or shorter) cassette must be used.

Derivation of the formula

The length of tape on the first revolution of the hub is \( \pi h \), where \( h \) is the diameter of the hub. The length of the second revolution is greater since its diameter is larger by twice the thickness of the tape (t). Its length is \( \pi (h+2t) \) and so the length of the nth revolution is \( \pi (h+2(nt-t)) \).

The total length of the first n revolutions of tape is equal to the sum (addition) of the lengths of each revolution. This sum is an arithmetic series whose first term is \( \pi h \) and whose common

by M. E. Theaker, B.Sc., M.I.E.R.E.
difference is $2\pi t$. The total length of tape for n turns is

$$L = \pi n(h + (n - 1)k)$$

Using this equation and the information found when measuring the thickness of the tape, you can calculate the total length of the tape in the cassette by making n equal to the total number of revolutions of the cassette (nt). The nominal length for a C60 cassette is 90m and for a C90 is 135m, plus a leader of about 0.5m at each end. The length of tape between $n_1$ and $n_2$ revolutions is

$$L_{21} = \pi n_2[h + (n_2 - 1)k] - \pi n_1[h + (n_1 - 1)k]$$

Similarly, if the revolutions of the feed spool are counted, then the length of tape is

$$L = \pi n[h + (2nT + 1 - n)T]$$

where nT is the total number of turns on the cassette. The length of tape between revolutions $n_1$ and $n_2$ in this case is

$$\pi n_2[h + (2n_2 + 1 - n_2)T] - \pi n_1[h + (2n_1 + 1 - n_1)T] = \pi (n_2 - n_1) \times [h + (2n_2 + 2 - n_2)T]$$

### Accuracy

The accuracy in measuring the speed error (and the speed) depends upon the accuracy with which the various measurements have been made. If the difference between the full-speed diameter and the hub diameter is measured to within 0.1mm then the apparent speed error will be 0.05%. An error of 1 in determining the total number of revolutions will introduce an error of 0.02%. The most critical is the measurement of the duration of the revolutions from $n_1$ to $n_2$. If the number of the revolutions for the entire side of a C60 cassette (30 mins) is timed with an accuracy of 0.5s, then an error of 0.03% will be introduced, which brings the total error of 0.1% if, however, the revolutions for the first 5 minutes are timed to an accuracy of 0.5s, then the resulting error is 0.15%, bringing the total error to 0.22%. It is important, therefore, to carry out the time measurement over as long a period as possible to achieve the highest possible accuracy.

by T. Loughlin
B.Sc. (Hons.)

**10-bit digital recorder**

Using modern data conversion i.c.s, very low-frequency analogue signals can be recorded on tape with high accuracy.
Fig. 1. Record section. Analogue signals are converted into a 10bit digital word and fed to the uart in sections.

Fig. 2. Record timing. In this system, a logical one is encoded as a rising edge and a logical zero as a falling edge.
A problem may arise here. The start conversion going low initializes the ZN432E sar so data present at uart inputs TBR1-5 will change. The maximum hold time requirement for the uart is 960ns so the delay from TBR high through IC26, IC4 and IC5 must be greater than this.

However since typical propagation delay of IC5 is 160ns and the typical uart data hold time is 40ns, problems should not normally arise. If this does cause a problem then delay the start-conversion pulse from TBE.

The converter takes 11 clock cycles or 143μs at 4800 baud to make a conversion. When the uart has finished transmitting the first character TRE goes high (Fig. 2c). Output of 'Byte' is low at this stage gating the lower five bits of the sample into the uart. Signal TBR1 loads the transmitter-buffer register and the TRE(TBR1) rising edge transfers this data into the transmit register and starts transmitting it. "Byte" low output inhibits the start-conversion pulse and is also transmitted as bit six.

The falling edge of TRE toggles the 'Byte' bistable device high. Fig. 2b, and the five most-significant data bits are loaded into the uart by TBR1 being low with bit 6 high. When the uart i.e. has finished transmitting the lower five data bits and associated bits, TRE again goes high on a clock falling edge. The five most-significant data bits and 'Byte' are loaded into the transmit register ready for transmission.

Being high, 'Byte' output gates a start-conversion pulse to the a-to-d converter, Fig. 2c. which begins taking a new sample while the upper five bits are transmitted. The sequence thus repeats itself and is self-driven.

Serial output data from the uart, IC1 pin 25, is encoded into a biphase form by IC11, IC18 and IC17 (Fig. 1) as shown in Fig. 2a. In this system a one data bit is encoded as a rising edge and a zero as a falling edge of the digital output to the recorder. Output level is around 50mV. Inspection of the output waveform shows that the highest frequency present is equal to the baud rate used e.g. at 4800 baud the maximum is 4800Hz.

High level replay signal from the recorder would normally suffer from phase distortion because of the recording process itself and appears usually as shown in Fig. 4a. This signal is applied to a phase equalizing circuit comprising IC10a and associated components (Fig. 3) to compensate for this distortion. It is then amplified, IC10b and squared, IC2c, to obtain a t.t.l.-level signal that is close to the original recorded signal.

The biphase decoding circuit comprises IC7a, IC9a, IC26, and IC7b. Clipping circuit IC7b produces a narrow pulse for each transition of the encoded digital signal. Counter IC19b, driven by the 16x uart clock, counts to 12 or greater unless reset by clipper output pulses. If the counter goes to 12 or greater. IC2d output goes low then high causing bistable device IC9b to toggle.

Output of IC9b as can be seen from the timing waveforms is decoded serial data. It is however possible that bistable device IC9b may be in the wrong state initially in which case the decoded data will be inverted. This produces a parity error and/or a frame error signal from the uart which cause bistable device IC17b to toggle. Output Q of this bistable device drives exclusive-or gate IC9 pin 13 which gates decoder output to the uart serial input; the net effect is to invert the data stream seen by the uart. The circuit then rapidly synch-
oscillates itself to incoming data, Fig. 4d.

Assuming that a correct stream of data is being received the problem is to reconstruct the 10bit analogue samples. When a full character has been received, data-received flag DR, IC1 pin 19, goes high in the middle of the stop bit on the clock rising edge, Fig. 4c.

Data-received bistable device IC17a is driven by the inverted clock so the next clock falling edge transfers DR to its outputs. Signal Q of IC9 is used to reset DR via RR to prepare for the next character and the next clock falling edge transfers DR low to IC17a output which is thus a pulse one clock period wide.

If the received character contained the lower five bits of the sample then bit 6, IC1 pin 7, is low so bistable-device output is gated via IC13b, to register IC12 which stores the data.

The next received character will contain the five higher bits of data and bit 6 will be high so the data received pulse is gated via IC13a to the output d-to-a converter, IC13, Fig. 4b. The five lower bits from IC9 and the five upper bits from the word are thus clocked into the DAC1000 output register and the analogue output attains the latest value.

The output d-to-a converter obtains its reference voltage from the ZN432E a-to-d converter so ensuring good tracking between the two devices. However the output, IC16 pin 6, will be inverted so after filtering (IC10a) to remove quantizing noise it is inverted (IC10b). If no signal is being received or the re-played data is incorrect for some reason then parity or frame-error signals inhibit output-latch pulses and cause the 'signal present' lamp to go out.

The circuit described here was built and tested to determine the validity of the design concept and has been used to good effect for recording e.g. signals. Certain features which contribute to the absolute overall accuracy of the system are not included such as converter offset and gain adjustment potentiometers. Note however the use of separate analogue and digital power supplies and grounds.

Dynamic sampling accuracy can be improved by using a sample-and-hold circuit such as the LF398, which may be connected as shown in Fig. 5. The circuit as shown without a s/h device will have a dynamic sample error of 2% on a 50Hz full scale sine wave input.

**References**

At Olympia, in Hammersmith, London, the British Electronics Week has come round again. Occupying even more space, with a greater number of exhibitors, the show has become a major event in the electrical/electronic calendar. From the 29th April to the first of May, Olympia will be full to overflowing with exhibitors.

The week actually consists of four exhibitions; The All-Electronics/ECIF Show, Circuit Technology, Electronic Product Design, and Fibre Optics. A fifth section has been announced for inclusion in the Week in 1987; Power Sources and Supplies. We had planned to provide a map of the stands and a list of exhibitors, but this would have taken up too much of our space; it is better left to the catalogue, available at the Show; instead we have concentrated on presenting some recent announcements of new products by exhibitors. Some companies are very chary of releasing details of products to be launched at the Show; so we will report on such releases after the event.

Your correspondents will have the unenviable task of attempting to visit every stand in this mammoth circus. For those unwilling or too busy to spend too much time there, we would recommend that you get a catalogue and then find a spot to sit down and read the sections that interest you. This will save a lot of time. Also at the entrance to the Show there are stations that can provide computer print-outs of the positions of the stands that have the products that may interest you.

Olympia has its own underground station, served during exhibitions by a shuttle train from Earls Court, which is the exhibition hall for the Fibre Optics section.

**Function generator**

Among the products to be displayed by Global Specialties is the Sovereign 8200 series of synthesized 20MHz function generators. Fully programmable through the GPIB interface, the generators provide sine, square and triangle waves and pulses with variable amplitude, symmetry and offset over a 2mHz to 20MHZ frequency range. The company are also showing d.c. power supplies, surface-mounting breadboards using plastic leaded chip carriers, a low-cost universal counter-timer and a wide range of rack systems and test-and-measurement instruments. Global specialties corporation (UK) Ltd, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ. EWW 207 on reply card. Stand no. 260.

**SIL resistors**

High volume production and improved manufacturing techniques have allowed Allen-Bradley to extend the range of its 700 series of cermet resistor networks in single in-line (SIL) packages. The resistors are available in 4 to 14-pin packages with resistances from 220 to 2.7MΩ. They are connected internally to a common bus (style A), as individual resistors (style B) or as digital line terminators (style E). All are fully tested. Allen-Bradley Electronics, Ennia House, High Street, Edenbridge, Kent TN8 5LY. EWW 216 on reply card. Stand no. 106.

**Alternative to tantalum**

Subminiature electrolytic capacitors with radial leads are suggested as a low-cost alternative to tantalum beads. The Waycom WSQ series has a capacitance range of 0.1 to 100μF with rated voltages from 6.3 to 63V. The aluminium capacitors are cased in aluminium with welded internal connections. High-grade paper separators for long-term reliability. BA Electronics Ltd, Hitchin Road, Arlesley, Beds SG15 6SG. EWW 212 on reply card. Stand No. 482.

**Mains filter**

Compufilter has been designed to remove noise, r.f.i., and voltage transients from mains lines used with microcomputers and allied peripherals. Each model comprises a series of filters designed to eliminate both incoming and outgoing interference by providing a high level of attenuation. A two-stage filter protects against incoming asymmetry and includes a transient suppressor. Each socket is protected against asymmetry and is isolated from the others. There is a choice of output socket types. Each output is limited to 3A. Cetronic Power Products Ltd, Hodeston Road, Stanstead Abbotts, Ware, Herts SG12 8EJ. EWW 209 on reply card. Stand no. 561.
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Electronics & Wireless World May 1986

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British rival for Amiga

The new Amiga computer from Commodore with its exceptionally fast graphics created a good deal of interest at the recent Which Computer? show. But now comes a British rival to the Amiga, the Microbox 3, which on paper outpaces it.

Microbox 3 is a colour graphics computer designed around the 68000 (or 68010) processor running at 8MHz and Motorola's Raster Memory System chip set. It offers 40 different screen modes, with resolution ranging up to 640 by 500 pixels, plus features such as a 4096-colour palette, eight re-usable sprites, and a virtual screen of up to 512K in size with smooth horizontal or vertical scrolling. The video standard is 625-line PAL or NTSC and the output can be genlocked to an external video source.

The board carries 512K of D-RAM plus 128K of system rom and has room for 64K of user rom. An 8M-byte plug-in expansion board with a floating-point co-processor is promised. Also on the way is a Transputer co-processor.

There is a twin 800K floppy disc interface built in and a choice of four operating systems — CP/M68K (GEM), OS-9/68K, Tripos and SMS-2, which should enable the machine to run most software designed for the Amiga or the Atari 520ST. In addition there is an SCSI bus interface for a 20M-byte hard disc.

Other details include a real-time clocks, a stereo sound generator, a dual RS232 port, parallel printer port, mouse interface and a built-in emporium programmer.

The board alone, is available at £650; boxed versions of the computer with built-in disc drives will be ready later. Applications suggested by the makers include image processing, engineering work, video games and Kanji word-processing. Micro Concepts, 2 St Stephen's Road, Cheltenham, Gloucestershire GL51 SAA. EWW 220 on Reply Card.

FFT on the BBC

A second-processor board will allow the BBC Micro (or many other computers) to perform fast Fourier transformations very rapidly; 1024 complex points in less than 50ms using 16-bit two's complement arithmetic. Magnitude scaling is included to maintain a high dynamic range. Computing power is provided by the TMS 32010 digital signal processor from Texas Instruments with 4K of program memory and 64K of 16-bit memory with 100ns access time. The instruction set is optimized for single processing. For example a 16 by 16 to 32-bit multiply takes only 200ns and 32-bit accumulates can be pipelined with the loading of the next operand.

A hardware interface enables the transfer of data and programs between the BBC and the TMS at about 2Kword/s. Operation is controlled by software running on the BBC. It takes assembled program data from discs, sends them to the TMS for processing and displays the results either graphically or as a table of numbers. A compatible a-to-d board is available to allow processing of incoming data in real time, sampling at frequencies up to 500kHz for 8-bit resolution.

The processor board, interface and software to perform FFT's and design matching filters is all bundled together to provide a development system for the TMS processor in a variety of real-time digital signal processing applications such as spectral analysis, finite and infinite impulse response filters. It makes a useful teaching aid for students of digital signal processing. Practical applications include the possibility of recording sound in real time digitally with a resolution comparable with that on compact discs; real time encryption is also possible.

The hardware can be used with other computers since it only requires two i/o ports on the host. Enquiries about adapting the interface to work on any host computer bus would be welcomed by Graham Sutherland and James Ervine, 71 Linden Gardens, London W2 4HJ. EWW 211 on reply card.

Signal generators

Two new signal generators cover the frequency spectrum from 10Hz to 450MHz in overlapping ranges. The audio frequency model has an accuracy of +3%, generating sine waves up to 1MHz and square waves up to 100kHz with a rise-time of 200ns. Output voltage is variable from 0 to 4V. It has an output impedance of 5000.

The r.f. model covers six bands from 100kHz to 150MHz on fundamentals extending to 450MHz on harmonics, with a continuously variable output of 0 to 0.1V. r.m.s. Modulation is by an internal 1kHz tone or can be supplied externally. The provision of an external crystal socket makes it easy to use for spot frequency calibration. Available through MS Components Ltd, Zephyr House, Waring Street, London SE27 9LH. EWW 213 on reply card. MS was part of the Steatite Group who are also showing a range of r.f. protection and shielding products; capacitor and resistors; semi-conductors, cells and batteries and many other products. Stand No. 219.
Battery-powered oscilloscope

The new T0315 oscilloscope from Electroplan is a dual-trace 15MHz instrument weighing only 4.5Kg. The low weight and small dimensions make it suitable for field service and for application where a.c. power may not be available. It has sensitivity ranges from 2mV to 10V/division in 12 ranges, automatic selection of chopped or alternate mode and TV line or frame display. It can operate from batteries or a.c. mains with internal rechargeable batteries offering up to two hours of continuous operation. Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH. EWW 217 on reply card. Stand No. 132.

Compact switch-mode power

Peak current may be drawn from all outputs in this 350W switched-mode power supply. The F350 is a compact, open frame supply that can provide 5V at 50A, -5V at 5A, -12V at 5A and +24V at 5A. Power-failure indication is included and pulse overload capability is available on all outputs. 'Power trading' between the outputs is used. Meeting a number of IEC, BS, VDE and TG standards the supply is intended for use on computer systems with disc drives, printers and other electromechanical devices that demand high peak power. Powerline are displaying a wide range of other products including the Vicor VI100 d.c. - d.c. converter that switches at zero volts. It is claimed to produce half the heat of a conventional switched-mode regulator and to have a minimum efficiency of 80% — typically 90%. Powerline Electronics Ltd, 9 Nimrod Way, Eglat Road, Reading, Berks RG2 0EB. EWW 211 on reply card. Stand No. 118.

Modular measurement systems

The introduction of a family of Eurocard computer products comes from Measurement Systems. Modular 96 supports the Unix-like OS-9 operating system, giving multi-user, multi-tasking capability. OS-9 can be contained in a rom and can be used in turnkey systems, with or without discs. The family includes a wide selection ofrom, ram and i/o functions including disc, parallel, serial, isolated parallel, GPIB, analogue and graphics interfaces. A key feature is that all the modules in the range are provided with OS-9 software at no extra cost. Support includes comprehensive documentation, regular training courses and on-site consultancy to ensure rapid system development. Available through R.C.S. Microsystems Ltd, 141 Uxbridge Road, Hampton Hill, Middlesex TW12 1BL. EWW 218 on reply card. Stand No. 527.

Surface-mount connectors

In order to obtain the best benefits from surface-mounted p.c.b.s, it is necessary that all the components used should mount on the surface. Erni, in West Germany have come up with two-part connectors specifically developed for surface mounting. They conform to DIN 41612 and allow the use of conventional p.c.b. size, spacing and racking. The materials used are suitable for vapour-phase and reflow soldering. Fixing holes are supplied and the makers recommended screwing or riveting the body to the p.c.b. Available through Radiatron Components Ltd, Crown Road, Twickenham, Middlesex. EWW 214 on reply card. Stand No. 375.
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SmartWatch

A battery-backed real-time clock/calendar with 64Kbit non-volatile ram for under £35.

This real-time clock/calendar from Dallas Semiconductor includes a battery-backed c-mos ram capable of holding data for 10 years. SmartWatch keeps track of:
- Hundreds of seconds — seconds — minutes — hours — day — date — month — year in any computer or controller application.

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Normally the computer sees SmartWatch as a standard memory i.c. but when a special code is sent to the socket, internal address decoding triggers the clock/calendar function, allowing time and date information to be read and written.

This means that both clock and memory occupy the same computer address range and no external decoding is required.

Only a small software routine is needed to trigger the clock function and read and write time/date information.

Built into the socket are the real-time clock, a lithium battery, address decoding and power-down switching.

Because of their extremely low power consumption, the 8264-type static memory i.c. and clock/calendar remain powered for 10 years using the same battery.

*JEDEC pinout

SmartWatch

ELECTRONICS & WIRELESS WORLD MAY 1986

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CIRCLE 69 FOR FURTHER DETAILS.
Logarithmic video amp

Among the products to be displayed by Exar is the XR-7000 a log video amplifier i.e. with a wide bandwidth, suitable for many applications from audio to radar and including test instruments, video and audio systems, smoke detectors, ultrasonic detectors, medical instrumentation and so on. The single-chip device has seven logarithmic stages which may be cascaded for increased dynamic range.

Power supplies

Advance Power Supplies have extended several of their ranges. The d.c. driven Powerflex range now includes a PD500 which has a nominal input of 48V, but which will operate between inputs of 40.5 and 63V, believed to be the widest input operating voltage swing in the world. Outputs are available in four versions: 5V at 60A, 12V at 30A, 24V at 13A and 48V at 7A. Plug-in p.c.b.s offer auxiliary outputs of 5, 12, 15, 18, 24 and 48V. 'Power trading' between outputs is a standard feature.

The Powermag A1500 is a 5V, 300A switchmode power supply working from 110V or 220V a.c. inputs. These are nominal and the supply will operate from almost any a.c. supply and input frequency. Its largest dimension is 280mm.

To complete the additions to the Advance range there are the Powerite A200 series of five-output, 200W openframe power supplies. They use 100kHz EES to allow the use of small transformers and be 'highly efficient and reliable'. The supplies operate from a.c. mains and offer a main output of +5V at 40A, with auxiliary outputs of -5V, 5A, +12V, 5A, -12V, 5A and +24V, 8A.

Advance Power Supplies Ltd, Raynham Road, Bishop's Stortford, Herts CM23 5PF, EWW 255 on reply card. Stand No. 251.

Desolderer free from static

A new addition to OK Industries' 'Anti-static' range of products is this desoldering pump, the DP3, which conforms to standards of electrostatic-free materials. It has a conductive tip that is easy to clean and change.

Presently available at a special offer of £3.16 inclusive — 40% off the list price. OK Industries UK Ltd, Dutton Lane, Eastleigh, Hants SO5 4SL. EWW 210 on reply card. Stand No. 250.

Telecomms transformers

An expansion of its range of audio transformers for telephone coupling applications, is the TA series from Dale-ACI. All the new models are designed to meet FCC part 68 requirements. A wide range of sizes, mounting configurations and circuits are available to provide line isolation, four-wire to two-wire hybrid termination, impedance matching and line balance functions over a frequency range of 300 to 3500Hz for data and voice applications. Modifications to the impedance, frequency response or other electrical characteristics are available to meet specific design needs. Dale-ACI Components Ltd, River Park Industrial Estate, Berkhamstead, Herts HP4 1HL. EWW 215 on reply card. Stand No. 99.

High-frequency power sensor

Marconi Instruments has added a high-frequency, 50Hz power sensor to its range of detectors for use with its digital and analogue power meters. The new sensor, 6913, extends the upper limit of the overall sensor frequency range to 26.56Hz and a 50dB power range from +20 to –30dBm. Applications for measurement in microwave, radar and satellite communications. Marconi Instruments Ltd, Longacres, St Albans, Herts AL4 0JN. EWW 206 on reply card. Stand no. 357.
Low-cost data logger

A comprehensive range of industrial and scientific data capture tasks can be performed by the Vela data logger from Data Harvest. At its heart is a 6802 processor, 8-bit d-to-a and a-to-d converters, ram software and 4K of battery-backed c-mos memory. Sockets are available internally for additional applications 28x. There are four analogue inputs plus an additional pulse input for counting, triggering and recording. Internal pulses for timing and triggering are also provided. Various transducers and sensors can be connected directly to the inputs, or through amplifiers and signal-conditioning units which are available as optional extras and which can be plugged directly to the inputs. The instrument can be mains or battery powered and the recorded data is retained in memory for later downloading. Vela's programs are selected by simple push-button instructions, selected from the front panel. These include transient recording, data collection, timing, pulse counting and waveform generation. Channel number and required parameters are all selected through the membrane keyboard and shown on the led display at the top of the panel. After an event is captured it can be stepped through with the recorded values being displayed on the leds. All of the four channels can be used simultaneously.

The instrument can also output its data to an analogue oscilloscope or a microcomputer. Both can display the recorded waveform and if possible to step through it sequence to get a felt waveform at the cursor. This has the added advantage of turning the laboratory oscilloscope or micro into a digital storage oscilloscope. The micro has the added advantage of being able to store the recorded events as waveforms or as tables of data, make comparisons and perform such analyses as FFT and statistics. The data can be also output to a printer to obtain a graph of the waveform or a table of the data. Graphical output can also be obtained on a pen plotter and as the data is all recorded, there is not disadvantage in the slow speed of the plotter. Vela may be connected to a BBC micro, an Apple II and many other computers.

Applications are varied and use is to be designed to be as versatile as possible. If it is possible to use a sensor it is possible for Vela to record the output. Some examples are structural stress analysis using accelerometers and pressure sensors. Analysis of gases, recording the vibrations in machinery and then analysing potential failure, using FFT etc. Data Harvest believes that its instrument will become a standard piece of lab equipment alongside the multimeter and the oscilloscope. They also believe that at the low price of £275 there is no rival for use in industry or higher education. The instrument is also being marketed under their own name by a well-known component distributor and is featured as a new product in the latest edition of their catalogue. Data Harvest Ltd, 28 Lake Street, Leighton Buzzard, Beds LU7 8RX. EWW 222 on reply card.

Fans on show

Papst needs two stands — one each in the All Electronic and Electronic Production Design shows — to display all their air-moving products. New are a range of 25mm rugged a.c. fans and 120mm electronically commutated d.c. models. Also on display is an "intelligent" cooling system that can automatically control d.c. fans to suit varying requirements of ambient temperature and operating load. Papst Motors Ltd, East Portway, Andover, Hants SP10 3RT. EWW 208 on reply card. Stands no. 101 and 1031.

Assembler + emulator = instant development

Developing object-code software for a target system presents problems. However, one solution is to use an emupro emulator. Such a device is the Portal emulator one port of which plugs into the development system and the other to the target. Portal has the advantage of being developed by Andy Green, who also wrote the Meta assembler — and of being cheap. When a program is assembled by Meta, in the machine code of the target system, the object code is immediately available on the target and may be run instantly. Meta can translate a program into machine code for all the popular 8-bit processors (68000 is under development). This means that the Meta/Portal combination can be used on a wide variety of target processors and is not dedicated to one specific system. Up to four Portals can be chained together and addressed individually and can be used in sockets for a 2716 up to a 27512 i.e. 64Kbyte. Two may be used together, one each for the high and low data strobes of a 68000 system. The system runs from the user port on a BBC micro with no hardware modification. Meta is on two rons. Crash Barrier. Freepost Flitwick, Bedford MK45 1YP. EWW 219 on reply card.

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- **1500 £32k £950 (c)**

**TAXAN** P80 10 (80 coil) £160 (a) P910 (1150 coil) £339 (a)

**BROTHER HR-15** £285 (a) JUK 6100 £289 (a)

**Canon GLP/GR QL Printer** £109 (a) Tractor Feed £28 (a)

**HPI2** = NML Rom for Epson £28 (a)

**Epson Hi-Bo Printer** £325 (a) Integrates Colour Printer £569 (a)

**MODEMS**

**MIRACLE WS 2000** The world standard B.T approved modem covering all standard CCITT and ITU-T (outside UK only) standards up to 1200 baud. Allows communication with virtually any computer system in the world. Expandability to Auto Dial and Auto Answer with full software control enhance the considerable features already provided on the modem. mains powered. **WS 2000 £100 (b)** Data Cable £7 (d)

**NEW WS 2000 RANGE** the new professional series. All are intelligent and ' Hayes compatible. allowing simple English commands to control its many features. All models feature Auto-Dial with 10 number memory, Auto Answer, Speed-Dialing, printer port, data security option etc. All models are factory upgradeable. All **WS3000 V2123 (V2 & V23)** = Bell £235 (a) **WS3000 V22** (as above plus 1200 baud full duplex) £485 (a) **WS3000 V22bis** (as above plus 2400 baud full duplex) £650 (a)

**BBC Data Cable for WS3000 £62 (d)** Data Cables for other micros available.

**GEC DATACHAT 1223** An economically priced B.A.T approved modem complying with CCITT V23 standard capable of operating at 1200/75bps and 75/75bps and 1000/2000 bps baud. It is line powered does not require external power source. It is supplied with software compatible to Prestel, Micronet 800, Telecom Gold and a host of bulk ordering boards £890 (a)

**SOFTH II** This is our own intelligent operating system earning carpanet 2716, 2516, 2533, 2720, and with an adapter, 2546 and 2748. Display 128 byte display screen size. Accesses a serial and parallel I/O devices. Can be used as an emulsion, cassette interface CPU, microcontroller and **£35 50 (d)**

**ACORN IEEE Interface £278 (a)**

**PRODUCT ACCESSORIES**

**PRINTERS & PLOTTERS**

- **EPSON LX 8000** £195 (a) Optional Tractor Feed £20 (b)
- **EPSON LX 8000** £195 (a) Optional Tractor Feed £20 (c)
- **FX85 (80 coil)** £315 (a) FX 105 (136 coil) £449 (a)
- **EPSON LX 40 Colour Printer** £435 (a)
- **EPSON LG 4000** £285 (a) £200 £875 (a)
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**INTERCONNECTIONS**

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**ACORN IEEE Interface £278 (a)**
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(223)

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(228)
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For full details and an application form (to be returned by 9 May 1986) write to Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (or telephone 031 556 8400 Ext 4317 or 5028). Please quote ref PM(PTS)1/3/86.

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