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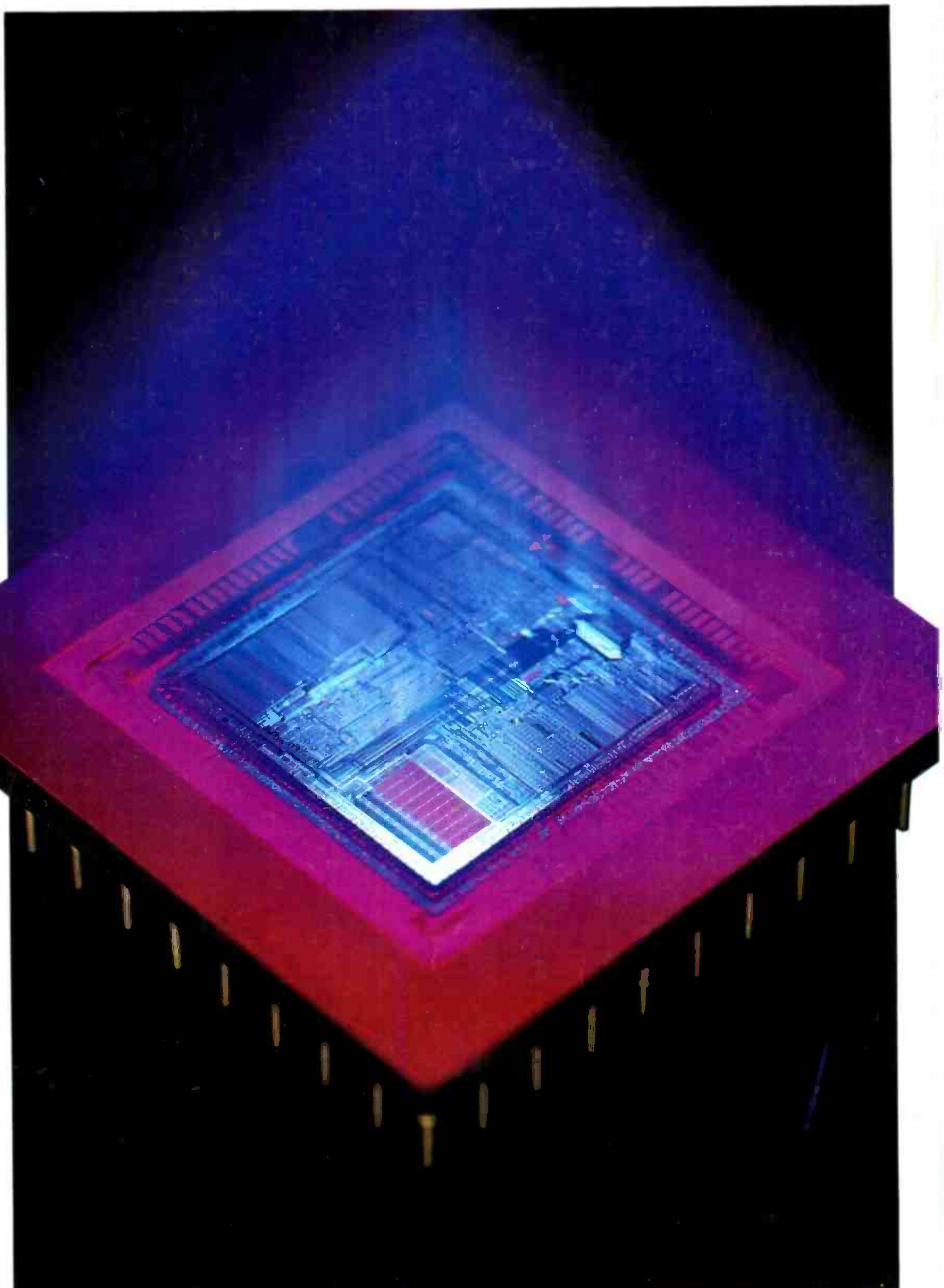

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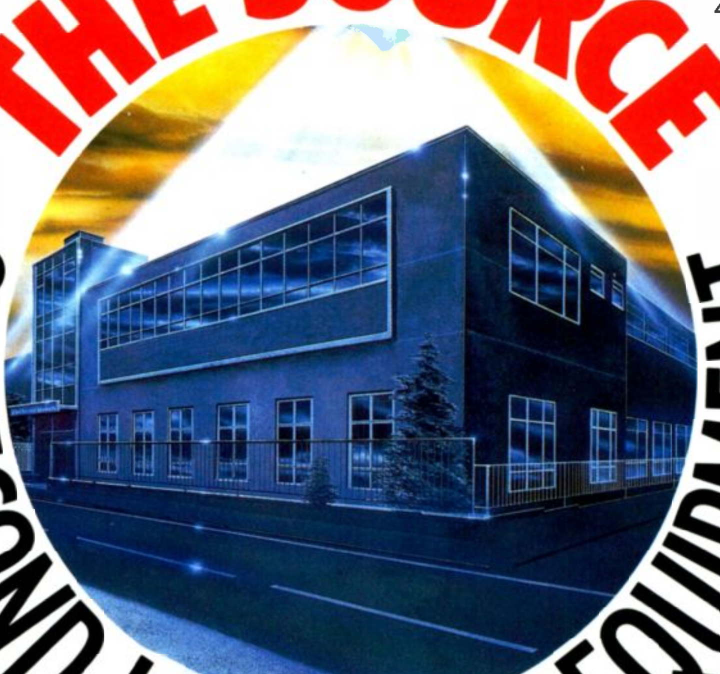

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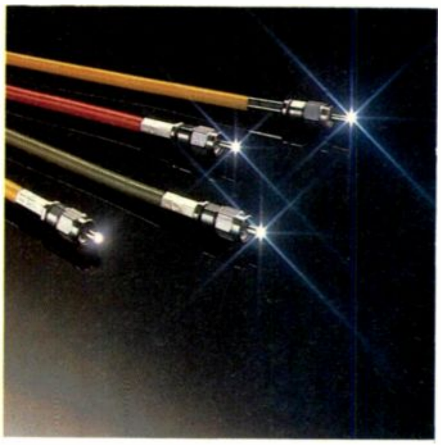
FEATURES

COVER

False-colour electron micrograph of integrated circuit leadouts bonded to chip pads is courtesy of Standard Elektrik Lorenz of Stuttgart.



Optical-fibre links will shortly be accommodated in the IEEE802 'Ethernet' standard for local area networks, as our feature on page 774 explains. (Photo courtesy of Pilkington Communication Systems of Rhyl.)

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Forethought

In the beginning, around the time someone discovered how to walk upright, was science or knowledge. During the succeeding several million years, the pace of scientific advance was scarcely dramatic, and its effect on life barely discernible. There was the occasional flurry of excitement over fire and iron and the wheel and the husbandry of grain crops, but in general the seeker after knowledge and its application to progress did not have to spend a great deal of time worrying about the possible consequences of his actions in the years to come.

Passing lightly over the ensuing period with the merest of nods at the invention of gunpowder and the discovery that coal will burn, and arriving in the late 19th and 20th centuries, one is made very aware that invention and discovery quickly begin to carry with them an imposing array of unlooked-for repercussions. It is now becoming ever more difficult to foresee and, therefore, avoid quite disastrous side effects of progress in almost every field of acitivity.

The list already accumulated is formidable: everyone can reel off a long statement of afflictions that have come about through well meant and apparently civilized innovations. As examples, the use of earth resources cannot have seemed likely to cause excessive depletion in the foreseeable future to early exploiters; and it must have appeared improbable that the pushing of fumes out of a few factory chimneys and horseless-carriage exhausts would lead to acid rain and brain damage. But these effects have happened and they are the responsibility of scientists and engineers.

By definition, engineers are problem-solvers. Since, by their ingenuity and knowledge they have created these problems, albeit unknowingly (for the most part, at any rate), it is now within their area of responsibility to alleviate their effects. They are presented with the greatest problems to solve that anyone can ever have seen. Pollution, the ransacking of the earth's store of materials, the reckless haste to harness atomic power, the threat of military hardware, destruction of forests, over-exploitation of animals, the use of electronic "entertainment" to convert whole populations into zombies: all these and many more are problems waiting for a solution – quite the reverse of much modern engineering effort.

Perhaps it is not now possible to call a halt, or even to arrange a breathing space, in the insane rush to develop more technologies to satisfy immediate requirements with not a thought, or at least only a quickly suppressed one, for the future, the future being far too remote to worry about. But if it is, the future begins to appear less than inviting – and relatively short.

It is, of course, little use addressing oneself to "science" and "engineering". The attitudes of scientists and engineers must be radically changed, as must those who employ them and who direct their efforts. And since the problems to be solved are global ones, any effort to orchestrate the problem solving must also be worldwide, undertaken by a body comparable in might and authority to the United Nations Organization.

Whoever takes the job on, assuming anyone thinks it necessary, had better start soon, because the day the last of the ozone layer disappears is not a good time to start thinking about the advisability of rethinking spray cans.

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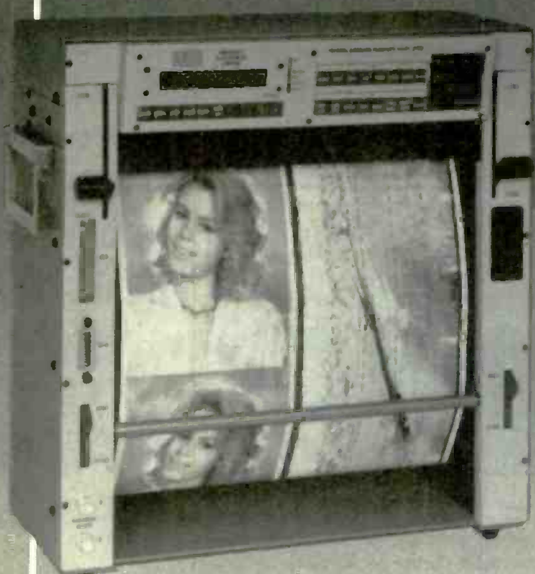

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Isolan: a fibre-optic Ethernet

For a fibre-optic network the most suitable layout is a 'snowflake' topology composed of multiport repeaters and active fibre hubs.

D. A. ROWARTH and N. HOWE

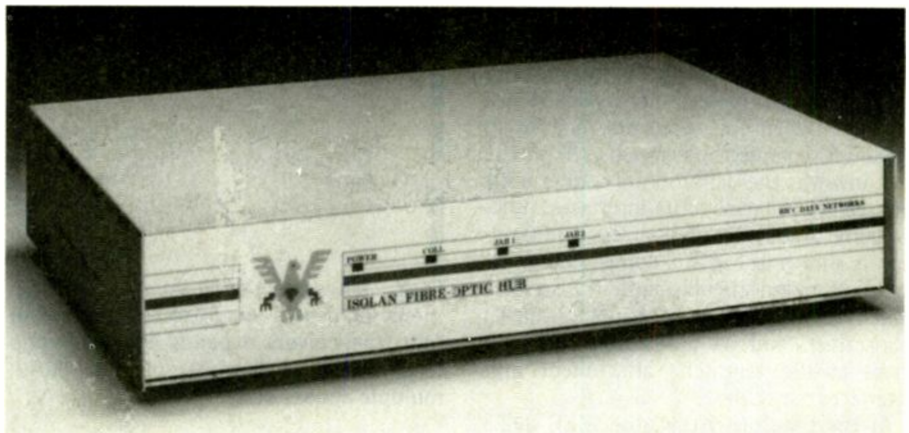
Title photograph courtesy Pilkington Communication Systems

The use of fibre optics in local area networks is a relatively simple application of the technology; point-to-point optical links with a maximum distance of 2km and 10Mb/s Manchester encoded data rate do not demand a high degree of technical sophistication. Nevertheless, the application to local area networks as in Isolan demonstrates the ability of fibre optics to overcome with ease the difficulties with safety and performance which may be experienced with metallic data networks spanning large sites and several buildings.

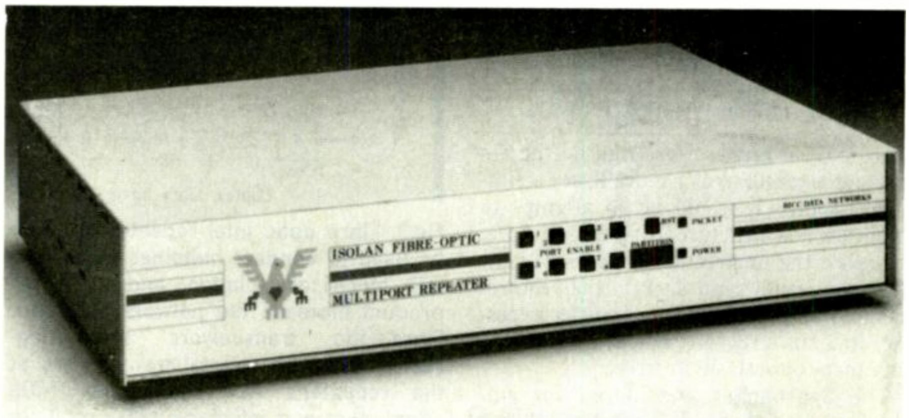
International standards for local area networks providing open systems interconnection have made substantial strides in recent years, but there are still significant areas where even at the physical layer the standards-making process is not complete. One such area is the use of fibre optics in lans conforming to the IEEE 802.3 standard[1] which up until now has covered only the coaxial medium. The appearance of this standard, which has effectively superseded the earlier joint proprietary Xerox Ethernet specification[2], and more recently of its international counterpart[3] has greatly encouraged the adoption of Ethernet lans, since users know that they can source complying products from a number of vendors and be assured of compatibility.

The ability to mix media will further enhance the attraction of Ethernet as an effective simple-to-use lan solution for a variety of applications, and work is in hand to extend the standard to specify fibre-optic elements. These lan components may be used as part of a coax network or to provide a fully fibre-based installation. This further evolution of the standard is not proceeding on an abstract basis; the work is undertaken by engineers who are directly involved in advancing the technology. The products described have been developed in association with this ongoing work in the standards arena.

Ethernet is a contention bus system operating at 10 Mb/s, with up to 1024 nodes in a single network. Access by a node to transmit onto the network is determined by a carrier-sense multiple-access protocol with collision detection. If a node needs to send a packet of data it waits until the bus is inactive and then starts to transmit. If a node elsewhere on the network has also started to transmit, a collision will occur which is detected by each node; both abort transmission before trying again after a random delay. As a result of the Manchester encoding scheme used for packet transmission, there is a fixed mean d.c. content of each packet which makes identification of collisions relatively simple in a copper-based network, though this simplicity may not apply in the case of a fibre optic implementation.



Isolan fibre-optic hubs, available in 6 and 12-port versions, form the basis of a simple star network and provide the means of connecting devices up to ½ km apart on an all-fibre network.



Fibre-optic multiport repeater allows the interconnection of up to seven fibre optic segments and one ethernet segment. Used with a fibre-optic hub, an all-fibre network can be implemented with a diameter of up to 4km.

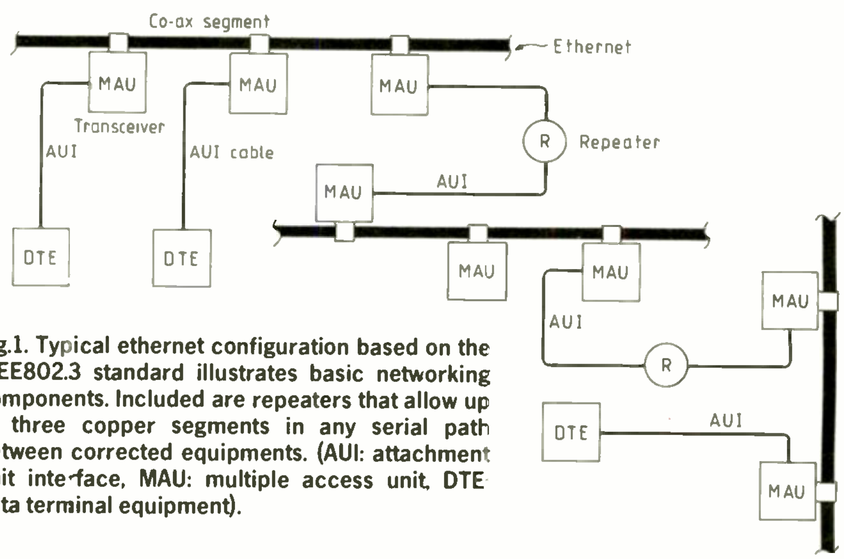


Fig.1. Typical ethernet configuration based on the IEEE802.3 standard illustrates basic networking components. Included are repeaters that allow up to three copper segments in any serial path between corrected equipments. (AUI: attachment unit interface, MAU: multiple access unit, DTE data terminal equipment).

FIBRE OPTIC INTER-REPEATER LINK

As published, the IEEE 802.3 standard defines a multidrop bus network consisting of copper coaxial segments which may be interlinked by repeaters to form a network with up to three copper segments in any serial path between connected equipments, Fig. 1, and permits the network to have a maximum diameter of 1.8 km. It allows expansion beyond this by the inclusion of repeater links to connect segments together giving a maximum diameter of 3km (Fig.2).

Studies on network characteristics since the standard was published have shown that up to five repeaters may be used to connect active segments in series within the overall diameter constraint of about 3km, provided that the repeaters meet specific performance requirements. An appropriate amendment is planned for a future issue which will detail possible topologies in a more flexible manner.

The 802.3 Working Group established a task force to draft a vendor-independent fibre-optic i.r.l. standard so that different suppliers may implement end-equipment which will interwork over an optical link. This fibre-optic inter-repeater link enables

This article is based on information first published by SPIE at Fibre Optics 86.

isolated copper segments to be incorporated into a single lan without introducing metallic connections between them – a key feature for safety, security, reliability and resistance to e.m.i. when the segments may be in buildings separated by as much as 2km. The task involves the definition of a fibre-optic transceiver in terms of its interfaces, functionality, and compatibility. The configuration is shown in Fig 3; a duplex fibre-optic cable interconnects fibre-optic transceivers which take the place of standard coaxial transceivers and are plug-compatible with them at the repeater's attachment unit interface connection.

At the time of writing, the IEEE 802.3 working group has approved the draft of an additional section defining the fibre-optic link, and allowing the use of all popular fibre sizes, but optimum for 62.5/125 and 85/125 microns. Following balloting by the IEEE standards board this is expected to be fully approved by the third quarter of this year.

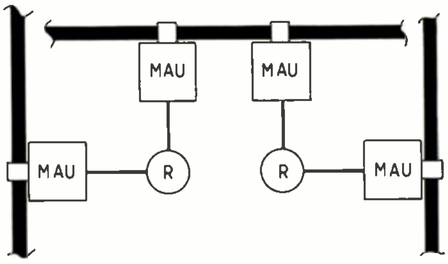


Fig.2. Connection of three ethernet segments achieved using two repeaters with four transceivers expands area coverage to a maximum diameter of 3km. (MAU: multiple access unit)

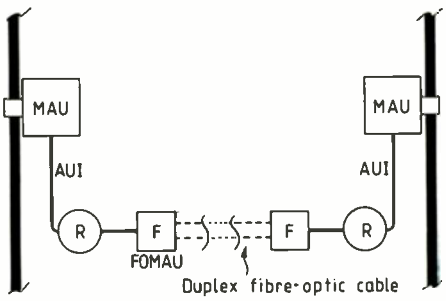


Fig.3. Fibre optic inter-repeater link can be used to connect buildings and maintain electrical isolation, and as a by-product increase the network diameter. Fibre-optic transceivers are plug-compatible with coaxial transceivers at the repeater's AUI connectioin. (AUI: attachment unit interface, MAU: multiple access unit)

FIBRE OPTIC ETHERNET LAN

Since coaxial carrier-sense multiple-access lans are configured as passive buses a simplistic approach would be to attempt to duplicate this structure using optical fibre. However, the undirectional nature of light does not readily lend itself to the requirements of bidirectional data transfer necessary in a bus structure, nor is it feasible to have many optical taps in series.

The approaches considered for implementing a fully fibre Ethernet mainly use a star-configured bus with duplex fibre transmission. In effect the bus has shrunk to a point at the hub of the star, and the duplex fibre links extend this out to the nodes Fig.4. Collisions now occur at the hub, and arguably the most crucial aspect of designing and specifying the network lies in determining an effective method of detecting them. The simple electrical method of collision detection by examining the mean d.c. content of the signal level as employed in the coaxial case is not applicable for superimposed optical signals which may differ substantially in amplitude. A further requirement is that it should allow the specified maximum of 1024 nodes to be achieved – and both these needs should preferably be met by the simple assembly of off-the-shelf network components from a mix of vendors without alignment or adjustment, with easy addition of nodes to cover later needs for expansion.

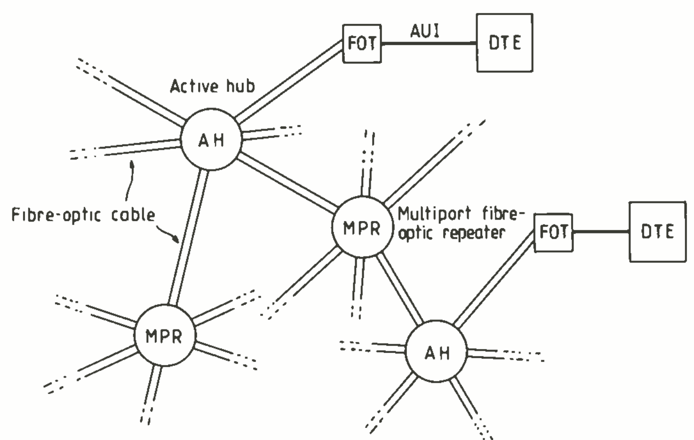


Fig.4. Fibre-optic ethernet in which the bus is effectively shrunk to a point at the hub, duplex links extending this out to the nodes. Collisions now occur at the hub and the design of collision detection becomes crucial. (FOT: fibre-optic transceiver, AH: active hub, MPR: multiport fibre optic repeater.)

Four basic approaches have been examined for an optical Ethernet to be plug-compatible with the coaxial system at the level of the attachment unit interface. These differ in their characteristics, as reviewed next.

Passive star with collision detection by signal analysis

This approach relies on an entirely passive hub consisting of a transmissive star coupler which distributes to all nodes a packet transmitted from any node, Fig.5. The received power level at a node can vary substantially depending on which node is transmitting, and care must be taken in setting up the network to minimize the range of variation so that strong transmitters do not swamp weaker ones.

Various schemes have been proposed by which a transmitting transceiver can examine the signal to detect collisions, including sensing of average power level, monitoring of pulse widths to detect code violation, bit-wise comparison between transmitted and looped-back signals, as well as patented methods of coded high-amplitude pulses in the preamble. At best, collision detection with this type of system is only modestly effective, and only if the received signals are within a few decibels amplitude of one another. 'Tuning' the network becomes more difficult as the number of ports at the star coupler rises, so this type of approach tends to find more application for the smaller networks.

Passive star with detection by time domain analysis

To overcome the requirements for careful matching of received optical powers, a system relying on signal tuning has been proposed[4]. The network configuration is identical to the passive star with signal analysis, but collision detection is performed in the transmitting transceiver by timing from start of transmission to start of receipt of the looped-back packet. If a transmission arrives early it must be a colliding packet. The disadvantage is that each node must now be tuned for its particular path length to the coupler. Unfortunately, the collision detection can never be 100% effective because a tolerance band must be allowed on the correct loop-back delay.

Active star

To overcome the difficulties with collision detection posed by the use of a passive star, and active hub approach may be used, as shown in Fig.6. The fibre optics consist of individual duplex point-to-point links; the receivers can accept a wide dynamic range, so the received optical power can vary widely among the ports without impact on the system performance.

Collision detection is achieved within the fibre optic transceivers by the simultaneous detection of transmission and reception of a packet at the optical ports. The hub facilitates this process by performing the following switching algorithm on the incoming packets.

– If only a single packet is being received by a port, that packet is output from all ports apart from the port on which it is received.

– If more than one packet is received by the hub, a collision exists and the hub transmits valid carrier with null data to all its ports as output. In some variants of the proposal a special distinguishable signal is used by the hub rather than the null data.

This method give 100% effective collision detection within the full dynamic range of the receiver.

Hybrid star

The remaining technique, shown in Fig.7, is optically the most complex. It also addresses collision detection by an active approach at the hub, but only collision detection is active, with the data path still using a transmissive star coupler. The collision indication signal is superimposed on the transmitted data, rather than replacing it as in the active star approach; the transceivers have to detect this superimposed signal to become aware of the collision. This hybrid system can provide collision detecting approaching the effectiveness of the active hub system; however, as with the passive cases, addition of extra nodes is not straightforward and the design is best suited to smaller networks.

Examining the four techniques against the essential criteria, the only approach that fulfils all the requirements is the active star, provided that adequate redundancy techniques are used in the design of the hub.

The standard for fibre optic Ethernet is still in development at the time of writing. The IEEE 802.3 working group has requested the fibre optics technical advisory group to advise on the suitability of the various design approaches, with particular reference to collision detection. In view of the technical advantages of the active hub outlined it seems likely that the approach will finally be adopted if the specification calls for the same interoperability at network component level as in the coaxial case.

NETWORK COMPONENTS

To provide a flexible implementation of fibre optic or mixed-media Ethernet complying with the existing and developing requirements of IEEE 802.3, a group of network component products is required.

Fibre-based products (fibre optic transceivers, active hubs, and repeaters) developed by BICC Data Networks in association with the fibre optics advances in the lan standards arena are discussed next.

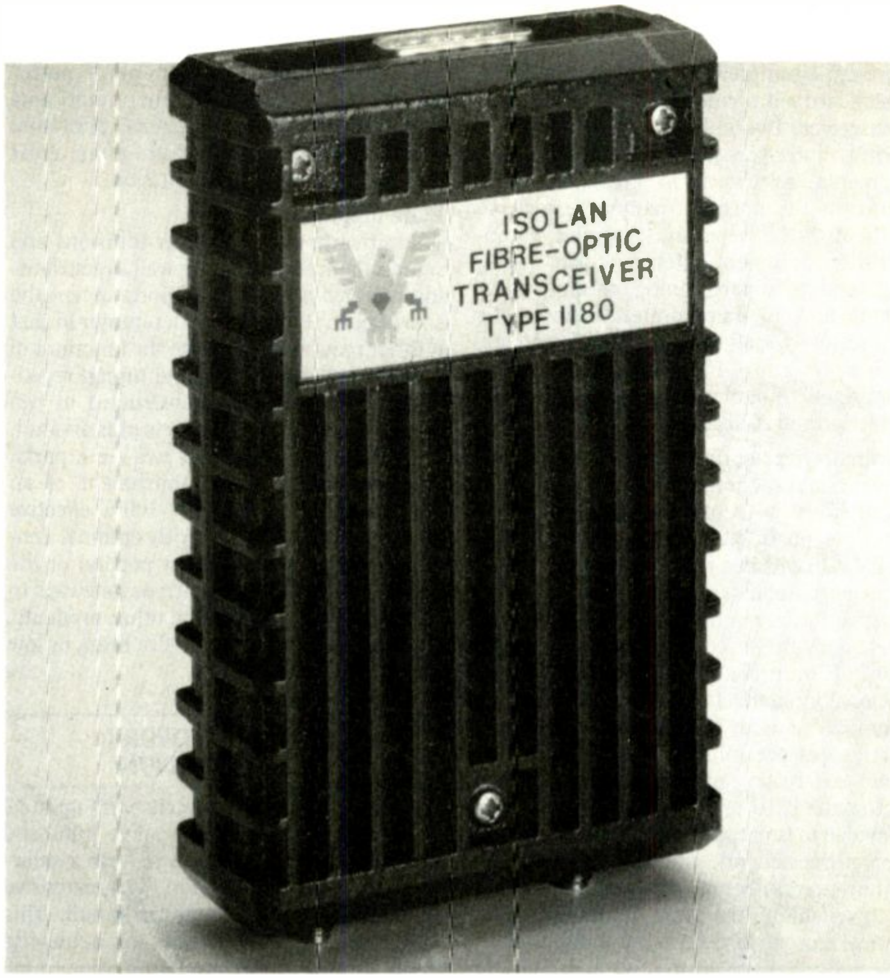
Fibre-optic transceiver

The transceiver is a fundamental component, since it establishes the duplex fibre-optic link upon which the other products depend, and is incorporated in hubs and repeaters. The transceiver interfaces between a standard IEEE 802.3 a.u.i. electrical connection and twin 9mm SMA optical connectors, and is implemented using a custom thick-film hybrid receiver. The link carries a continuous signal at all times, contributing to the excellent 25 dB dynamic range and allowing detection of fibre break or low light level conditions.

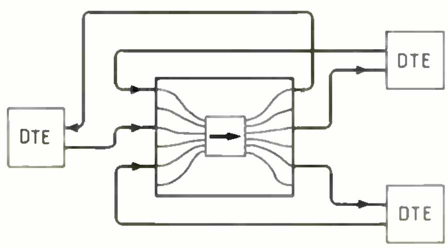
The wide dynamic range permits use without adjustment on links of any length up to 2km with any of the graded-index fibres likely to be selected as standard for lans (50/125, 62.5/125, 85/125, 100/140 micron). The stand-alone transceiver is packaged in a robust and compact die-cast case.

Fibre/optic two-port repeater

The two-port repeater contains one internal



The transceiver has been designed to use all the popular fibre-optic cable diameters for ease of installation, and features jabber protection, idle signal modulation, loss of light indication, and switch-selectable 'heart-beat' (SQE) test.



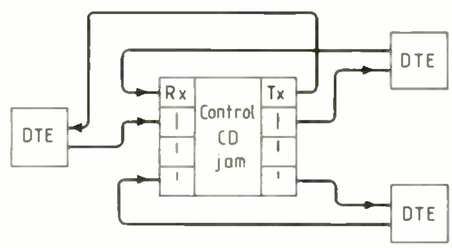


Fig.5 Passive fibre-optic hub acts as a junction box directing and redirecting the light paths, but is sensitive to all errors on the network. Collision detection is only effective if the received signals are within a few dB of each other. Fig.6. In the active hub system, which isolates segments as well as regenerating signals, collision detection is achieved by simultaneous detection of transmission and reception of a packet at the optical ports. Switching algorithm (see text) gives 100% effective detection within the full dynamic range of the receiver.

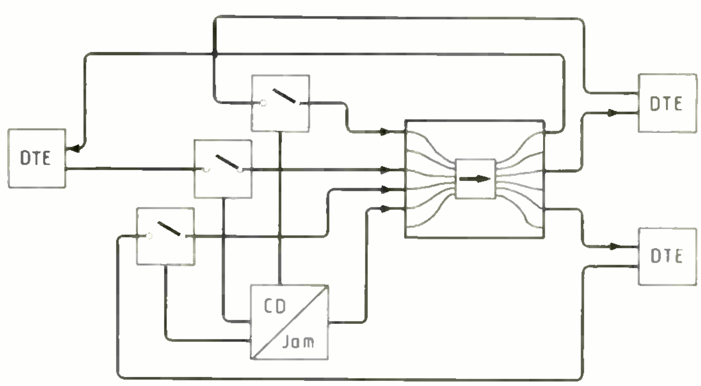


Fig.7. In this hybrid star the data path is passive whilst collision detection is active. An indication signal is superimposed on the data rather than replacing it as in the active star approach. Transceivers detect this signal to become aware of a collision. Scheme is very effective but addition of other nodes is not straightforward and it is best suited to smaller networks.

fibre-optic transceiver, the other port being a standard a.u.i. connection to an external transceiver. Two units can thus be used to form an inter-repeater link between coaxial segments, as shown in Fig.3. The unit performs the normal functions associated with an 802.3 repeater (preamble reconstitution, fragment extension, data retiming, and auto-partitioning of faulty segments) and also incorporates the fibre-optic transceiver functions of loopback of data, jabber protection, 100% collision detection, idle signal modulation, and loss of light detection and indication.

Multiport fibre-optic repeater

The repeater section of IEEE 802.3 is written in such a way as to allow a repeater with multiple ports, able to form a repeating radial hub within a network. The fibre-optic multiport repeater which has been developed has seven fibre ports and one a.u.i. port, and allows economical interconnection of multiple fibre links as well as optionally connecting into a copper lan segment. As with the two-port repeater, it carries out preamble reconstruction, fragment extension, and signal regeneration. Automatic partitioning and reconnection is provided to isolate a faulty segment from the rest of the network, implemented with the minimum number of components to ensure high reliability, the same thick-film hybrid optical receiver circuits as the transceiver.

The optical links for a multi-port repeater may be connected to another multi-port repeater, a two-port repeater, an active hub, or to a fibre-optic transceiver, giving great flexibility in network construction.

Fibre-optic hub

The active fibre hub detects collisions and signals them to all ports, as well as distributing received packets to all ports except the source port. It differs from a repeater in that it is not required to perform the functions of preamble reconstruction and timing regeneration. The design is constructed in two configurations: Six fibre ports plus an a.u.i. port or 12 fibre ports plus two a.u.i. ports, allowing the simple establishment of an optical star network with 100% effective collision detection, and with optional central connection to a copper portion of the network or to facilities such as gateways to other services. As with the other products, each port has detection for fire break or low light level.

OPTICAL NETWORK CONFIGURATION

A single hub will provide a star with up to 12 arms, but by interlinking active hubs and multiport optical repeaters to form a snowflake topology, as shown in Fig.4, extensive but cost-effective networks can be built. This provides a simple means of achieving maximum-size fibre-optic lans with up to 1024 nodes and up to 4km in diameter using off-the-shelf units and without the need for adjustment or optical alignment.

Fully effective collision detection is guaranteed throughout the network, and the functions of the repeaters ensure transmission performance to IEEE 802.3 requirements as well as providing automatic partitioning of the network in the event of local faults. Connections to copper segments can be established by using the attachment unit interfaces on repeaters and hubs, permitting mixed-media Ethernets in which the most appropriate medium is used for each portion of the network.

References

1. IEEE 802.3: CSMA/CD Access Method and Physical Layer Specifications, July 1983.
2. The Ethernet, a Local Area Network, Data Link Layer, and Physical Layer Specification, Version 1.0. DEC, Intel, Xerox Sept 1980.
3. ISO DIS8802/3: CSMA/CD Access Method and Physical Layer Specifications, July 1983.
4. S Moustakos and H Witte: Passive Optical Star Bus with Collision Detection for Local Area Networks, IOOC 83, June 1983.

Don Rowarth is director of advanced technology at BICC Data Networks. Nigel Howe is in the market support group.

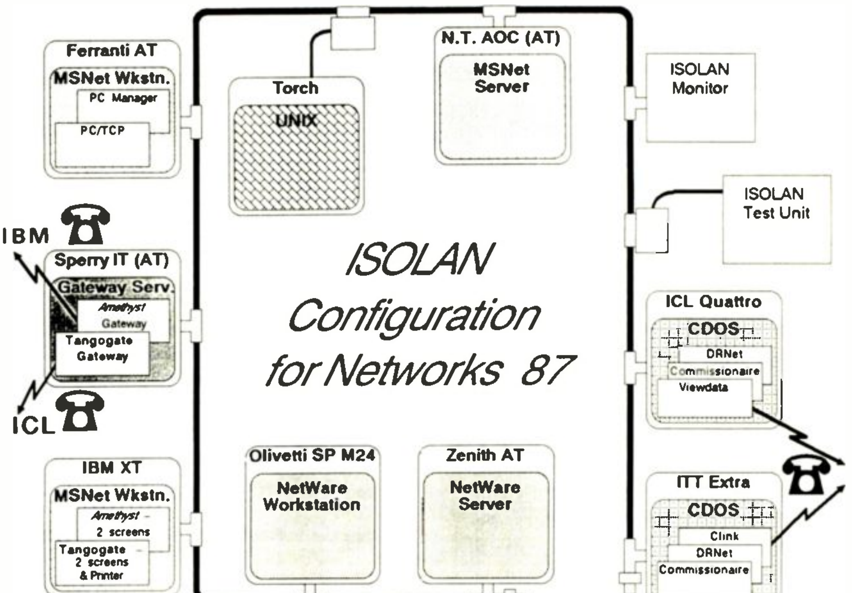
Software interfaces for Isolan

The first networking product that allows interworking of the popular PC networking systems as well as any mini or mainframe computer using industry-standard protocols has been announced recently by BICC Data Networks. Together with a plug-in controller card, the new software enables PCs to share 10mbit/s networks for rapid communication by allowing different protocols to work together in sharing files and printers on the same network, and to directly access mini and mainframe hosts at the same time.

– The new software, called Multi-Protocol Support, allows communication in a network between, for example, an IBM-compatible PC, a mini such as a DEC VAX, and IBM mainframes, and using MS-Net, Novell NetWare and DR-Net, all of which can co-exist on the same network.

Ease of connection is simplified through additional packages for simple networking of small PC clusters. Multi-Protocol Support ensures optimum network efficiency by stopping any one application from monopolising the controller.

The handler is provided with and without ISO transport; both are on the distribution disc as 'terminate and stay resident' applications. The controller itself is an intelligent IEEE802.3 Ethernet interface with the extensive input buffering necessary for multi-tasking. Support for Unix environments–in two formats,



the MIT implementation and a file transfer protocol – is avaiable separately, as is the PC Serial Connection for terminal emulation.

The company says its commitment to the international Open Systems Interconnection standards underpins its Isolan range of products, which now include Multi-Protocol Support. Both OSI and non-OSI protocols can now run simultaneously on the same network. "It's about time users were given the opportunity to make full use of the benefits that an open system can give," said Ian Laurence, BDN's marketing director "and not be forced into buying products with dubious lifetimes".

Formed in 1984, BICC Data Network has already established itself as Europe's leader in the design, manufacture and marketing of local area network products with a turnover approaching £2 million per month. Its Isolan products are the first to fully comply with IEEE802.3 standard, and won a Queen's Award for Technology earlier this year.

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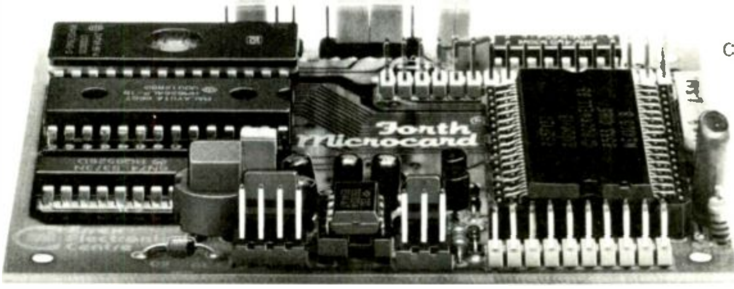

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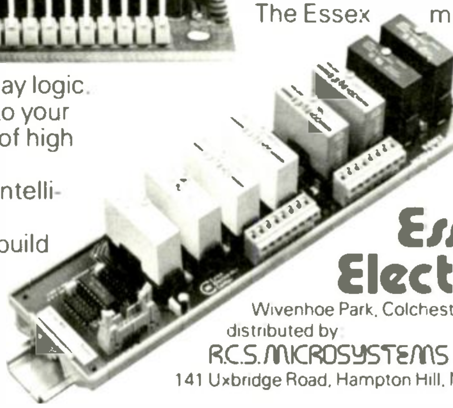

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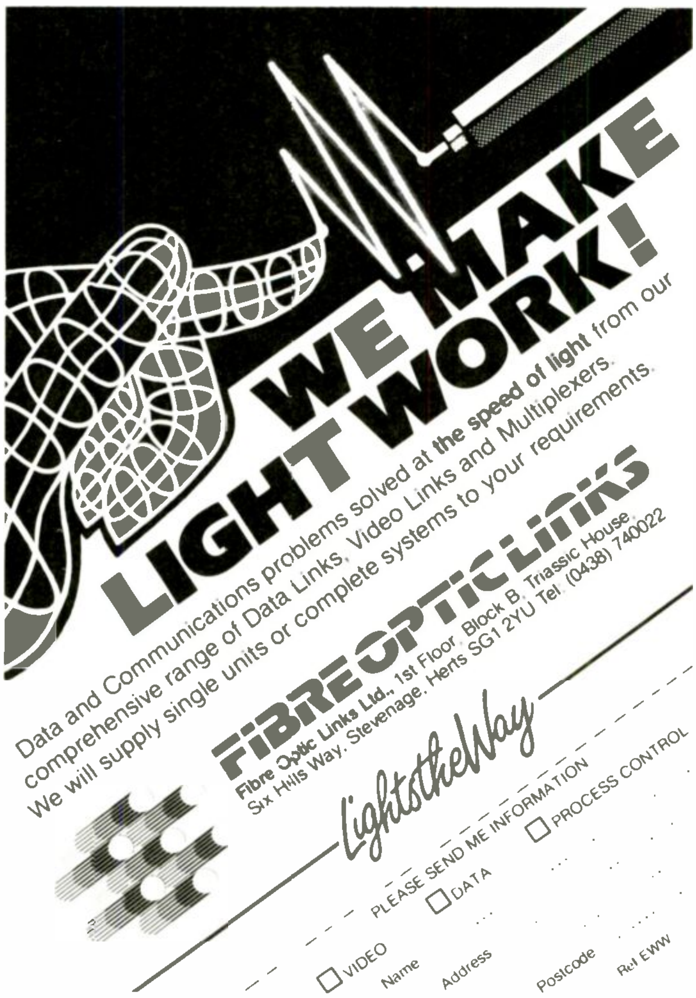

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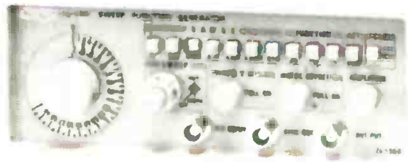

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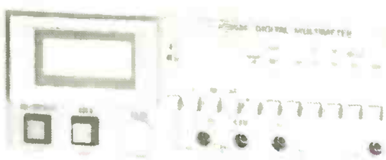

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Variable-speed video – the ultimate

This report on new developments in variable-speed playback for C-format professional video tape recorders up-dates our seven-part review.

JOHN WATKINSON

In the C-format, one diagonal tape track contains one video field, and the tape is wrapped almost completely around the drum so that a single head can be in almost continous contact with the tape. The interruption, known as the format dropout, is timed to coincide with the vertical interval where there is no picture information. The advantage of field-per-scan operation is that variable-speed operation is eased when compared with formats which segment the field into several tracks. In variable speed, the drum speed remains the same, locked to field rate, but the linear tape speed is changed by driving the capstan asynchronously. A track-following head in the rotating drum deflects to follow tape tracks, and jumps during the format dropout to omit tracks at higher than normal speed, or to repeat them at less than normal speed. As a result, the field rate remains the same whatever the tape speed over the speed range of the track-following system, usually −1 to +3× normal speed because of geometric restrictions.

The physical length of the track is determined by the field period, the signal bandwidth and by the minimum wavelength which can be recorded reliably. In the C-format, this results in tracks which are about 15 inches long, and a rather large drum. Timebase stability of helicalscan recorders can never be as good as transverse scan machines because the long length of flexible tape around the drum is excited along its length by head rotation and tension variation.

The timebase stability needed in a professional video signal is a few degrees of subcarrier phase, so that composite signals from various sources can be mixed. Since one cycle of subcarrier represents 225 ns, the time stability is of the order of a nanosecond. Since the field period in PAL is 20ms, this represents a proportional accuracy along the tape track of one part in 20 million, which is asking rather a lot of a flexible medium.

It is not an exaggeration to assert that without the digital timebase corrector, the C-format would not be a viable medium. The timebase errors introduced by the transport fall into various caterories, all of which the t.b.c. has to correct. The drum construction is such that the upper half is free to rotate whereas the lower half is fixed. Tape enters the drum at the lower elevation, and rises around it. As a result, the tension does not change uniformly around the scan, as the force needed to pull the tape over the fixed lower drum is greater than that needed to pull it round the air film boundary on the rotating upper drum. Fortunately, the same effect takes place on recording and playback, and largely cancels out. The effect of tape tension is critical, as a minute percentage elongation can result in an enormous change in field period when it is measured in cycles of subcarrier. Dimensional changes due to humidity variation have similar effects to tension changes. These effects change relatively slowly, and timebase correction can be assumed to be the same over the duration of a video line.

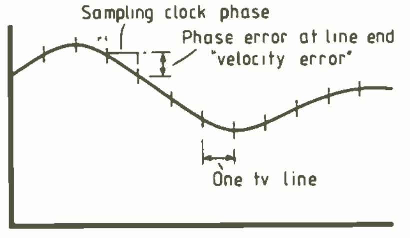


Fig.1. Conventional timebase corrector up-dates the phase of the sampling clock at each burst, but in the presence of velocity errors this results in a phase error at the end of the line.

There are also dynamic phenomena which are more difficult to deal with. Head impact and the release of tension as a dragging head lifts off the tape, known as expact, cause shock waves which propagate down the tape causing the instantaneous head to tape speed to rise and fall slightly. The shock waves will be at the mechanical resonant frequency of the tape's mass with its own elasticity, typically a few kilohertz. The dynamically varying subcarrier phase changes within the line period, and is much harder to correct. Unfortunately the term 'velocity error' has been given to this kind of instability, possibly to distract attention from the fact that its origins are in accelarations. When the machine is in variable-speed mode, tape acceleration as the speed is changed will also cause significant subcarrier phase changes throughout a line. Such instabilities will also be found in recordings made on portable machines that have been carried while in operation.

Fig.1 shows the subcarrier phase changing as the result of a head impact. There is no subcarrier in the chroma signal carried in the composite video because it is suppressed, and the only information that can be used to determine subcarrier phase, and hence the meaning of the chroma, is in the burst. As the burst only occurs once per line, the subcarrier phase transmission is a sampled system, and according to Nyquist, the frequency with which the phase changes cannot then exceed half the line rate.

Fig.2 illustrates the digital timebase correctors used with C-format machines, where the incoming video waveform is sampled at three or four times off tape subcarrier frequency, obtained from the burst, and quantized into eight or nine bits, the last allowing for more processing in the digital domain. Samples are stored in memory and are read out according to a stable sampling clock derived from reference timing. Drop-out compensation and colour processing are also necessary.

Returning to Fig.1 you will seen that if there are velocity errors, this apparently simple process becomes difficult. The only phase information which can be used for sampling comes from the burst, and the sampling phase then remains constant until it can be up-dated by the next burst. In practice, the subcarrier phase changes continously, and there will be a chroma phase error which increases towards the end of the line. The conventional solution to this problem is to measure the phase change between successive bursts, and thus establish what subcarrier phase was at both ends of the line. In this way the phase of the memory read clock can be dynamically shifted as the line proceeds in order to oppose the phase error between the sampling clock and the chroma.

Fig.3 shows how this conventional form of velocity compensation is performed, but illustrates that it is quite unsuitable where digital processing of the stored samples is contemplated, because the phase of the samples with respect to subcarrier is constantly changing.

In composite video signals such as PAL, there is an endless structure where the relationship of the chroma to the line timing only repeats at eight field intervals, to interleave the sidebands of the chorma into spaces between the luminance sidebands. When a tape is played at variable speed, the resulting head jumps cause the eight field sequence to be broken. The sequence must be restored on the video output of the timebase corrector so that it can be mixed with other signals. Traditionally this has been done by analogue circuitry after the d-a convertor, or before the a-d convertor, which decoded the composite video to baseband according to the burst phase offtape, and encoded according to reference burst phase. This circuitry is generally referred to as the colour processor.

An improvement in the performance and stability of the colour processor could be obtained by using digital techniques, but this would require some means of aligning the phase of samples with offtape subcarrier in the presence of velocity errors. It would be possible to construct a digital interpolator which could compute the values of the waveform at arbitrary points between samples, to produce a sample stream with a constant phase relationship to subcarrier, but this approach is very difficut to implement because of the phase sensitivity of the signal. When working to a few degrees of subcarrier, the number of interpolater phases necessary would be extremely large, and the coefficient store would be enormous. The wordlength of the samples would also need to be increased to hold down chroma noise.

In the Ampex Zeus video processor, digital colour processing is used, requiring a stable phase relationship between sample points and offtape subcarrier. This is ensured by controlling the phase of the sampling clock.

If the sampling clock phase is to be made to track the offtape subcarrier phase instabilities, it is necessary to use information from the burst before and after the line of interest. As the burst at the end of the current line will not be avaiabele until after the line has passed, a one-line delay is necessary. In the Zeus Processor, a c.c.d., delay is used, running at 27MHz. The bandwidth and noise performance of this delay are engineered to be in excess of the constraints set by the sampling and quantising parameters of the machine, so it is essentially transparent.

As Fig.4 shows, the delay is actually slightly longer than one line, and an analogue switch allows the delay to be bypassed briefly, so that part of the sync. pulse is replaced by the burst from the end of the line which has been advanced by omitting the delay. This signal is fed to the a-d convertor, which makes it available to the memory and to the sampling clock control circuits.

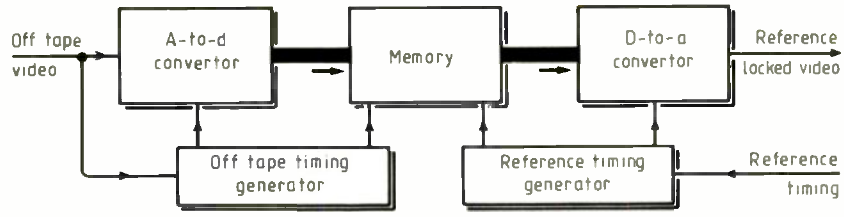


Fig.2. Simple timebase corrector temporarily stores samples which are produced from unstable video and reads them out with a stable reference – derived clock. Dropout compensation and variable speed circuitry are not shown.

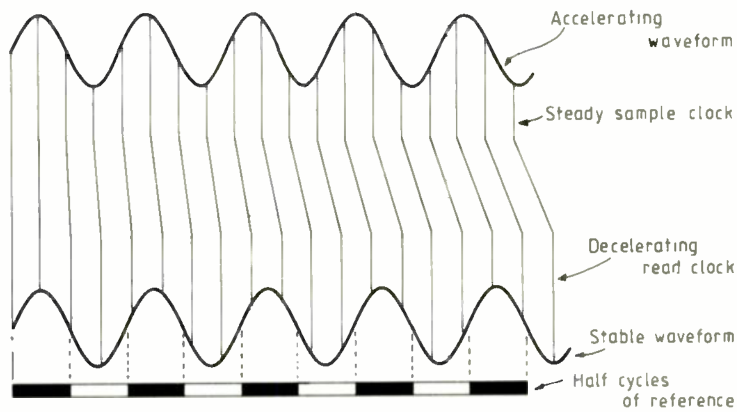


Fig.3. In conventional velocity compensation, the real clock is phase swung to correct the phase error on sampling. This works well for an analogue output but the phase between samples and chroma becomes arbitary.

The effect of sampling the burst with a four-times subcarrier clock is to produce a repeating set of four sample values which reveal the phase relationship between the clock and the burst in rectangular co-ordinates. In practice there will be noise on the burst, but by adding together the sets of sample values from several cycles, and dividing by the number of cyles acquired, a noise-free determination of the co-ordinates can be made. The actual phase relationship can be expressed in angular terms by some trigonometrical calculations. By successively processing the two bursts coming from the analogue switch, it is possible to compute the current phase error in the sampling clock – i.e. the amount by which the clock phase needs to be changed to correctly sample the beginning of the line, and to compute what the phase error will be when the end of the line is reached. To get into lock, it is necessary to know the approximate clock frequency needed. This is obtained by timing the period between h-sync. pulses. The sampling clock is obtained from a frequency synthesizer, which has no drift or tolerance mechansisms and thus needs no initial or periodic adjustments. The equivalent of the v.c.o. control voltage is the digital burst phase errors.

There is very little time between the end of the second burst and the start of the active line, and so the digital burst phase filters and phase measuring circuitry must work very fast indeed.

When the speed of the tape is varied, the line period also varies, and the length of the delay must be adjusted to suit. This is achieved automatically by clocking the c.c.d. delay from the digital synthesizer. If the tape speed were to increase, the first sign of this would be that the advanced (undelayed) burst would have a phase lead relative to the sampling clock, whereas the delayed burst would not. This would cause the synthesizer to speed up the clock to cancel the phase lead over the line. The raised clock frequency would then make the delay period correct for the next line and so on. In this way the sampling clock tracks offtape subcarrier

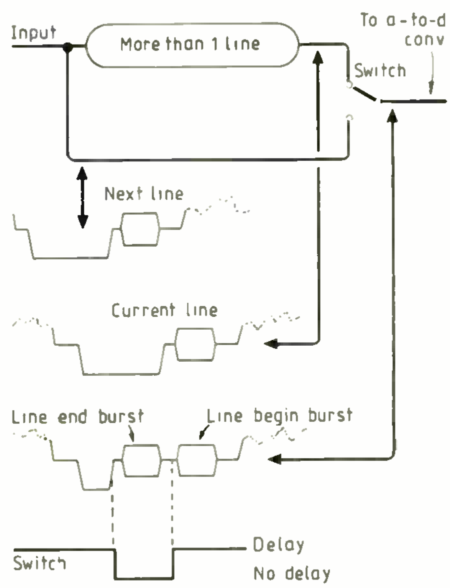


Fig.4. Using a delay of a little over one line it is possible to switch the delay out momentarily so that the current and next bursts appear side by side. Both are digitized to compute the velocity error over the line.

over the speed range where colour is provided. As with all phase-locked loops, the damping has to be critically set to the best compromise between jitter and speed of response. In a sampled system, the response cannot exceed half the line rate, and so the synthesizer is damped so that it cannot produce frequency changes more rapidly than that during sampling of the active line.

An advantage of this method of clock generation is that the a-d convertor is contained within the loop because it is the digital samples which are used to control the clock. Phase errors due to drift in the convertor or component tolerances are thus eliminated, along with corresponding adjustments.

When memory chips were of relatively small capacity, it was convenient to assign a given set of chips to the storage of one tv line. Now that chip capacities have increased, it is no longer practicable to do that. In modern t.b.cs there is just a large ram and the individual lines can only be discriminated by their different addresses. This means that the memory must be able to read and write at the same time. There is a further problem that the high rate of digital video is beyond the access rate of economic ram chips. The solution to both problems lies in interleaving the memory.

A number of samples is assembled into a superword by a serial to parallel register. The superword rate will now be the sampling rate divided by the number of samples in the superword. The superword period is now divided into a period when the memory can read, and a period when it can write. The switching between read and write functions involves both address and data multiplexers, and arbitration. In general, the memory timing will be locked to stable reference clocks, and when the memory is being read, the write process is locked out. A small buffer silo is installed before the memory which allows the write process to be interrupted by reading, and accommodates the difference between stable read clocks and unstable write clocks.

For variable operation, the write clock rate will vary. At lower than normal speeds the data rate falls, so that not every write period will be used. Clearly at higher than normal speeds this approach cannot be used. The solution is then to subdivide the superword period into three time slots, one for reading and two for writing if necessary. Thus at low rates, the silo may not have a superword ready when a write period ocurs, whereas at high rates it may have two superwords ready. Fig.5 shows the general arrangement of an arbitrating ram and shows the input silo. In some machines, such as the Ampex TBC-6, the silo performs timebase correction to the nearest superword, whereas in the Zeus, the silo has a four line capacity and corrects to the nearest line leaving the main memory to correct timing in integer line steps.

The digital colour processor of Zeus will now be described, beginning with the functions it has to perform, which result from the structure of the PAL signal. The eight field sequence comes about as a result of the quarter cycle offset of subcarrier against line rate. There are 283¾ cycles of subcarrier in one line so that four lines must pass before the same relationship occurs between subcarrier and h. The odd number of lines in a frame necessary for interlace means that four frames must elapse before the four-line sequence assumes the same relationship with vertical sync. It follows that the task of the colour processor is to take one of the four line types from the input field and make it into the necessary line type for the field being output. The presence of the V switch on alternate lines which gave PAL its name complicates this process.

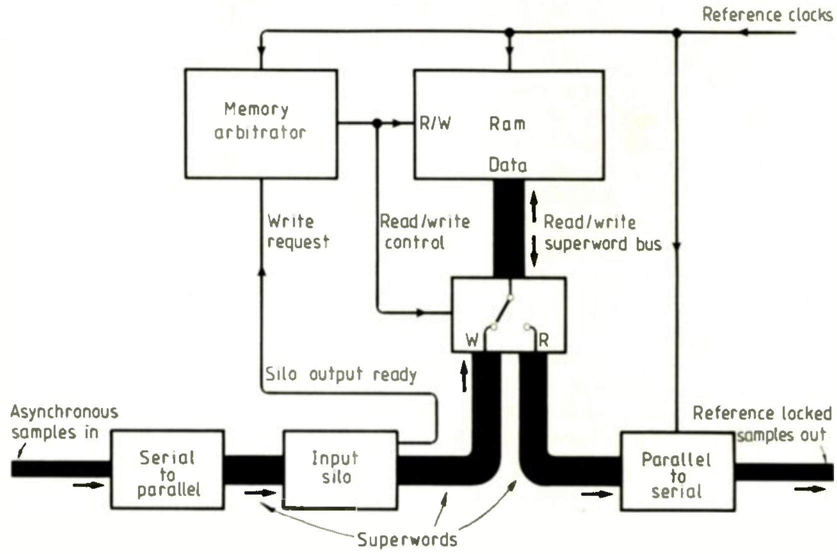


Fig.5. In a ram-based timebase corrector ram is reference synchronous, and an arbitrator decides when it will read and when it will write. During reading, asynchronous input data backs up in the input silo, asserting a write request to the arbitrator. Arbitrator will then cause a write cycle between read cycles.

Fig.6(a) shows that from line to line, the phase of U advances 90 degrees due to the quarter cycle offset, and the phase of alternately leads and lags U. Fig. 6(b) shows that if chroma is sampled on the U and V axes the result of these two effects is that from one line to the next, the chroma samples represent different sequences of U and V. The shift to the right of the U sample due to the quarter cycle offset can be seen. It is not immediately obvious how one line of chroma could be made into another with this approach.

The solution adopted in the Zeus is to sample at 45° to the U and V axes, i.e. in phase with the burst. Fig.6c shows that when this is done, the samples represent U cos45 + Vcos45 etc. If everything is normalized by dividing by cos45, the samples become U+V, −U+V etc.

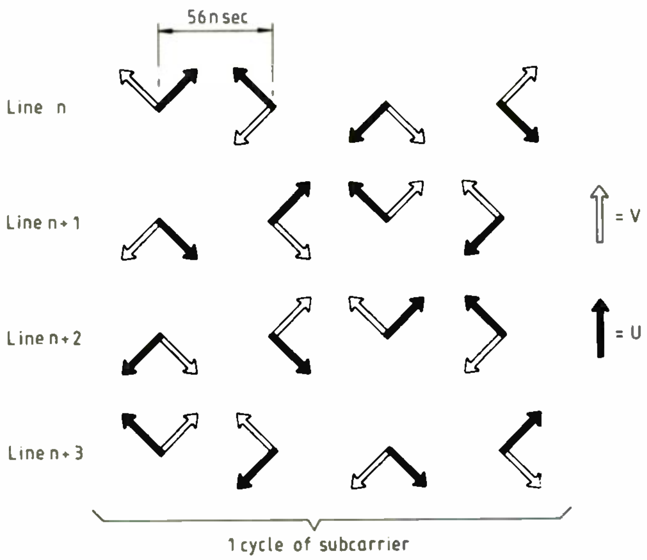
If it is required to convert a line in to the next line type, having the opposite sense of V switch, this can be done by inverting the samples where U and V have different polarities, but not where they have the same polarity.

If the difference is two lines, the only requirment is to invert the whole chroma waveform, as V switch is the same after two lines, and there have been two quarter-cycle offsets of subcarrier making 180°. If the difference is three lines, an inversion combined with V-switch reversal is needed, and this can simply be done by inverting samples where U and V have the same polarity and not where the polarity is different.

The line type is entered into the memory along with the samples for the line, and is available when the line is read out. The required line type is available by decoding the ScH phase of the reference sync. input, and by comparing the two-line types, the conversion to be performed by the colour processor can be determined. The chroma must be separated from the luminance signal before the colour processor can operate, and this is done by a digital filter. A combination of chroma band pass and comb filtering is used. The comb filter gives good separation of sidebands, but fails when there are vertical chroma phase changes in the picture. The chroma phases at the beginning centre and the end of the delays are monitored by a corellator, and when the comb filter fails to mesh, the bandpass signal alone is used. The filtered chroma signal is then subtracted from the composite signal to give digital luminance. Once chroma and luminance are separated, a digital chroma gain control can be incorporated simply by passing the chroma samples through a multiplier.

Owing to the use of interlace, the head jumps may result in an odd field being played when an even field is needed, and vice versa. The vertical picture movement which results from outputting the wrong field can be completely removed by vertical interpolation.

The output raster and the input raster are shifted slightly so that neither input field aligns with either output field. By using memory to produce three delays of one line each, samples representing four-points in a vertical line on the input field are simultaneously available to a four-point f.i.r. filter. If the output field is to be the same as the input field, the phase of the interpolator will be such that the sample value for a line ¼ of the way down from an input line will be computed. If the opposite type of field is required, the order of the coefficients to the



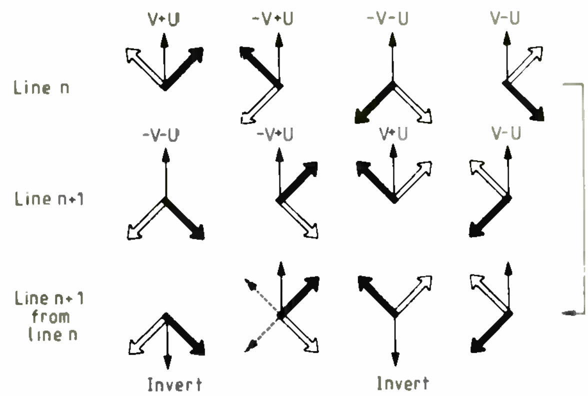
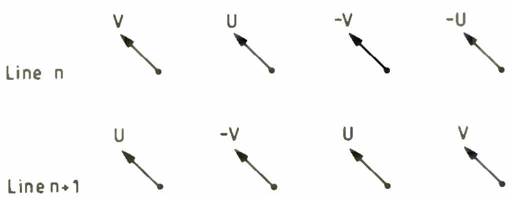


Fig. 6(a) above left. **The combined effects of V-switch and quarter-cycle offset in PAL cause the above relative phases of U and V from line to line, in a four-line sequence which only repeats after four frames.**

Fig.6(b) left. If a sampling system tapes samples on the U and V axes it results in the samples having the values shown here. It is then not possible to convert from one line type to the next because, for example, V cannot be processed to become U and so on.

Fig.6(c) above. If sampling is performed with sample phase between U and V axes (thin arrow) the samples represent sums and differences of the two signals (cosine term neglected). Line n can be be made into line n + 1 by inverting the samples when U and V have the same sign. When the sample is made, phase information is lost and only amplitude is known. For this reason the non-inverted samples phase mirror (broken arrow) because the phase is determined in the context of adjacent samples.



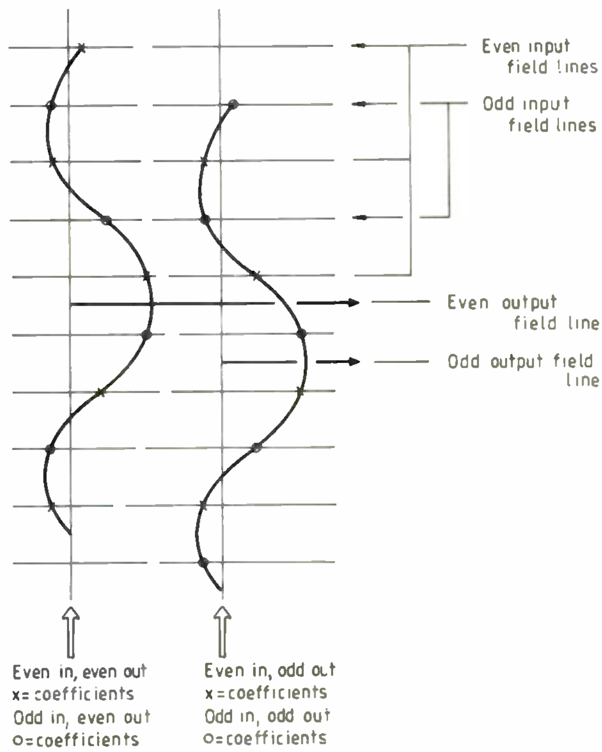


Fig.7. In vertical interpolation a f.i.r. filter will take an odd or even input field and interpolate an odd or even output field from it by choosing coefficients to obtain the correct impulse response. ▶

f.i.r. filter will be reversed such that a line ¾ of the way down from an input line will be computed. Fig.7 illustrates how this process results in the image staying at the same vertical position on the screen irrespective of the relation of input and output fields.

The luminance conveys the subjective resolution, and so the vertical chroma interpolation can be done with a simpler filter having only one line of delay to give two points.

Dropout compensation in v.t.rs is by substituting samples from nearby in the picture. The v.t.r. sends a logic level signal to the t.b.c. when the replay r.f. level falls due to a dropout. When samples are stored in the memory, one of the 512 codes is used to specify the presence of a dropout so this can be detected when the memory is read. The improved type of drop-out compensation used in Zeus uses delay lines to give simultaneous access to the previous line and the next line. Where a dropout code is detected in sample values, samples from the previous and next lines are added and divided by two to give an interpolated pixel value. A correlator watches for the condition where dropout occurs in the same place on two of the lines, since in this case interpolation is impossible, and samples from the remaining line are used instead. As the chroma phase and V-switch sense are different on successive lines, processing is necessary to obtain the correct type of chroma to substitute for the dropout.

Once the dropout compensation, colour processing and vertical interpolation are completed, the digital chroma and luminance can be recombined in an adder, and the functions of the processing amplifier can be undertaken. These include black clipping, to prevent luminance going blacker than black level, black level and pedestal adjustment, the re-insertion of syncs and burst at the desired ScH phase, and a chroma phase control. Traditionally, all of these processes have been carried out in the analog domain after the d-a convertor, but in Zeus, these are all carried out in the digital domain prior to the d-a, with resultant stability and freedom from periodic adjustment. A further advantage of the all-digital approach is that all parameters are set in output ports of a control microprocessor, and this makes remote control very easy. The t.b.c. is controlled from the control panel of the v.t.r. by a serial link to the microprocessor.

John Watkinson, M.Sc. is senior technical support engineer and educational consultant with Ampex Great Britain Ltd.

FEEDBACK

The ether

I believe the concept of an ether is a necessary construct to enable reasoning about reality with a physical mechanism. It is erroneous philosophizing to say that the slick mathematics of asymptotic equilibrium phenomena does not need it. The 'iterative' causal process of an ether mechanism is the intermediate 'scaffolding' that defines and converges to the asymptotic limit – but seemingly vanishes in importance (like all constructional scaffolding) in the final oversimplified formula. *But it is an essential explanatory intermediate.*

The ether model I envisage, of a virtual electron-positron sea, is not the same as Maxwell's ether. In modern understanding, matter and energy are interconvertible. Extrapolating that one stage further, I would say that matter and energy are one. Matter *is* energy trapped in the ether, and not Maxwell's ether somehow passing through the interstices of matter.

So, in ether-drift experiments, it is not the ether that passes through matter, but the energy of matter that has to propagate through the ether the same as any non-localized light rays in the apparatus. Hence the null results of all the misconceived experiments.

P. J. Ratcliffe
Stevenage
Hertfordshire

M. G. Wellard's letter in the May edition of *EWW* rationally and convincingly argues the case for using a model based on 'ether wind' to help explain and understand magnetic phenomena. All physics relies on using models which reflect the 'perceived physical reality' to a degree dependent on the current 'range of perception' or in other words, the state of measurement technology. It may or may not be possible in the future to in some way perceive an ether, and until such time it could be that the ether does not 'exist'. It could equally well be said – leaving aside current controversy – that relativity effects did not exist in Newton's time; his laws of motion described the perceived physical reality to an accuracy far beyond the range of perception at that time. The 'existence' or not of an ether, while perhaps of philsophical interest, is hardly relevant to its scientific application (show me a complex number) and only its usefulness in understanding and predicting physical phenomena will (or should) determine its eventual acceptance or rejection by the scientific and technical world.

As an afterthought, it would seem reasonable to suppose that, if an ether model proves successful in explaining 'instantaneous action at a distance' for magnets, then possibly a second ether to model electrostatic force may be appropriate. Naturally, gravitational force must have its own ether and of course time is merely another type of 'ether wind'. Electromagnetic radiation is then an interaction between the magnetic, electrostatic and temporal ethers and mass, (which is of course equivalent to energy as long as you're not buying a pound of butter) is obviously tied up with temporal and gravitational ethers.

Not quite fire, earth, air and water but maybe Eddie is in the space-time continuum after all.

Keith Wootten
Reading
Buckinghamshire

My letter at page 44 of the November 1986 issue of *EWW* drew attention to the initial report in *Nature* of the experiment performed by E. W. Silvertooth with US Air Force sponsorship, which had detected our motion relative to the aether. The experiment measured variation of standing-wave node displacement with orientation of a laser light beam comprising light rays travelling in opposite directions and supplied from a common laser source. A speed of some 378 km/s relative to the aether had been detected.

Arising from my letter, several of your readers have written asking me for more information. Accordingly, I offer the following comments.

An account of the details of the Silvertooth experiment has already been reported by the editor of a book, just published, entitled: "Progress in Space-time Physics 1987". This is an edited collection of 28 papers on current research in the anti-relativist field. The book is obtainable from the publisher, Benjamin Wesley, Weiherdammstrasse 24, 7712 Blumberg, West Germany.

Of special interest, however, is the fact that the Silvertooth experiment has already been repeated in Austria by S. Marinov, using less sophisticated detector equipment and Silvertooth's findings are fully confirmed. The Austrian tests gave the speed through the aether on 4 January 1987 as 386 ± 38 km/s in the direction of right ascension 12.5 ± 0.5 h and declination $-22° \pm 6°$. Marinov's paper on this is one of the 28 in the book just mentioned.

Also, though Silvertooth has now built and demonstrated an improved test apparatus, which confirms his earlier findings, a report of his first experiment has just been published in his paper "Experimental Detection of the Ether" *(Speculations in Science and Technology, volume 10, number 3, 1987)*.

The sad situation, however, which echoes the views of Dr Essen (*Wireless World*, page 44, October 1978), is that these experiments are being performed by 'anti-relativists' and are, therefore, being ignored by the pro-relativity establishment.

It may be, therefore, that we must await a practical application of the Silvertooth discovery, perhaps as an aid to space navigation, before the situation really clarifies. Meanwhile, your readers may also like to hear that one to those writing to me, Dr J. A. Briscoe, tells me that he proposed a standing-wave detector for measuring our motion through space some 29 years ago. He even obtained a British Patent for it in 1958 (No. 884,830) and, in his paper in the Wesley book, he writes "my idea has now been substantiated by Silvertooth . . ." Hopefully, there will soon be more scope for inventions as we come to realize the potential of exploiting what the aether has to offer as relativity slips aside. Remember the last words of Essen's *Wireless World* article:

> "space contains an unlimited amount of high frequency energy which could possibly be extracted and used with safety and efficiency".

H. Aspden,
Department of Electrical Engineering
University of Southampton

Michelson-Morley

In your December 1986 issue you have an article and two letters on the Special Theory of Relativity. Einstein deduced in 1905 from the results of the Michelson-Morley experiment that there was present a Lorentz-invariant property. At that time little was known about quantum mechanics, and he concluded that the Lorentz-invariant property appeared to be in the coordinate system, which made it incompatible with the Newtonian coordinate system.

The Lorentz-invariant property follows from Heisenberg's principle and is a property possessed by some of the Heisenberg eigenstates. Such eigenstates can exist within the Newtonian coordinate system.

The reflection of light involves the absorption and re-radiation of a photon by an electron, and Heisenberg's principle states that in the interaction between a photon and an electron, if there is a change in the values of two parameters the dimensions of whose product are those of action, then the changes in the parameters can only be deduced to within a quantum of action. Two such parameters are distance and translational momentum, the last of which can be regarded as proportional to the translational velocity. Thus if the positions of two eigenstates are determined, then nothing can be determined about translational velocities associated with the two eigenstates, and this is the Lorentz-invariant property.

In the Michelson-Morley experiment, by positioning half-silvered mirrors and the plates of an interferometer it is attempted to establish the positions of Heisenberg eigenstates, so that comparisons can be made of the times that photons take to traverse a particular path. It follows that nothing can be determined about translational velocities associated with these eigenstates, and this is the Lorentz-invariant property.

Einstein deduced that there was present a Lorentz-invariant property, and the form of his formula is correct, but it represents a relation obeyed by some of the Heinsenberg eigenstates within the Newtonian coordinate system.

R. Fricker, Surbiton

Flow diagrams – a new approach

Novel approach produces clear and easy to maintain flow diagrams well suited to both high-level and assembly languages.

DAVID J. SWEENEY

When I was first introduced to the subject of computers and computing, the accepted means of planning and designing a program was to draw a flow diagram. As anyone who has ever performed such a task knows, it is far from simple.

By analogy, if you were to read a book on the subject of car maintenance, inevitably you would come across a description of how to remove or disassemble some complex item (a carburettor say). In the book the problem was disposed of in a sentence. In reality, the job took an hour of valuable time.

The difficulties of using conventional flow diagrams show themselves most vividly when you try to alter them. The boxes are never big enough to add those few extra words; you have to rub out and redraw boxes and text just to insert a box with i=i+1 in it; and you have to draw lines intersecting others and make the diagram unreadable.

So who in their right mind would use a flow diagram? Well, I am about to suggest that you should. A picture is worth a thousand words, and a flow diagram is – or should be – a clear picture of the program you intend to write.

By applying the kind of reasoning used in the evolution of the circuit diagram to the flow diagram, I can now claim to have a flow diagram which is easy to maintain, clear in its presentation of the facts and flexible enough to cater for high-level languages and assembly-language code.

BASIC PRINCIPLES

Using my method, flow of control passes along lines and proceeds down the page. Conventional start-of-program and end-of-program boxes are used, Fig.1. Actions are signified by a small black circle on a line, the description of the action being given to the left of the flow line.

Actions only take place on vertical lines. When a decision has to be introduced, the flow line branches to the right. The branch may be caused by either a true or false condition, this being signified by a small T or F in the box as shown. Where secondary flow rejoins the main flow an arrowhead is used. Note that it would be wrong to draw the second decision rejoining the main flow in Fig.1. The correct method is as shown.

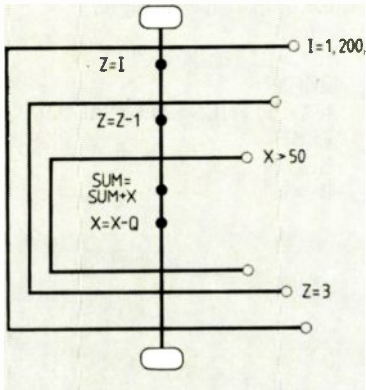


Fig.2. Three loops. Outermost is a 'for' loop in which counter I is indexed. Next is a 'repeat-until' loop where the exit condition appears at its end. The innermost loop for 'do-while' continues for as long as condition X>50 is true.

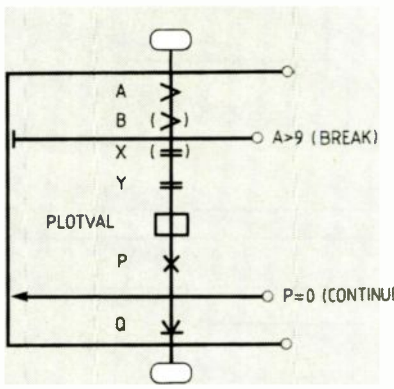


Fig.3. Subroutines are represented thus. Two parameters, A and B, are passed into the subroutine and one value, Q, is returned from it.

Subroutine calls are represented by a rectangle. The flow line is drawn through the rectangle, and examination of Figs 1-4 illustrates one of the major features of this method. All of the symbols are chosen so that if you need to insert a symbol, no lines need to be erased!

Figure 2 shows how loops are drawn, and the clarity with which the nesting of loops can be seen. I view this as a valuable feature since it allows immediate identification of such transgressions as jumping out of, or into, a loop. Two symbols not shown on the diagram are the symbol for an early exit from the loop, called BREAK in the C programming language, and the symbol for returning to the top of the loop for the next iteration, called CONTINUE in C. These symbols are shown in Fig.3.

Parameters for subroutines are shown as an equals sign when they are being passed into a subroutine; inside the subroutine are shown as a greater-than symbol. Brackets around the parameter symbols signify that the parameter is being passed by reference

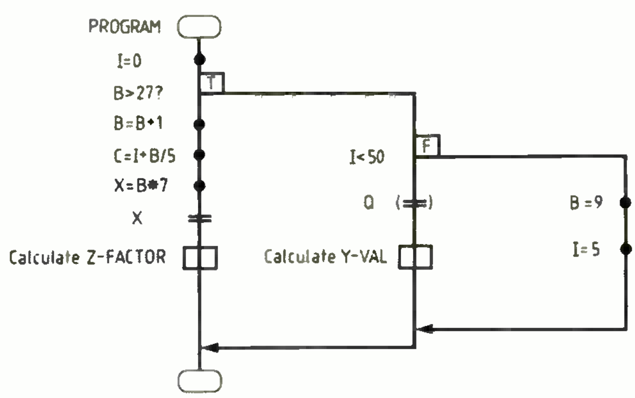


Fig.1. Two decisions are shown; the first branch will be taken if B> 27 is true and the second if I< 50 is false, as indicated by letters T and F within the rectangles.

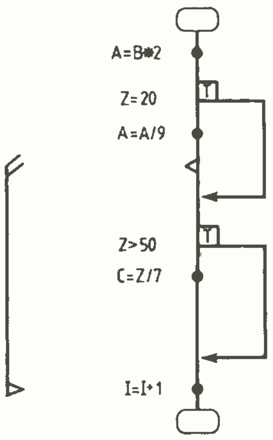
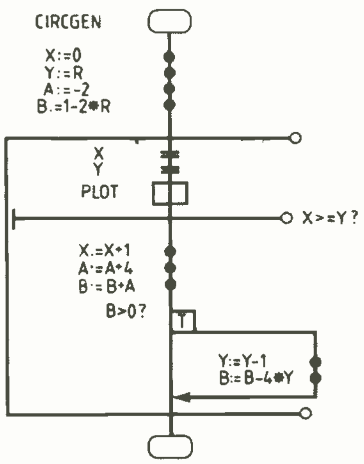
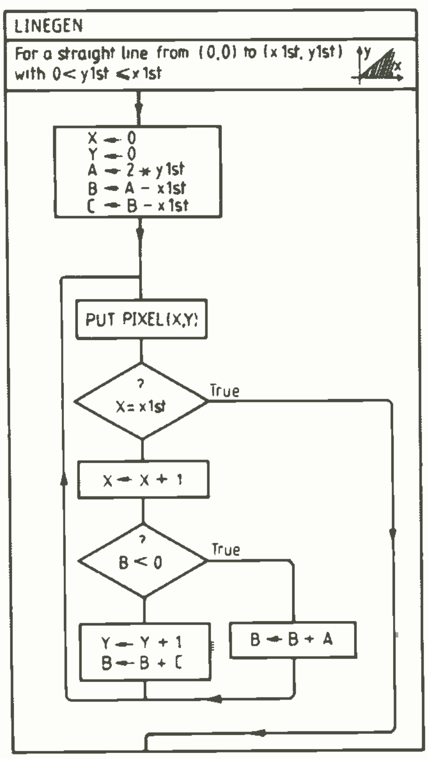


Fig.4. Control flow passes to the statement A=A/9 if Z is not equal to 20. After this control passes down the escape route.
Fig.5. Medes' line and circle drawing algorithms (bottom) redrawn to illustrate the new approach to flow diagrams (below).





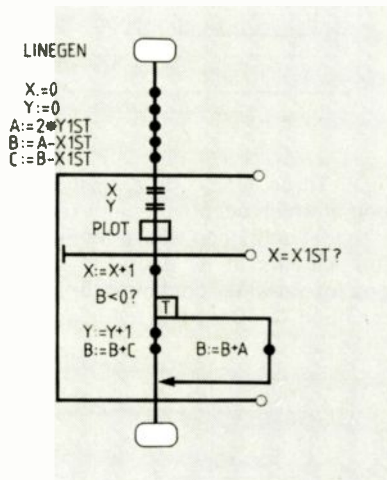
rather than by value.

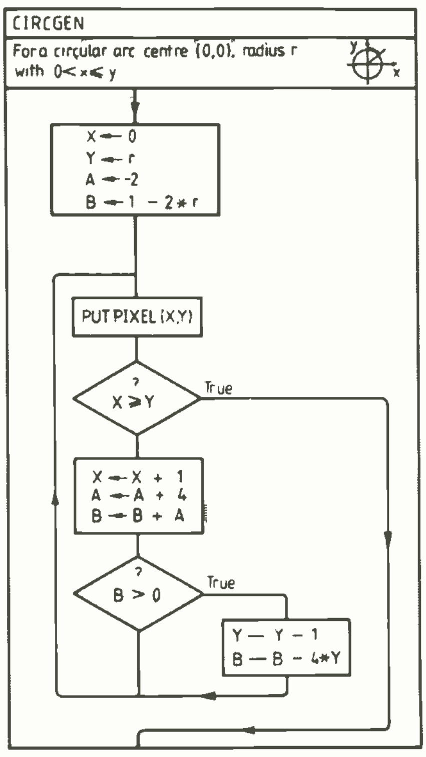
In Fig.3, value P has been returned by the routine PLOTVAL: value Q is being returned by the subroutine which comprises the whole of Fig.3.

ESCAPE ROUTES

Figure 1 shows how decisions are nested. With conventional flow diagrams, a difficulty arises when this nesting structure has to be translated into a high or low-level language. Actions taking place on the 'arm' of a branch do not align themselves with the source code which has to be written. The following Pascal example should clarify my meaning. Compare it with Fig.1.

```
IF B>27 THEN
BEGIN
IF I<50 THEN CALCYVAL (Q)
ELSE
BEGIN
B:=9;
I:=5
END
ELSE
BEGIN
B:=B+1;
C:I+B/5;
X:=B*7;
CALCZFACT (X)
END
END;
```





Notice how the layout becomes linear when compared with the diagram. It may not be easy to convince yourself that this is indeed an equivalent program to that in Fig.1. The escape route is the bent arrow appearing on the left of Fig. 4. A description of the actions in Fig.4 should illustrate its function.

The calculation is performed and a test made for Z=20. Assuming that Z does not equal 20, A is divided by 9. This done the small triangle diverts control flow to the escape route leading to the bottom of the diagram.

As with loops, escape routes can be nested, and a feature not allowed in decisions (well, frowned on by me), that of a second decision joining up with an outer one, is positively encouraged with escape routes.

AND FINALLY...

I have been developing and using my flow-diagram technique for the past ten years. However, I feel sure that having started along this road some of you will offer improvements and enhancements.

In the February issue of *E&WW*, Medes put the case for using flow diagrams, giving two examples. Figure 5 shows these same examples redrawn using my technique.

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TRANSCONDUCTANCE AMPLIFIERS CORRECTIONS

Several errors appeared in the above article in the June issue, for which we apologize to readers and to the author.

The order of the first three figures, on p.580, was incorrect: leaving the captions where they are and transposing the figures in the order 3:2:1 corrects the layout.

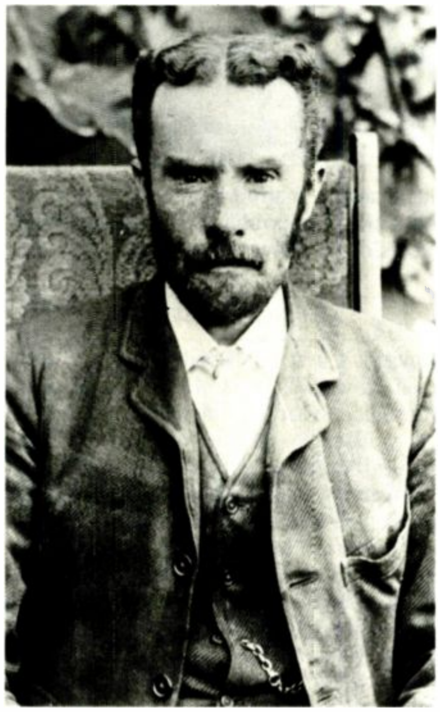
$$\frac{V_{DE}}{V_{AE}} = -\frac{R_2}{R_1} \qquad (4)$$

In equation 4 on p.581, V_{FE} should read V_{AE}, and a line is missing in the sixth paragraph from the end of the article, beginning "The differentially configured output stage...". The third sentence should read "An isolated signal source may be connected directly across A and B and supply rejection is achieved even if the signal source has finite impedance."

Pioneers

W. A. ATHERTON

8. Oliver Heaviside (1850 – 1925): champion of inductance.



Institution of Electrical Engineers

Sarcastic. Eccentric genius. A man with less than a competent grip on the ordinary affairs of life. A legend in his lifetime. Irascible. A gentleman of the old school. A dear old man. A hermit. All of these comments have been used to describe Oliver Heaviside.

Heaviside was a self-taught mathematical physicist whose discoveries made long-distance telephony possible. Traditional mathematicians and physicists struggled to understand his pioneering publications which initially he had to fight to get published. To practical engineers they were double-dutch.

He waged war on mathematicians (whom he said were as plentiful as mushrooms), the scientific establishment (the 'brays of the British Asses' was a phrase he used of members of the British Association for the Advancement of Science), and the infestation of the then current system of units with the 'disease of 4π'.

He was probably the first to use the concept of negative resistance, was one of the earliest engineers to use vector mathematics and he used his own calculus symbols. He suggested the existence of a radio-wave reflecting layer in the upper atmosphere and was the first to elaborate the skin effect. It was he who simplified Maxwell's electromagnetic theory having cleared away the debris of the battle fought by Maxwell, according to one biographer. And it was he who showed – insisted – that inductance is a necessary part of a telecommunications line. This insight led to the inductive loading of telephone cables and the subsequent leap in their performance. In short, Heaviside rewrote the theory of telecommunications.

Because of his unusual, near-incomprehensible approach, recognition of his genius was slow in coming. When honours did come his reaction was typical of the man: "I think honours have been very much overdone; the more honours the less value. It is depreciating the currency". One or two, he felt, were enough; and yet graciously he felt it unpleasant to refuse.

Perhaps the Faraday Medal of the Institution of Electrical Engineers (IEE), of which he was the first recipient, was the honour that gave him most pleasure. This annual award was, in part, specifically created to honour Heaviside.

He was a Fellow of the Royal Society and once wrote that maybe he should have stopped with the tail FRS, "with perhaps a good honorary degree to balance the tail, by giving one the title of Doctor". Even so, he observed, there are doctors in nearly every street (times must have changed) and to the public FRS means "nothing at all, being less than FRHS, to which our respected gardening townsman belongs by paying a guinea".

When the Faraday Medal was taken to him at his home in Torquay in 1922, he was 72 years old and living alone in a pleasant house decaying from long neglect.

J. S. Highfield, then President of the IEE, took the medal on behalf of the Institution. He recorded that he was met by Heaviside in a weed-covered drive and taken into a furniture-laden hall all covered with dust. In Heaviside's room the walls were papered with prints and reproductions of publications. They presented a pictorial record of his life. He retained his impish criticism and caustic wit and he was genuinely pleased at receiving the award. The fact that the medal was made of bronze and not gold compensated, in his eyes, for the "wasteful expense" of the leather-covered vellum document.

"His way of life made a pathetic background to his mental activity," wrote Highfield*, "but I am sure he did not regard it as pathetic."

Highfield's account is full of pathos. On reading it one is left with a sense of wonder and the wish that these unique moments in the life of a unique man could have been filmed for posterity. That would not have been to Heaviside's liking, however. Even a published photograph, he thought, "makes the public characters think they really are very important people". On one occasion he gave away a framed and glazed photograph of a group of IEE members to a Newton Abbot furniture dealer along with an old kitchen table. He described the photo with the words, "Giants at the back. Pigmies at the front".

BEGINNINGS

Little is known of Heaviside's early life. He was born at Camden Town, London, on May 18, 1850, the fourth son of Thomas and Rachel Elizabeth Heaviside. Charles Wheatstone was his uncle, having married his mother's sister. Both of his parents lived long enough to see him achieve some fame.

The family came from Stockton-on-Tees; his father, brothers, and two uncles were wood engravers. His mother came from Taunton. Evidently Oliver inherited some artistic talent for two of his drawings survive, one at least from the age of eleven.

Progress in photography must have made life harder for engravers and it may explain the family's move to London about 1849.

Oliver was educated at Camden House School and examined at 15, coming fifth and winning the Natural Science prize. He received no university education, though. What he subsequently learned of mathematics, physics and engineering was self-taught.

In his mid-twenties, supported by his family, he studied and worked through the night in his room at his parents' home, with windows and door shut, and an oil lamp burning. One has a picture of a serious man at work, oblivious to the stuffy atmosphere

*In "Oliver Heaviside" by Sir George Lee, British Council, 1947.

around him. It is said that when he was working during the daytime, food would be left outside his door for him to take when he was ready.

From around 1866 to about 1874 it appears that he was employed by the Danish Cable and Great Northern Telegraph Company. He became the principal operator at the Newcastle-upon-Tyne end of the Newcastle-Jutland submarine cable, usually operating on the day duty. His brother Arthur was a divisional engineer with the Post Office at Newcastle. There the two experimented with duplex telegraphy.

Heaviside's introverted and at times suspicious nature was perhaps encouraged by physical disabilities: he was deaf and had little if any sense of smell. For short periods his deafness vanished and he could hear perfectly. He enjoyed walking, a pipe of strong tobacco, music, and especially cycling. One of the few photographs of him shows him with his bike. He hated alcohol.

In 1889 his parents moved to Paignton in Devon and Oliver went with them. After their death he moved to Newton Abbot (where he gave away the Giants and Pigmies) and lived there alone from 1897 to 1909. Ill health struck and he was offered accommodation in Torquay by a friend. Subsequently he bought that house and saw out his days there as a hermit in solitary theoretical research. In his last years he bought his supplies via the local policeman who would attract Heaviside's attention by blowing his whistle through the letterbox.

In this house, with its shortage of home comforts, he became a scientific guru – a font of all wisdom. Researchers wrote to him from many countries and he developed lengthy and friendly correspondences with several, including Heinrich Hertz. Oxford physicists dubbed his hermitage the Inexhaustible Cavity. One story has it that the Post Office even recognized the title, delivering a letter addressed to him at "Inexh. Cavy. Torquay."

It was a far cry from the welcome given to his earliest papers.

"Oliver Heaviside, the Man", by the late Dr G. F. C. Searle, mentioned in our June books column, is available at £12 post free from C.A.M. Publishing, P.O. Box 99, St Albans AL3 4HQ.

This drawing, made when he was about 11 years old, is inscribed "2nd work by Oliver Heaviside (no others preserved)".

THE FOOLOMETER

Heaviside's first published article appeared when he was 22 years old, in *The English Mechanic*. A year later he had progressed to that respected scientific journal the *Philosophical Magazine*, with a paper on the best arrangement of the Wheatstone Bridge for use with specific circuit configurations. He even discussed the question of a name for the bridge, finding none of the terms then used wholly satisfactory: these included bridge, balance, lozenge, parallelogram, quadrangle and quadrilateral.

His careful attention to the choice of words led him to adopt many names for electromagnetic phenomena at a time when the terminology was in a state of transition.

Much of his terminology has remained, including resistivity, conductance, inductance, permittivity, impedance, admittance, and distortion. There were others. The vector mathematics term 'curl' was suggested by Maxwell, used by Heaviside and universally adopted. Kelvin grieved over that – he had preferred rotation or spin. Heaviside also used 'div' and may have originated it. And he adopted from Rayleigh the term attenuation as being "the very thing I wanted".

As Heaviside's writings grew more complex the troubles began. One editor stopped publishing his articles because hardly anyone read them and another observed that only a few professors read them: "Professors, you see, do not advertise".

A commercial magazine bravely took him on; and from 1882 to 1887 *The Electrician* devoted about 500 pages to his articles. Whilst these established his reputation, understanding of his work was slow to dawn.

Eventually his articles on electrical communications and electrical theory were collected and republished in book form. They became classics: 'Electrical Papers', two volumes, 1892; and 'Electromagnetic Theory', three volumes, 1893-1912.

Editors pleaded with him to make his writings more understandable. Apart from his unusual (vector) mathematics, he often omitted steps in the argument. "Our referees . . . complain of the exceeding stiffness of your paper. One says it is the most difficult he has ever tried to read", wrote one editor. To another Heaviside explained that he was not writing for posterity but for the present "stiff-necked" generation.

Even Hertz on one occasion said he could understand Heaviside's letters better than his book. Another engineer-scientist suggested that Heaviside write a simple book and offered his services as a "foolometer".

TRIUMPH

In 1889 came what one writer has called Heaviside's complete triumph. At the formal occasion when the Society of Telegraph Engineers changed its name to the Institution of Electrical Engineers, Lord Kelvin gave the address. In doing so he reflected that his own famous and well-used telegraph equation had ignored inductance completely but that now Heaviside had worked it out in full. From then on, Heaviside's work received more of its proper due.

Over long distances on a telephone line the different frequencies tended to arrive at different times, rendering long-distance telephony impossible. Heaviside showed that a 'distortionless circuit' could be achieved if inductance were used to compensate for the effects of capacitance. The official view in Britain and abroad disagreed. Only when M. I. Pupin in America proved the point in practice did views change. Eventually, induction loading coils and continuously-loaded cables made long-distance telephony a reality. Heaviside meanwhile viewed officialdom with scorn.

Eccentric genius is hardly adequate as a description of him. To some opponents his sarcasm hardly wavered, and yet he held no pompous view of himself. From about 1918 he called himself The Worm and signed himself Oliver Heaviside, W.O.R.M. He showed an impish delight when others took that as a distinction.

Much earlier he said of himself, "I am not fit for a cook; I forget. Then it all goes to cinder". G. F. C. Searle recalled having tea with Heaviside at Newton Abbot in 1905. "The tea party was a bit odd," he wrote affectionately; "the teapot spout was blocked with tea leaves so Oliver Heaviside simply poured from the lid."

Searle was perhaps the last to die of those men of science who really knew Heaviside. He described him as a strange but very attractive person, with an unquenchable spirit of fun.

Early in January 1925, Heaviside was found unconscious in his house by his faithful policeman friend and he was removed to a nursing home. There he improved, was full of fun and enjoyed the attention of the nurses and the good food.

To physicists and telecommunications engineers he was a legend. To those nurses he was simply a dear old man. The dear old man died on February 3, 1925.

Tony Atherton works at the Independent Broadcasting Authority's engineering training college in Devon.

Countdown to small-dish satellite tv

A recent satellite broadcasting conference revealed details of Britain's direct broadcast satellite tv service, due to start late next year.

Hughes Aircraft's HS 376 satellite, to be used for BSB's d.b.s. services to the UK, weighs about 630kg and has a design life of 10 years. The antenna and telescoping solar panel extend to about 7m overall in orbit. Broadcasts will be receivable on a dish 30cm in diameter. Thirty versions of the spacecraft have been purchased by customers in six countries. BSB's two spacecraft will cost it £200M.

Barring accidents during the launch, British viewers will have a further three television channels to choose from by Christmas next year. British Satellite Broadcasting, the contractor appointed by the IBA, has now selected the Hughes Aircraft Company to provide the two satellites needed for its service. A draft contract arrived from Hughes the night before the conference began.

Making a break with the conventions of the commercial satellite world, Hughes will hand the satellites to BSB only after they have been tested in orbit. This supply-and-launch arrangement is designed to help restore confidence in the space industry after its spate of recent failures, and it will greatly reduce the financial risk to BSB. Other companies, including British Aerospace, were on BSB's short-list, but they failed to match the Hughes package.

Each satellite will be equipped with three 110W transponders capable of an e.i.r.p. of 59dBW in the 12GHz band, giving high-power coverage of whole United Kingdom. Reception will be possible on 30cm dishes and BSB say the receiving terminals will soon become a mass-market item costing only £200.

Plans for the new services were outlined to the conference by BSB's Graham Grist. The three channels will be used for four programme streams. *Now* would be a news and events channel with a major input from Independent Television News; *Galaxy* would include light entertainment, quizzes and shows; and the remaining channel would be shared between *Zig-zag*, with daytime programmes for children and mothers at home, and *Screen*, which would offer in the evening a mixture of feature films ranging from new releases to cinema classics. The last service would be available on subscription only, at about £10 per month; the others would be supported by advertising. But all were to be encrypted. This was because BSB would buy only the UK distribution rights to programmes and would have to prevent reception abroad. However, decoders would be freely available on the home market.

The IBA, said Mr Grist, recognized the need for commercial success of the new service, and had exempted BSB from some of the regulations which govern its other contractors – for example, the duty to supply programmes for minority tastes and to guarantee a wide showing for programmes of merit. However, BSB would aim for a high general standard of programmes, with impartiality and without offence to decency. It expected to spend over £100M on programmes in its first year and it would accompany the launch by a promotional campaign which would put it among the top six advertising spenders.

Transmissions will be on the D-MAC standard, for which British Government approval is still awaited. No chip set is yet available for D-MAC, but Mr Grist told the conference that the Nordic countries now had on the drawing board a set which would cover all three MAC standards, C, D and D2. RCA were prototyping the video chip and would have sample quantities ready by the end of the year; Plessey and ITT were also taking an interest. He expected adequate supplies in time for the launch of the BSB service.

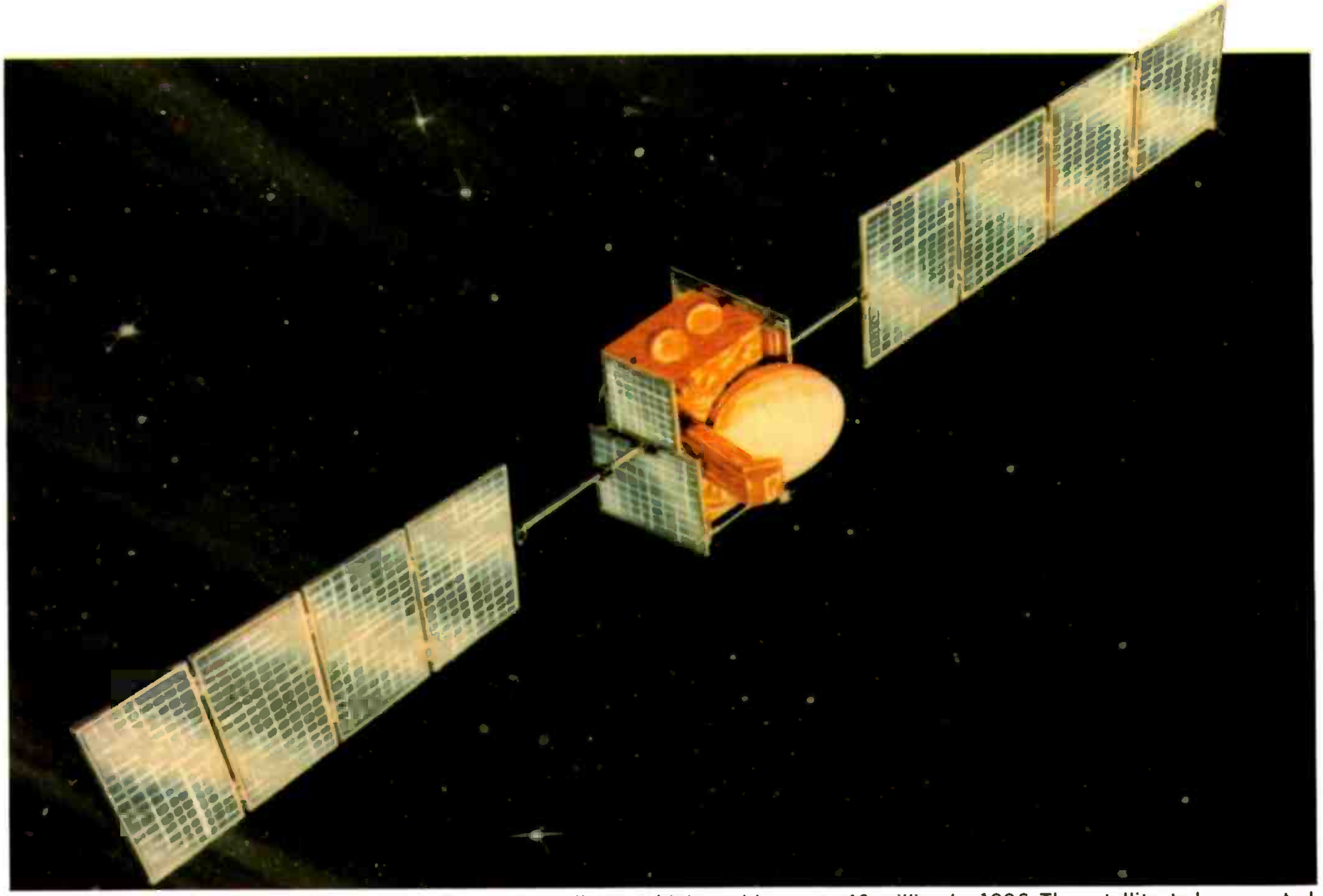
A special feature of the d.b.s. service will be the high data-carrying capacity of the D-MAC transmission. This BSB will use in three ways: for programme-related teletext, for subscriber services such as financial information, and for toll services such as business messaging. The company intends to maximize its use of this capability, to underpin the service whilst advertising revenue and a subscriber base are building up.

Mr Grist was confident that his service would begin on time. The launch vehicle, a McDonnell-Douglas Thor Delta I, had shown a 98% success record over the past 10 years. The standby satellite would be placed in orbit by a second launch, using the more powerful Delta II; this was scheduled for six months after the first launch.

DATA SERVICES

More information about the possibilities of business messaging was provided by Adrian Norman of Direct Business Satellite Systems, who hoped to reach agreement with BSB shortly to start such an operation. Through the vast capacity of the British d.b.s. satellite, his company could offer a store-and-forward electronic mail service which would significantly undercut its terrestrial rivals.

Four data channels on each of the satel-



Astra will bring 16 television channels to a European audience which could grow to 40 million by 1996. The satellite, to be operated by the Luxembourg company Société Européenne des Satellites, is due for launch on Ariane's Flight 27 in June or September 1988.

lite's transponders would give a capacity of 13.4Mbit/s averaged over the day, and out of programme hours the entire picture field would be available for data. The cost of sending a megabit over the space segment of path worked out at about 11p – enough to carry four pages of faxed typescript, a minute of compressed 64Kbit/s voice, or 128Kbyte of computer data.

Messages would be received via set-top demodulators, which would add relatively little (£100-£300) to the cost of a d.b.s. receiver. Demodulators would be individually addressable: only those terminals authorized to receive a particular message would be able to display or print it.

To ensure low administrative costs messages would be pre-paid. Each one would cost a few pounds to send. However, most items sent through the present-day mail were copies or near-copies of other messages. And since the satellite system would be able to address the same basic message to many recipients, the cost of an additional copy could be as little as 1p. Mr Norman said that he was re-introducing the penny post.

For senders, the service would mean they could fire and forget: next-morning delivery would be guaranteed. Recipients would incur no costs in receiving messages, other than hardware costs. With present e-mail systems, they have to pay for computer time even if they find no message waiting.

Demonstrations of the system would take place on the Olympus satellite and DBSS was looking for early customers willing to take part in the trials.

Voices from the floor commented that d.b.s. transmission was a one-way process and asked how senders might be given the confidence that their messages had arrived. A small number of non-received items might cause havoc in the system. The speaker replied that some redundancy would be provided: a list of messages to come would precede the main transmission by some hours, and the list would be repeated some time afterwards. If a recipient missed a message, he could call the centre; larger organizations could use viewdata to call for repeats or to resolve problems. The expected bit error rate was 10^{-7} or 10^{-8} and so the most likely cause of failure was accidental removal of the receiver's mains plug.

D-MAC TRANSMISSION STANDARD

Listed here are features of the EBU D-MAC packet system to be adopted by the IBA and BSB. A full specification will be published later; some details remain to be settled. The IBA will put out test transmissions to help manufacturers check compliance and tolerances.

Vision: **f.m. with pre-emphasis and d.c. restoration. Time-compressed luminance and chrominance information is multiplexed on to each line; alternate lines carry R-Y or B-Y signals. Basic standard for Europe is 625 lines, 25 pictures per second.**

Data: **duobinary coded packet system at 20.25Mbit/s, f.m.**

Aspect ratio: **normally 4:3; 16:9 possible. Line 625 is a status line giving details of this and other transmission parameters, enabling receivers to be reconfigured automatically.**

Sound: **stereo or mono, 15kHz bandwidth. Commentary channels, 7kHz.**

Teletext: **carried in the data multiplex.**

Vertical blanking interval: **reserved for future high-definition enhancements.**

Encryption: **by double-cut component rotation and the shared key over-air addressing system known as EBU System B.**

Full details of the MAC systems are given in the European Broadcasting Union's technical document number 3258.

D-MAC AND KITCHEN FOIL

Brian Salkeld of the IBA spoke in support of two IBA papers in which reasons for the choice of D-MAC were set out.

In choosing standards for the new service, he said, it was necessary to take a long-term view. Chips now being made for the forthcoming French and West German d.b.s. services did not allow scrambling and the rigid arrangements for sound lacked the flexibility of the D-MAC packet system.

The paper by Chris Daubney of the IBA argued that the principal alternatives, C-MAC/packets and D2-MAC/-packets were

Table 1: costs in pe... ...nding a message. The figures include eq... ...d subscription costs at both the sende... recipient's end (Direct Business Satell... ...td).

	min.	typ.	max.
	13	18	100
...s)	10	25	25
	10	20	40
...0s)	5	10	36
Mail (...es)	1	25	200
Tele... words)	1	2	200

F...

...uropean satellite tv systems (Philips-France).

	...urce	Vision	Sound
	...CIR	Pal/Secam	1 f.m.
	France, FRG	Pal/Secam	2 f.m.
	France	Pal/Secam	4-6 digital A
	Sweden	Pal/Secam	8 digital A
	UK BBC	Extended Pal	Digital
...82	UK IBA	MAC	Digital
6/1983	EBU	MAC	C/packets
6/1984	Independent	MAC	D2/packets
12/1984	EBU	MAC	C/D/D2 packets
7/1985	Ind., Fr., FRG	MAC	D2 packets

Applications of the various MAC systems (Gwyn Morgan, Logica). Opinion is divided as to whether D2-MAC can evolve to cope with high-definition tv.

	HDTV	DBS	Cable	SMATV	Home video
D2	●	●	●	●	●
D	●	●	●		
C	●	●			

both less satisfactory: the former because it called for a more expensive receiver (although it gave slightly better results under low signal strength conditions) and the latter because it had only half the data capacity and so failed to meet the criterion of making full use of the channel.

At the end of his presentation, Mr Salkeld produced with a flourish a small 12GHz dish antenna which looked as if it might have come from BBC-tv's 'Blue Peter': it was made, he said, of kitchen foil, a plastics lemonade bottle and its cap, Plasticene, a short length of copper water pipe, and papier mache composed of old copies of the Financial Times (the newspaper owned by the Pearson group, one of BSB's founder shareholders). Setting the aerial on the top of a tv set, he was rewarded almost immediately by a healthy set of colour bars – which showed, he said, how simple d.b.s. reception was going to be. Discussing the antenna afterwards, he revealed that the demonstration had been genuine: the microwave transmitter at the other end of the conference hall was set to give the actual field strength expected from d.b.s.

TAKING THE RISKS

All this, of course, is contingent upon a successful launch of the BSB satellite. A space insurance consultant, Rodney Buckland, examined some of the technical risks. With civilian communication and earth observation satellites, losses up to the apogee kick motor stage had risen from 8% to 18% over the last decade (taking a five-year moving average). Nothing seemed to have gone right for the space industry. Challenger, Titan, Delta and Ariane had all failed within months of one another last year. Atlas, Centaur, two Protons and an Indian satellite had also failed. Mr Buckland had just re-examined the figures for Delta and had found the true success rate to be well below the 98% optimistically quoted by BSB. That figure, he said, related only to the first stage of the launch. Of 39 basically similar Delta flights over the past ten years, three had resulted in a total loss of the satellite due to the launcher. Further failures had occurred on transferring satellites into orbit or during commissioning, making a cumulative loss rate of about 13%: better than the industry average of 16–18%, but worse than Mr Grist had suggested. A speaker afterwards observed, to laughter, that this one-in-six rate was the same as the chance of being killed in Russian roulette.

Last year, underwriters had lost $400M on satellite business on a turnover of $900M (a few claims were still unsettled) and so had a good deal of ground to make up.

Traditionally, satellites had been built launched on a 'best effort basis' by the companies concerned, with no guarantee of success. Mr Buckland congratulated Mr Grist on securing his 'buy in the sky' package deal with Hughes, which offered the industry a way forward where insurers had failed it.

WHO WILL PAY?

The main motive power for d.b.s.-tv comes, of course, from the advertising industry. Robert Dodds of BBDO, the second largest advertising agency in the world, outlined some of its potential advantages over the more restrictive climate of terrestrial tv. Currently, only two countries in Europe offered tv advertisers the freedom to buy time as and when they wanted it: one was Italy (with an astonishing 750 minutes of advertising time per day) and the UK (with about 144 minutes). In other countries, commercials were shown in blocks of up to 12 minutes: airtime might have to be applied for up to 15 months before transmission. This system denied advertising buyers the ability to book specific time-slots or to target a particular group of viewers; and it gave consumers the opportunity to miss the commercials altogether. In addition, it deprived advertisers of the leverage a sympathetic editorial environment could bring to their commercials.

In this context, the audience was diverted by another speaker from the marketing world who sought to demolish the view expressed by one sage that satellite tv would prove to be (er, excuse us) a cornucopia of crap. The hubbub which followed his showing of a montage of programme highlights seemed to hint that there were still a few sceptics around.

BBDO estimate that around $1400M of tv advertising business (at 1986 prices) is currently unable to be placed because of restrictions. Some proportion of this, said Mr Dodds, would be available to finance satellite tv through multinational companies wishing to promote pan-European super-brands.

ASTRA'S 16 CHANNELS

Europe's other high-profile d.b.s. vehicle is Astra, a privately-operated medium-power satellite due to be placed in orbit by the revived Ariane programme in mid-1988. Astra will essentially be a carrier of programmes provided by others rather than an originator. The spacecraft will offer sixteen 26MHz-wide downlink channels (with six spares) in the range 11.2 to 11.45GHz, all of them battery-backed and available 24 hours per day. Power output from the t.w.ts will be 45W, giving a nominal e.i.r.p. of 50dBW (48dBW in the north of Scotland). Viewers will be able to receive Astra on an 85cm diameter dish; though if they want BSB too, they are likely to need a second microwave front end – current models have insufficient bandwidth. Astra now has a tie-up with British Telecom, which is to build a fourth antenna at the London Teleport in the Docklands to uplink two of the channels. BT will also market Astra services in the UK.

Marcus Bicknell of SES, the Luxembourg company behind the Astra project, discussed some of its aims. UK viewers, he said, would be offered two or three English-language general entertainment channels, a pay-tv film channel, plus five or six pan-European single-subject thematic channels devoted to music, arts or sport. These thematic channels would be shared by other countries in Europe, where a similar pattern would be repeated. By this means Astra would give French viewers double the number of channels offered by their TDF satellite. One-third of leisure spending power in Europe was in German-speaking countries; these too could expect to be well-served.

Technical standards for the systems had not been decided, but would be announced between mid-July and early August.

A likely contender is the D2-MAC packet system chosen for the French TDF1 and German TVSAT satellites. This was described by Jacques Geninet, d.b.s. project manager for Philips-Portenseigne. D2-MAC is a narrow-band MAC system with reduced sound and data capacity, tailored to suit cable tv networks in continental Europe. After the presentation, Paul Ratliff of the BBC Research Department commented from the floor that if we were to adopt D2, we were being constrained by yesterday's cable systems. D2 had no capacity for expansion: high-definition tv could be accommodated only by doing without the sound. Geninet responded that C-MAC was the best possible system for satellite transmission; but the question was whether we should optimize for satellites or go instead for a multi-purpose system such as D2-MAC.

Another speaker at the conference, David Cutts, of Direct Broadcasting Ltd, a British company specialising in subscriber authorization for tv, observed that it was odd that the EBU – having got fairly near to a standard for MAC transmissions – actually encouraged a diversity of conditional access systems.

Meanwhile, British cable operators have declared their support for the IBA's system by announcing agreement on a data and conditional access standard based on the 20.25MHz data rate of C and D-MAC.

The 1987 European Satellite Broadcasting Conference and an accompanying exhibition were held at the Brighton Metropole in June. Further details from the organizers, Online International, on 01-868 4466.

Novel oscillators

Three new oscillator discoveries – an active-C tunable oscillator particularly suited to i.c. manufacture, a single op-amp capacitorless oscillator, and a current-conveyor based design with low sensitivity and non-interactive tuning.

Single-amplifier capacitorless oscillator

Accurate op-amp modelling produces a single op-amp capacitorless oscillator that works reliably over a decade frequency range. It uses at most four resistors.

M. T. ABUELMA'ATTI and W. A. ALMANSOURY

A number of schemes have been developed for realizing capacitorless oscillators over the past few years [1-10]. They exploit the frequency-dependent gain of practical operational amplifiers.

Analysis of such circuits usually involves a linear two-pole model for frequency-dependent gain of the op-amp. Using this two-pole model, which is well accepted for compensated op-amps, capacitorless oscillators cannot be realized with fewer than two amplifiers[1].

Using a more accurate model, a new capacitorless oscillator with a single op-amp and at most four resistors can be realized. An equivalent of the oscillator circuit, Fig. 1, is shown in Fig. 2 with the op-amp represented by its differential input capacitance and resistance[11,12].

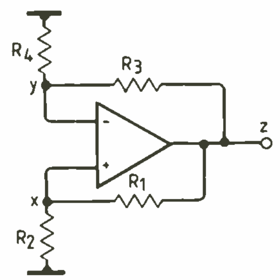


Fig. 1. Single-amplifier capacitorless oscillator designed using a more accurate model for the op-amp.

Open-loop gain of the op-amp is represented by the conventional two-pole model

$$A(s)=\frac{A_0\omega_a\omega_b}{(s+\omega_a)(s+\omega_b)}$$

where A_0 is d.c. gain and ω_a and ω_b are the first and second corner frequencies respectively.

Node equations of Fig. 2 are

$$\frac{y-x}{Z_d}=\frac{x}{R_2}+\frac{x-z}{R_1}$$

$$\frac{x-y}{Z_d}=\frac{y}{R_4}+\frac{y-z}{R_3}$$

$$z=A(x-y)$$

$$Z_d=R_d||\frac{1}{j\omega C_d}.$$

By eliminating x, y and z from the previous three equations the characteristic equation of Fig. 2 can be shown to be $\alpha+\beta A=0$, where

$$\alpha=\alpha_1+\alpha_2(1+s\tau)$$

$$\alpha_1=\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\left(\frac{1}{R_3}+\frac{1}{R_4}\right)$$

$$\alpha_2=\frac{1}{R_d}\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}\right)$$

$$\tau=C_dR_d$$

$$\beta=\frac{1}{R_2R_3}-\frac{1}{R_1R_4}.$$

Using the first equation with this one the characteristic equation reduces to

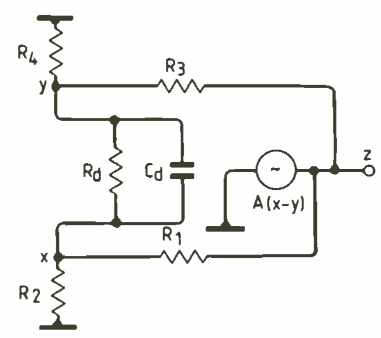


Fig. 2. Equivalent circuit of Fig. 1. The operational amplifier equivalent circuit incorporates differential input resistance/capacitance and frequency-dependent gain.

$$[\alpha_1+\alpha_2(1+s\tau)](s+\omega_a)(s+\omega_b)+\beta A_0\omega_a\omega_b=0.$$

By equating the imaginary part of this expression to zero, frequency of oscillation can be shown to be

$$\omega_0{}^2=\omega_a\omega_b\left[1+\frac{\alpha_1+\alpha_2}{\tau\alpha_2}\left(\frac{1}{\omega_a}+\frac{1}{\omega_b}\right)\right].$$

In a similar way, the condition of oscillation is obtained by equating the real part of the last but one equation to zero. Note that for most practical cases ω_b is much greater than ω_a and the condition of oscillation can be shown to be

$$A_0\geqslant-\frac{\alpha_1+\alpha_2}{\beta}+\omega_0{}^2\left(\frac{\alpha_1(1+\omega_b\tau)+\alpha_1}{\beta\omega_a\omega_b}\right).$$

From the previous two equations it is clear that by using appropriate resistances production of sustained oscillation from the circuit of Fig. 1 is possible.

We built and tested this oscillator using a 741 op-amp. Figure 3 shows a typical output waveform using 10kΩ for $R_{1,2}$, 68kΩ for R_3, infinity for R_4 and op-amp supplies of ±15V.

Variation of frequency with R_3 is shown in Fig. 4. When this resistance was varied from 33 to 470kΩ, frequency varied from 350kHz to 27kHz.

For stable operation, op-amp parameters A_0, ω_a and ω_b must be stabilized, so we therefore recommend a temperature-compensated op-amp such as the LM324. Power supply voltage should be stable.

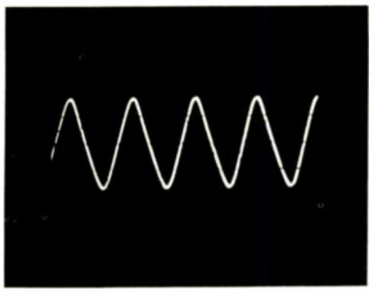


Fig. 3. Typical output waveform from the oscillator of Fig. 2 using $R_{1,2}=10k\Omega$, $R_3=68k\Omega$ and $\pm15V$ for the op-amp.

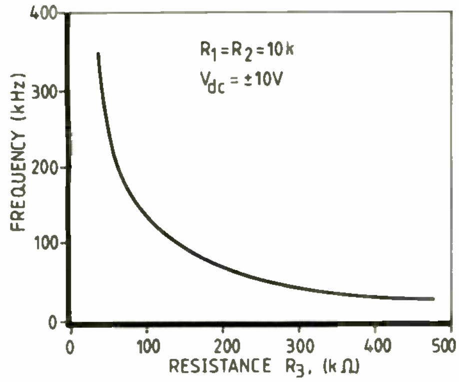


Fig 4. Variation of frequency with R_3.

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Active-C oscillator

With low sensitivity and non-interactive electronic tuning, this resistorless o.t.a. oscillator is particularly suited to integration.

M. T. ABUELMA'ATTI and R. H. ALMASKATI

Operational transconductance amplifiers have three main advantages over standard operational amplifiers. They require few if any resistors, tuning of their transfer gain (g_m) is electronic and highly linear, and their high-frequency performance is more reliable. For these reasons, o.t.as are replacing op-amps in oscillator and active filter designs.

Recently, a number of o.t.a.-based oscillators have been proposed[1-3]. Those by Saha et al.[1] and Nandi[2] are not particularly suited to integration because they include RC combinations to determine the frequency and condition of oscillation. Non-interactive electronic tuning of the amplifier proposed by Ahmed et al.[3] is impractical because of interdependence between the frequency and condition of oscillation.

Our new o.t.a. active-C oscillator has two grounded capacitors and is therefore highly suitable for integration. Moreover it has non-interactive electronic tuning and low sensitivity.

Figure 1 shows the oscillator, whose characteristic equation is

$$s^2 g_{m5}C_1C_2+s.g_{m3}(g_{m5}-g_{m4})C_1 + g_{m1}g_{m2}g_{m5}=0,$$

where g_{mi} is transconductance gain of the o.t.a. number i. By equating the real and imaginary parts of this expression to zero, the condition and frequency of oscillation can be shown to be $g_{m4}=g_{m5}$ and

$$\omega_o^2=\frac{g_{m1}g_{m2}}{C_1C_2}.$$

From the previous two equations it is clear that the circuit has non-interactive electronic tuning since frequency of oscillation can be varied without affecting the condition of oscillation. Moreover by making g_{m1} equal to g_{m2} and since g_{mi} is directly proportional to direct bias current of the o.t.a., frequency of oscillation will change linearly with direct bias current (or bias voltage).

Sensitivity figures are calculated from the definition

$$S_y^{\omega_0}=\frac{y}{\omega_o}.\frac{\partial\omega_o}{\partial y}.$$

where ω_o is oscillation frequency and y is the element of variation. Using this equation, ω_o sensitivities are

$$S_{g_{m1}}^{\omega_o}=S_{g_{m2}}^{\omega_o}=-S_{C_1}^{\omega_o}=-S_{C_2}^{\omega_o}=½$$

which indicates that sensitivity figures are low.

We built and tested the oscillator using a CA3080E o.t.a. and polystyrene capacitors. Figure 2 shows the variation of oscillation frequency with direct bias current $I_{B1}=I_{B2}$. When bias current was varied from 10 to 110µA the change in frequency was from 5

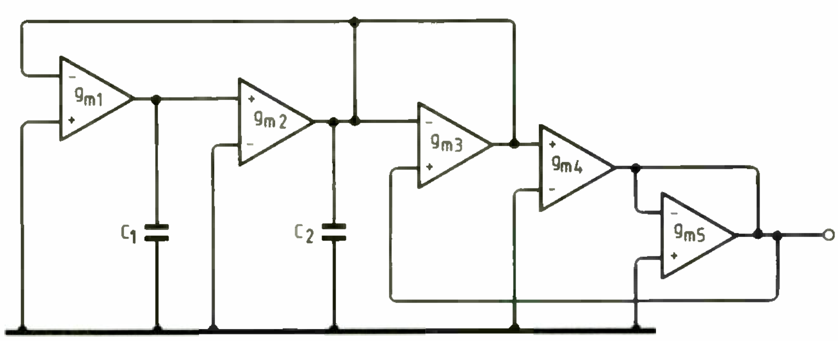

Fig. 1. Proposed resistorless oscillator uses five operational transconductance amplifiers and two grounded capacitors.

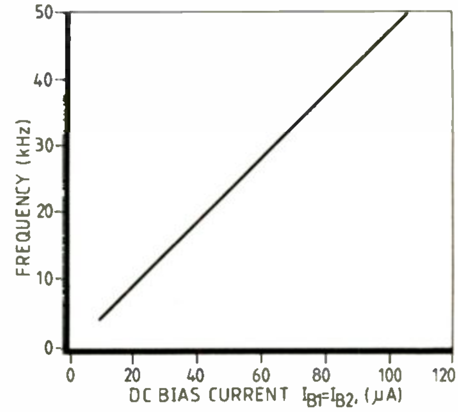

Fig. 2. Variation of oscillation frequency with direct bias current.

to 51kHz. Currents and capacitors used were 4.5μA for I_{B3} and I_{B5}, 27μA for I_{B4} and 47pF for $C_{1,2}$.

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Current-conveyor RC oscillator

One current conveyor makes a low-sensitivity sinewave oscillator with non-interactive single-capacitor tuning.

M. T. ABUELMA'ATTI and N. A. HUMOOD

Because of its distinct advantages over the operational amplifier, the current conveyor has attracted the attention of many researchers in the field of active filters and oscillators[1]. Recently a number of oscillator circuits using a single current conveyor have been proposed[2]. Here we explore the possibility of a new design for such an oscillator.

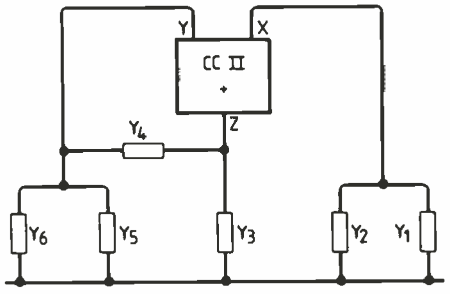

Fig. 1. Current-conveyor oscillator forms the basis of the new oscillator.

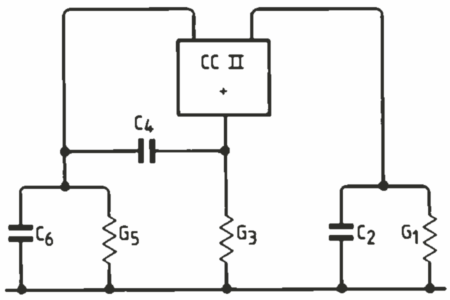

Fig. 2. New RC sinusoidal oscillator using three grounded resistors and three capacitors, two of them also grounded.

Three grounded resistors and three capacitors are used, two of them grounded and one not. Assuming that the current conveyor in the oscillator structure of Fig. 1 is ideal, with $i_x=i_z$, $i_y=0$ and $v_x=v_y$, routine analysis yields the characteristic equation ot this circuit configuration given by

$$Y_3(Y_4+Y_5+Y_6)+Y_4(Y_5+Y_6)=Y_4(Y_1+Y_2).$$

By performing all possible permutations to explore the possibility of oscillation, two oscillator circuits resulted. With $Y_1=G_1$, $Y_2=j\omega C_2$, $Y_3=j\omega C_3$, $Y_4=G_4$, $Y_5=j\omega C_5$ and $Y_6=G_6$ the oscillator circuit reported by Jana and Nandi is obtained, and with $Y_1=G_1$, $Y_2=j\omega C_2$, $Y_3=G_3$, $Y_4=j\omega C_4$, $Y_5=G_5$ and $Y_6=j\omega C_6$ a new oscillator is obtained, Fig.2.

Oscillation frequency and the condition of oscillation of the new circuit can be obtained by equating the real and imaginary parts of the resulting characteristic equation to zero. Frequency of oscillation will be

$$\omega_o^2=\frac{G_3G_5}{C_4(C_2-C_6)}$$

and the condition of oscillation will be

$$G_1C_4=G_3(C_4+C_6)+G_5C_4.$$

From these two equations it is clear that oscillation frequency can be changed without affecting the condition of oscillation. This can be done by changing C_2.

The various sensitivity figures are calculated using sensitivity definition

$$S^{\omega_0}_y=\frac{y}{\omega_o}\cdot\frac{\partial\omega_o}{\partial y}.$$

From this equation, ω_o sensitivities for Fig. 2 were calculated and are given by,

$$S^{\omega_o}_{G_3}=S^{\omega_0}_{G_5}=-S^{\omega_0}_{C_4}=1/2,\ S^{\omega_0}_{C_2}=-1/2\frac{1}{\left(1-\frac{C_6}{C_2}\right)},$$

$$S^{\omega_0}_{C_6}=1/2\frac{1}{\left(\frac{C_2}{C_6}-1\right)}.$$

Using the current conveyor implementation of Fig. 3, the oscillator in Fig.2 was built and tested. Figure 4 shows variation of oscillator frequency with capacitance C_2. Components used to obtain these results were $R_1=1.4k\Omega$, $R_3=11.2k\Omega$, $C_4=100pF$, and $C_6=500pF$. When capacitance C_2 was varied from 22 to 79nF, oscillation frequency varied from 77 to 38kHz.

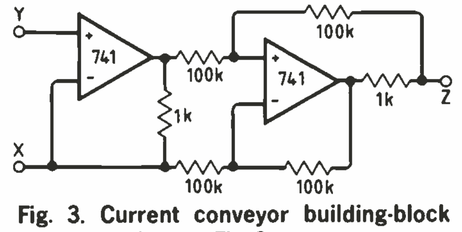

Fig. 3. Current conveyor building-block used to implement Fig. 2.

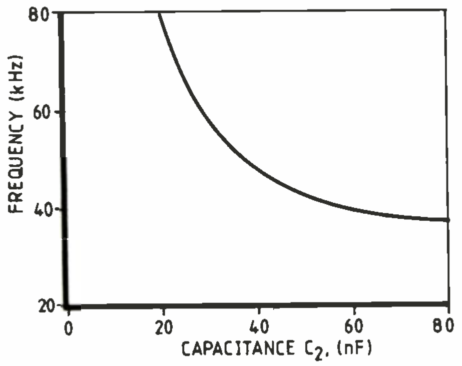

Fig. 4. Variation of oscillation frequency with capacitance C_2.

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RESEARCH NOTES

Fluoride for long-hop fibres

Optic-fibre technology is developing so rapidly at the moment that most of us would be very happy to have a few shares in silica glass. But although the best mono-mode silica fibres can now achieve attenuations down to 0.2dB km^{-1} even this makes it impossible to dispense with repeaters that are inevitably expensive and awkward to power. The planned transatlantic fibre link TAT-8 will, for example, require boosters every 50km. And while the fibres themselves require no electricity, the boosters certainly do, necessitating power cables in parallel with the fibres.

What may well oust silica in the end is one of a new range of materials based on fluorine chemistry, especially beryllium fluoride and fluorozirconates. The potential advantage of fluoride glasses is that they will transmit the longer wavelengths that are increasingly opaque to silica. Over the last decade there's been a steady move into the infra-red part of the spectrum as the technology – especially laser technology – has made it possible. The phenomenon of Rayleigh scattering dictates as long a wavelength as possible because of a fourth-power loss/frequency relationship. Unfortunately, if the wavelength of transmission gets much beyond the current 1.55μm maximum, then a new loss mechanism comes into play due to resonances in the chemical lattice of the material. This places a physical limit on silica fibres. Fluoride glasses have a different chemical structure and will therefore transmit longer wavelengths where Rayleigh scattering is less of a problem.

So far, this promise has yet to be fully realised, since fluoride-glass technology is relatively new. Attenuation figures of 0.7dBkm^{-1} have been achieved in the laboratory, but there are considerable problems in practice because many of the materials are chemically unstable or lacking in durability. Fluorozirconate glasses are potentially prone to devitrify, that is to crystallize spontaneously and become opaque. Beryllium fluoride, on the other hand, is dangerously poisonous and very prone to absorb water. Water is not just a mechanical problem but a limitation on operating wavelength: even small amounts in any fibre can introduce a strong absorption at about 2.9μm.

For the future it looks as if the fluorozirconate glasses will probably extend the operating wavelengths down towards about 2.5μm, where in theory operating losses are much less than they are at 1.55μm. That, in turn, if the manufacturing problems can be solved, heralds the possibility of long-distance links with repeater spacings of several hundred kilometres. Researchers in Japan, the USA and at various UK universities and British Telecom are now actively pursuing that goal.

New research in parallel computing

A major £10 million international collaborative research project, to spearhead the development of powerful parallel computer systems able to integrate numeric and symbolic processing, is being led by Thorn EMI's Central Research Laboratories.

Involving participants from five European countries, the three-year 'SPAN' project is being 50% funded by the EEC through the Esprit programme for Information Technology Research and Development. An important aim of the project is to establish a *de-facto* standard for software/hardware interchange between parallel computers. In addition to Thorn EMI the collaborators include CISMA SINTRA (France), PCS (West Germany), University College London, CTI (Greece) and INESC (Portugal).

The objective of SPAN is to bridge the gap between conventional computers supporting arithmetic operations and newer types of symbolic computers supporting Artificial Intelligence applications. The goal is to develop powerful parallel computers able to undertake the rapidly expanding range of applications involving both arithmetic and symbolic computation. Areas of application already identified include image interpretation, weather forecasting, and real-time expert systems.

The project will make extensive use of up-to-date research on parallel computers, notably the concept of parallel-processing building-block components, pioneered by Inmos in the transputer family of microprocessor chips, together with the results of other current Esprit projects.

Magnetic peaks

The High Field Support Group at the Clarendon Laboratory, Oxford, has achieved a magnetic field of 52 Tesla for 10ms using a solenoid fitted with a special high-strength conductor (*Physics Bulletin* Vol.38, No 5). The research undertaken in conjunction with the Catholic University of Leuven in Belgium used a relatively simple layer-wound device precooled in liquid nitrogen at −196°C. Electrical energy involved was about 80kJ at 4kV from a capacitor bank.

The conductor, specially developed at Harwell Laboratory, consists of a rectangular pure copper core surrounded by a layer of stainless steel for strength. This 'wire', approximately 4mm^2, was insulated with polymide plastic, wound into a solenoid, vacuum impregnated with epoxy resin and given an outer binding of Kevlar.

So far, the solenoid has successfully withstood fairly punishing tests in which fields in excess of 50T have been regularly created. There has been no sign of either mechanical or electrical breakdown. The Clarendon group are confident that fields in excess of 60T should be achievable with minor modifications and still greater fields as and when more exotic conductors are employed.

Towards a plastic magnet

With the exception of a few exotic alloys based on metals like samarium, cobalt and neodymium, virtually all magnets contain iron. So much so that the term ferromagnetism was coined to describe the property exhibited by all strongly magnetic materials. Such materials owe their properties to the fact that the atoms have unpaired electrons that align their spins in areas called magnetic domains. When magnetized by an external field, these domains themselves line up to produce a net overall permanent magnetism. What is special about ferromagnetic materials is the unpaired electron of the iron atom. Most atoms and molecules have paired electrons with opposite spins which means that any magnetic moments cancel out, leaving only weak magnetic properties known as paramagnetism and diamagnetism.

In principle, there's no reason why it shouldn't be possible to create molecules that have odd numbers of electrons and which as a consequence exhibit ferromagnetism. In practice it's exceedingly difficult because of the chemical reactivity of molecules with unpaired electrons. Such radicals, as they're called, tend to combine with other radicals to even things out.

Recently, however, there have been a number of research reports indicating that organic polymers and crystalline salts can be made ferromagnetic, just as some of them can be made conductors of electricity. In fact the parallels are remarkably close, and just as some normally insulating materials become super-conducting at low temperatures, some normally non-magnetic materials become ferromagnetic.

One such material, synthesized in the USA, employs two different constituent molecules: decamethylferrocene and tetracyanoethylene. The first of these loses an electron to the second, resulting in ions with unpaired electrons that line up alternately to form a lattice structure. At temperatures below −268°C the electron spins fall into line, causing the crystal to behave like an iron magnet.

Other materials that hold out the promise of exhibiting ferromagnetic properties include a variety of polymers developed by research groups in Japan, the USA and the USSR.

One intriguing material made by reacting triaminobenzene with iodine is claimed to be

RESEARCH NOTES

ferromagnetic. The problem, as the researchers from IBM readily admit, is that the reaction is rather unpredictable and the resulting black material extremely unstable. Nevertheless as much as 2% can consist of a ferromagnetic polymer that maintains its properties up to almost 400°C.

Rather similar results have been achieved in the USSR and Japan by polymerizing an acetylene derivative. The Russians from the Institute of Chemical Physics and Mendeleev's Institute of Chemical Technology (*Nature* vol.326, no. 6111) in Moscow ended up with a material of which about 0.1% was ferromagnetic. The polymerization process is, however, claimed to be highly explosive!

Taken overall, these various attempts to create magnetic plastics seem a long way from any practical application. Nevertheless, a cogent theory is now emerging and it may be – as with superconductivity – just a matter of time before some dramatic breakthrough occurs.

Fastest photodiode

Workers at the GEC Hirst Research Centre and St Andrews University in Scotland have successfully fabricated an indium tin oxide/gallium arsenide photodiode with a –3dB bandwidth of 115GHz and an external quantum efficiency of greater than 25%. This, they claim, is not only the fastest device of its kind but also has the highest responsivity-bandwidth product ever recorded.

The diode employs a transparent indium tin oxide layer to form a Schottky barrier and is grown on a semi-insulating substrate to reduce cpacitance. This approach also makes the device such that it can readily be incorporated into a monolithic chip.

In their paper in *Electronics Letters* (vol.23, no. 10) the authors point out that at the highest frequencies of operation the packaging of the device is critical. The experimental diodes were fitted in a quartz microstrip submount with a millimetric transition into conventional waveguide. Testing was accomplished using a colliding pulse mode-locked dye laser with a pulse duration of less than 100 femtoseconds, that is more than ten times faster than the diode response.

Copper oxide valley?

The obscurity of that title is perhaps a measure of the speed at which developments are taking place in a subject that leaves even the editors of learned journals gasping for breath. That subject – superconductivity – has suddenly taken off in the way semiconductor physics did in the forties and early 1950s.

It began in earnest in April last year when two IBM physicists discovered that a compound of barium, lanthanum, copper and oxygen would superconduct, that is lose all its electrical resistance, at 30 degrees above absolute zero. That may sound no great achievement when superconductivity has been known for over 80 years. Until last year, however, the best superconductors were metal alloys that needed to be cooled to within about 8° of absolute zero.

The race has since hotted up in more ways than one with a profusion of new ceramics that become superconducting at liquid nitrogen temperatures, that is 77K and above. Paul Chu of the University of Houston and Maw-Kuen Wu of the University of Alabama of Houston jointly produced a compound only a few months ago that would superconduct at 98K. Here in Britain, Plessey has demonstrated superconductivity at around 88°K – the highest temperatures yet announced by a UK industrial laboratory. Plessey have now established a whole new research programme at Caswell.

The breakthrough in establishing superconductivity at practical engineering temperatures is obviously a great step forward towards commercial applications. So much so that the race is well and truly on to the ultimate goal of a room-temperature superconductor that requires no cryogenic equipment. Chemists around the world are scanning the periodic table, concocting thousands of new recipes in a desperate attempt to push the magic temperature ever higher.

All that, however, would have been largely academic but for another discovery announced on May 10th at the company where all the excitement began: IBM. Until then virtually all the known superconductors had one serious practical snag: they ceased to be superconducting above a critical current density. In the best available materials the self-generated magnetic field would destroy all superconducting properties above a current density of about $1000Acm^{-2}$. What IBM scientists have now done is to increase that limit by two orders of magnitude using a compound of yttrium, barium, copper and oxygen.

Further progress at the practical level is now dependent on the serendipitous discovery of new ceramics and also on better methods of fabrication. Many researchers believe that a lot will depend on new methods of growing pure crystals of some of these exotic materials. Meanwhile industrialists in Britain, the USA and Japan are struggling with practical ways of applying the new materials. Some US and UK companies have reported success in applying thin films and wires of superconducting material to a variety of substrates. (See, for example, July Update, page 762.)

According to Plessey the mechanical engineering industry could also be a major beneficiary from the development of high-temperature 'hard' superconductors. When used in conjunction with magnets, levitation can be achieved, opening up the prospect of friction-free bearings, for example. Small wonder the call has gone out in the USA for the creation of a "Copper Oxide Valley" to exploit the latest discoveries.

A flood of papers has appeared recently in *Nature* indicating the extent to which theory is chasing practice.

A team from the University of Birmingham for example, has shown that the electrons making up the current flowing around a superconducting ring move in pairs, not singly as they do in room-temperature metallic conductors. This narrows down to three the models postulated to explain superconductivity.

Another research group in Cardiff has been using electron microscopy and X-ray diffraction techniques to examine the molecular structure of some of the latest ceramic superconductors. These seem to indicate the existence of a multi-layered structure, which in turn suggests that the superconducting materials have different electrical properties in different directions.

An important clue to the origin of high temperature superconductivity has arisen from measurements at the British Rutherford-Appleton Laboratory by a team of physicists from the Universities of Warwick and Durham. By scattering neutrons from one of these ceramics based on lanthanum and barium, the team has been able to show that there are two energies at which the crystals most readily absorb energy from the neutron beam, presumably because vibrations of the atomic lattice at the energies concerned are coupled with exceptional efficiency to the movement of electrons throughout the system.

It is well understood that all superconductivity relies on some kind of coupling between lattice vibrations and electron motion. The importance of the new observations is that they suggest a direct way of studying the conditions favourable for ceramic superconductivity. Watch this space....

Note added in proof

Now, Indian physicists at the National Physical Laboratory in New Delhi claim to have made the first room-temperature superconductor. In an attempt to circumvent the delay of academic publication, they have released brief details of their achievement. A report (*Nature* vol. 327 no. 6121) describes a phase of yttrium barium strontium coper oxide that is said to become superconducting below +26°C. Further details are eagerly awaited.

Research Notes is written by John Wilson.

Image localization and interchannel phase difference

Using the wavefront reconstruction approach to predict image position in stereophonic systems

F.O. EDEKO

The use of phase delay in stereophonic systems as a means of conveying spatial impressions is not widespread. This is probably because subjective experiences have shown that a stereophonic image reproduced by a system having an interchannel phase delay is less well defined and difficult to localize than when interchannel intensity difference is involved[2-14].

The wavefront reconstruction theory in stereophony has been developed in a previous paper[1] and this contribution is intended to utilize these principles in providing a new explanation for image localization in stereophonic sound systems with interchannel phase difference.

WAVEFRONT RECONSTRUCTION

Consider the stereophonic system geometry in Fig. 1 for speakers having an interchannel phase delay of γ radians. The wavefront generated along the x-axis, H(x) is given as[1]

$$H(x) = \frac{L}{r_1}\exp(jk\,r_1 - \gamma) + \frac{R}{r_2}\exp(jk\,r_2) \quad (1)$$

where L,R are the amplitudes of the left and right channels respectively and $K = 2\pi/\lambda$ is the wave constant.

Neglecting the radial amplitude reduction in the divergent wavefronts and assuming speaker polar diagram variations are small over the region occupied by the head, we have

$$H(x) = L\exp(jk\,r_1 - \gamma) + R\exp(jk\,r_2) \quad (2)$$

For the listening geometry chosen and frequencies to be considered[1]

$$r_1 = S + \frac{x^2}{2s} + x\sin\theta_o \quad (3)$$

$$r_2 = S + \frac{x^2}{2s} - x\sin\theta_o \quad (4)$$

Substituting equations (3) and (4) into equation (2),

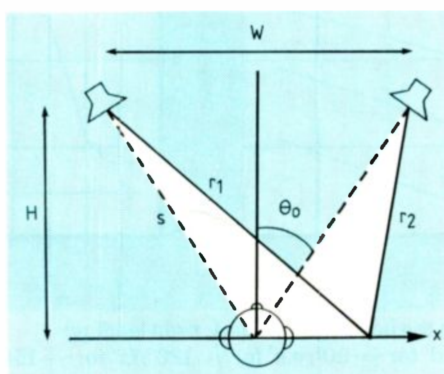

Fig.1. Stereophonic system geometry, where W=2.3m and H=2m.

$$H(x) = \exp\left[jk\left(S + \frac{x^2}{2R}\right)\right]\{L\exp(jk\,x\sin\theta_o - \gamma) + R\exp(-jk\,x\sin\theta_o)\}. \quad (5)$$

Neglecting the multiplicative term, as it carries no directional information,

$$H(x) = L\exp(jkx\sin\theta_o - \gamma) \times R\exp(-jkx\sin\theta_o) \quad (6)$$

Since the system is to provide directional cues by employing phase delay only, the channel amplitudes will be assumed equal, so that R=L, and hence

$$H(x) = L\exp(kx\sin\theta_o - \gamma) + L\exp(-jkx\sin\theta_o) \quad (7)$$

$$= 2L\exp(-j\,\gamma/2)[\cos(kx\sin\theta_o - \gamma/2)]. \quad (8)$$

If the delay $\gamma = 0$, then

$$H(x) = \cos(kx\sin\theta_o). \quad (9)$$

Equation (9) is maximum if $kx\sin\theta_o = 0$ and the wavefront is symmetrical about $x = 0$.

However if $\gamma \neq 0$, then the maximum shifts away from the point $x = 0$. For equation (8) to be maximum,

$$kx\sin\theta_o - \gamma/2 = 0. \quad (10)$$

Therefore

$$x = \frac{\gamma}{2}\cdot\frac{1}{K\sin\theta_o}$$

$$= \frac{\gamma}{2}\cdot\frac{\lambda}{2\pi\sin\theta_o} \quad (11)$$

From equation (11) it is evident that when an interchannel phase difference exists between the signals in the left and right channels, the reconstructed wavefront in the region of the listener is displaced towards the leading loudspeaker. Depending on the amount of displacement and the frequency, the head could be immersed in either a section of one complete interference pattern of the wavefront H(x) or in between two interference lobes.

Figure 2 shows the amplitude and phase of the wavefront reconstructed by the two loudspeakers in Fig. 1 along the x-axis over a range of 60cm for a 500Hz signal, when the right loudspeaker leads the left by 90° and 180°. Here, H = 200cm, W = 230cm and $\theta_o = 30°$. The wavefront for the zero delay is also shown. The computer simulations of these wavefronts are based on equation (1) and therefore do not include the later approximations. These graphs show that for a delay of 90°, the wavefront is displaced to the right by 17.15cm and for 180° by 34.3cm as equation (11) would suggest for a 500Hz signal. In the computer simulations the velocity of sound in dry air at 20°C was taken as 343 m/s.

Curves C, C′ are of particular interest as they show discontinuity in the phase characteristics of the wavefront and a zero of the interference pattern in the centre. This is expected when the two speakers are in anti-phase. Under such conditions the perception of a well defined image is highly unlikely, as the phase characteristics lack the continous nature normally associated with a localized source[1].

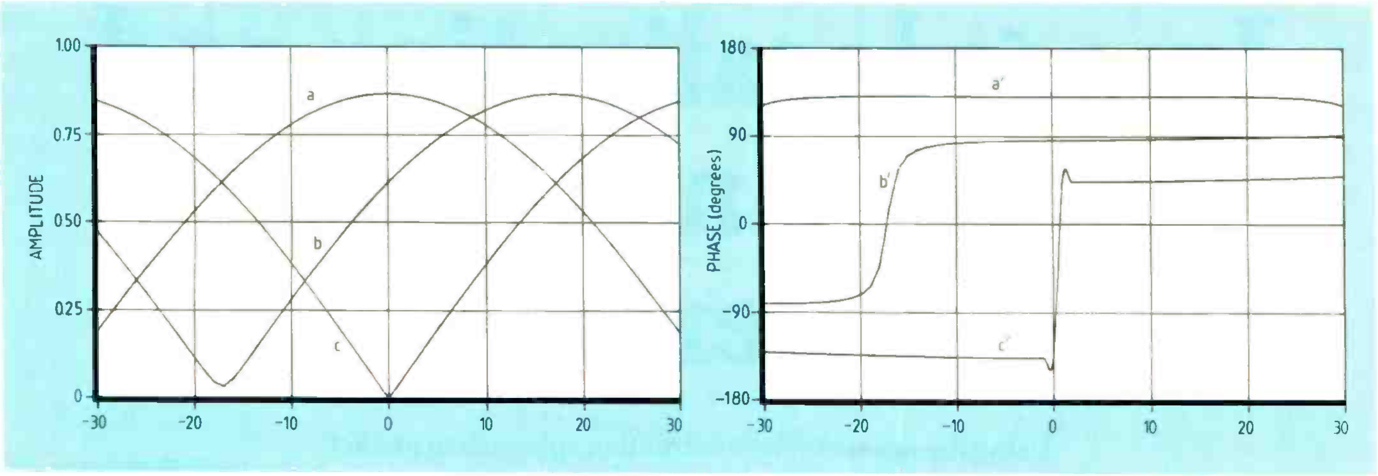

Fig.2. Wavefront reconstruction, with f=500Hz and R=L.
a,a' – amplitude and phase when γ = 0° b,b' – amplitude and phase when γ = 90° c,c' – amplitude and phase when γ = 180°

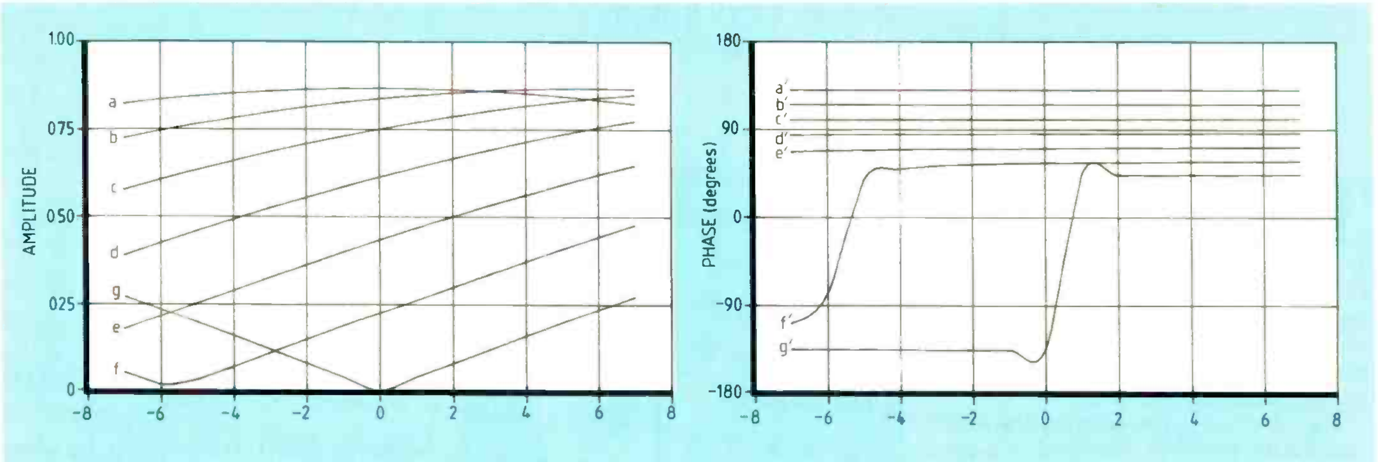

Fig.3. Amplitude and phase of wavefront across the head (500Hz, R=L, right leading)
a,a' for γ=0°; b,b' for γ=30°; c,c' for γ=60°; d,d' for γ=90°; e,e' for γ=120°; f,f' for γ=150°; g,g' for γ=180°

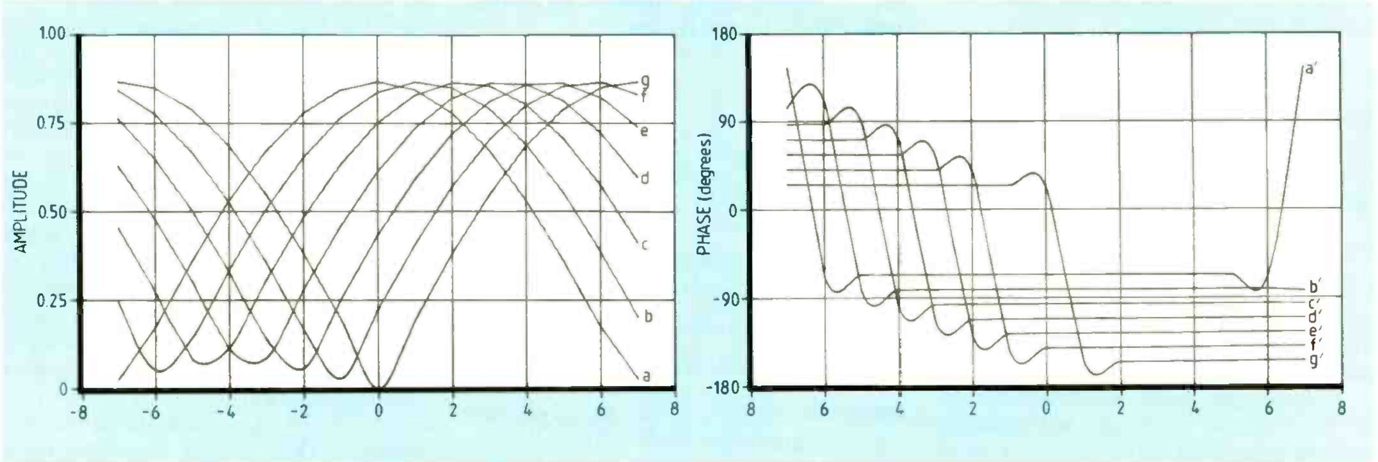

Fig.4. Image localization with interchannel phase delay

In attempting to develop a theory of image localization with interchannel phase difference it is important to examine the form of wavefront across the head.

IMAGE LOCALIZATION

The wavefront reconstruction theory developed in reference 1 proposed that the wavefront reconstructed by two loudspeakers in a region of space occupied by the head of a listener contains the fundamental directional information of the image. Initially it might appear that the phase $\psi(x)$ of wavefront H(x), equation (8), could provide the directional cue in a stereophonic system with interchannel phase delay.

However, analysis of equation (8) shows that the phase slope of H(x) is constant for low-frequency signals until γ is increased to a value where an interference null can be sensed by the listener. Therefore, even in the low-frequency range, where the theory of phase shift in signals suggest at least that the ear/brain combination can still follow the wavefront parameters,[1,14] the linear phase slope of H(x) contains no directional information when only an interchannel phase difference is present.

There is therefore only one remaining parameter of the wavefront H(x) that can provide directional information, and this is the amplitude. To obtain a correct assessment of the amplitude of H(x) and its variations with interchannel phase difference, it is necessary to generate H(x) over the region head. Figure 3 shows the graphs of computer simulations of the amplitude and phase of H(x) generated by the two loudspeakers in Fig. 1 along the x-axis over a region $-x_m \leq x \leq x_m$ occupied by the head for different interchannel phase delays and for a 500Hz signal. The software is based on equation (1) and the head width used is $2x_m$ = 14cm.

As expected, the phase slope of the wavefront across the head is zero for all the phase delays less than 150°, above which discontinuity in the phase characteristic of the wavefront occurs. The zero phase slope indicates that the apparent source is located at a distant point in front of the listener[1]. There is no indication of image displacement from the on-axis position from the phase characteristic of the wavefronts.

However, the amplitude of the wavefront across the head shows significant variations for a given phase delay. This, then, must provide directional information. Amplitude does not normally provide directional information in a propagation wavefront: this is a role normally associated with the phase. Therefore, the manner in which the ear/brain combination used amplitude variation across the head to deduce image direction appears to be based on the sound pressure levels directly present at the two ears. This means that the amplitude values of the wavefront at the points $-x_m$ and x_m are the cue to directional localization in stereophonic systems with interchannel phase difference.

Clark *et al* derived the following expression[15]

$$\sin\alpha = [(L-R)/(L+R)]\sin\theta_o \qquad (14)$$

where L and R are the average instantaneous pressures at both ears from the left and right loudspeakers respectively. In wavefront reconstruction, the question of crosstalk does not arise and therefore the values of L and R can be taken as the sound pressures at position $-x_m$ and x_m of the reconstructed wavefront H(x). Equation (14) can therefore be used to predict image location α for low frequency signals in a system with interchannel phase difference.

Equation (14) has been used in conjunction with computer predicted values of the amplitude of the wavefront H(x) at ear positions, $-x_m$ and x_m to determine image azimuth angle α for various interchannel phase differences for a 500Hz signal. The theoretical curve of image displacement with interchannel phase difference is shown in Fig. 4.

Several interesting effects are seen here. Firstly, no amount of interchannel phase difference can completely displace the image to either of its extreme positions. This is a major hindrance to the deliberate use of phase delay in stereophonic sound reproduction. Secondly, small interchannel phase differences result in no significant change in image positions at low frequencies.

The use of equation (14) indicates that when $\gamma = 180°$, image position is indeterminate. This true since L = R. The interpretation to this is also evident in the curves in Fig. 3. When $\gamma = 180°$, the head is in contact with two interference lobes of the reconstructed wavefront and the phase values of these lobes are actually displaced from each other by 180°. This implies that, the sound pressures at the two ears are in anti-phase. This is a most unnatural situation which has no counterpart in normal hearing experience and is generally understood to lead to a loss of localization.

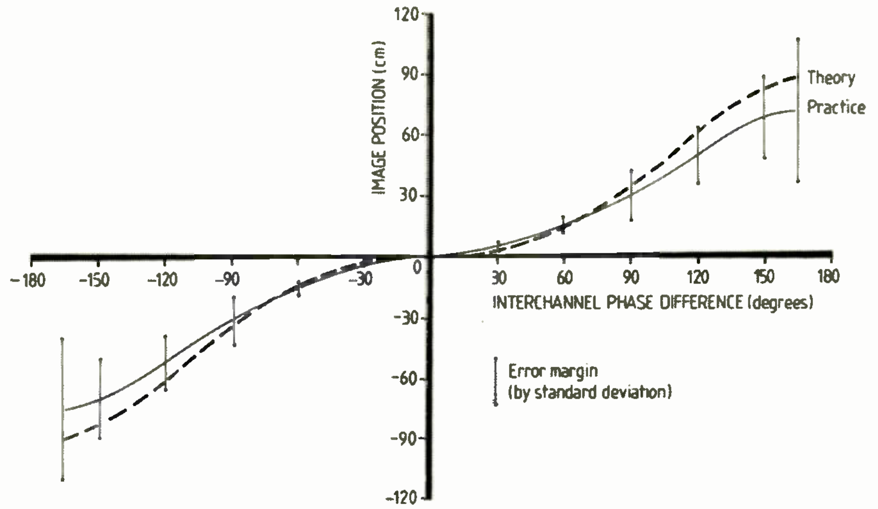

Fig.5. Amplitude and phase of wavefront across the head (2500Hz, R=L, right leading). The curves have the same meaning as in Fig.3.

At high frequencies, the wavefront H(x) shown in Fig. 5 for a 2500Hz signal, essentially also has a constant phase for $\gamma = 0$. However, increases in interchannel phase difference create a shift of the wave pattern towards the leading loudspeaker so that the head soon becomes immersed in more than one of the interferences lobes. Image localization in this situation is anticipated to be difficult as the circumstances are very similar to $\gamma > 150°$ in the 500Hz case. Therefore the introduction of elementary types of phase delay into a stereophonic system would appear to be unsuitable for high frequency information.

LISTENING TESTS

Practical tests have been carried out to determine image positions when interchannel phase difference is introduced into the two-loud speaker system in Fig. 1. The phase delays were introduced by using a stereo channel phase control system consisting of an SQ decoder circuit designed by EMI Research Laboratories. The tests were carried out in an anechoic chamber with a reverberation time of less than 0.25 seconds for all frequencies down to 125Hz. The signal used for all subjective tests was ⅓ octave pink noise with a central frequency of 500Hz produced by a random noise generator in conjunction with a bandpass filter set (Bruel and Kjaer Type 1402 and 1611). Each loudspeaker cabinet housed a single type 8P unit produced by Goodmans Loudspeakers Limited and ten listeners participated in the tests.

Each subject, occupying the median plane and looking directly towards the stage centre, (Fig. 1) was asked to give the position of the sound image as phase delay was gradually increasd from zero to 180°. The tests were repeated several times for each participant. The listeners were unaware of the delays introduced into the system during the tests. The mean of individual results is shown in Fig. 4 as the practical curve of image displacement with interchannel phase delay with the error margins for the given image position shown as vertical bars.

Comparison between theory and practice indicated that the use of equation (14) to predict image positions provides results that agree very well with practice for values of interchannel phase difference up to 90°. For phase delays above this value, the theoretical predictions begin to increasingly overestimate the image positions and the difference between theory and practice increases as phase delay approaches 180°. The 90° phase delay value also marks the stage when individual results tend to differ much more widely as shown by the error bars. It is interesting to note that during the practical tests many subjects reported image spread across the entire stage width and sometimes beyond it when interchannel phase difference exceeded 90°.

The increased divergence between theory and practice when $\gamma > 90°$ can be attributed to the increased uncertainty of localization as these images tend to be very wide.

When the two channels were 180° out of phase, most of the subjects could not localize the image and others reported an in-the-head image. This is what was anticipated from the theoretical analysis.

CONCLUSIONS

- The wavefront reconstruction theory provides a means of assessing the performance of stereophonic systems with interchannel phase differences.
- Image position variations with interchannel phase delay can be predicted using the stereo sine law at low frequencies. Provided the L and R in the expression are taken as signal values in left and right ear respectively for values of $\gamma \leq 90°$.
- No amount of interchannel phase delay can completely displace the image to either

the left or right speaker. This is a limitation in the use of phase delays in stereo systems as the stage width is greatly contracted.

- For the reproduction of a reasonably well defined image, interchannel phase delay should not exceed 90° and the use of phase delays should be limited to low-frequency signals. Phase delays greater than 90° would result in the reproduction of very broad images.

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F.O. Edeko obtained an M.Sc degree in Sound Electronics from Leningrad's Institute of Motion Picture Engineers in 1979 and in 1985 obtained a Ph.D degree from Sheffield University. He is currently a Lecturer with the University of Benin, Nigeria. His research interest involves the wavefront analysis of stereophonic systems – an area where he has many publications to his credit. He is an Associate Member of the Institution of Electrical Engineers.

Top brains' exodus

The brain drain is really about the loss of skills rather than numbers: senior researchers going abroad are not being replaced.

Britain's best brains are leaving the country because they are fed up with being mistreated, poorly paid and having their research grants cut year after year. This is the verdict of a report published this month by the Royal Society on the brain drain.

According to the report "the effects of current policies are likely to be seen in years to come as one of the most disastrous examples of this country's post-Victorian reluctance to invest in the future but rather to gobble up the present."

The Royal Society's report is the first quantitative study into the brain drain for many years. Questionnaires were sent to 750 heads of research departments in universities, government laboratories and industry. They were asked who had left or entered the UK between 1975 and 1985 and the reasons why they moved.

"The continued emigration of talented scientists and engineers from the UK is a matter for concern and undoubtedly represents a loss of research talent," said Sir David Smith, Secretary of the Royal Society.

The survey found that the number of scientists leaving the country to be relatively small, about 931. And this outflow was largely made up by the influx of 685 scientists from overseas. On the face of it seems hardly like a dire situation at all.

But the study reveals those leaving the country are more senior, more experienced and leaving long-term posts which will be difficult to fill. The scientists arriving from overseas are less experienced and 80% of them have taken short-term posts of less than three years after which they may leave and take knowledge earned here with them. According to the report we are seeing the emigration of "a few key staff which is having a debilitating effect of UK research."

Over 68% of respondents from universities said that it was difficult to find replacements for those that left. In electrical engineering departments the task was found to be even harder with 90% of respondents saying posts were difficult to fill.

Of those leaving industry to go overseas 19% were senior people of professor or reader rank. Of those coming from overseas to fill their shoes only 4% were of senior rank.

The report concentrates on five key research areas: electronics, physics, chemistry, biochemistry and earth sciences. Electronics is singled out as a particular area for concern. Over 70% of electronics engineers leaving Britain left senior long-term posts which will be difficult to fill.

"The problem in electronics is how to find people prepared to work in universities" said one of the respondents. "We used to rely on overseas Ph.Ds, but this supply is drying up as other countries offer more attractive prospects. The total number of British graduates is far too low to satisfy demand."

The vast majority of disgruntled electronics engineers, over 70%, go to the US and Canada. Their next most favourite haven is Western Europe, with 16% going there.

The main reason for all types of researchers both in industry and universities leaving the country is because they feel their careers in the UK are limited and believe that better opportunities are to be had abroad. The next most popular reason for leaving is a desire to widen experience, followed by rates of pay. University researchers put level of equipment and research facilities fourth on their list, just behind pay, whereas those in industry put research facilities sixth on their list.

The most worrying part of the report is the section on future trends. Already there are fewer young talented students choosing to carry on research in the UK than there were 25 years ago. Over half of the 314 most recent Ph.Ds chose to continue their careers overseas.

"In the present climate it is difficult to understand why any new Ph.D student should wish to enter scientific research in this country" comments one respondent "Scientists have low status relative to other professional groups and are relatively poorly paid in comparison to other professional groups."

Many replying to the questionnaires said the number of overseas offers being made to them were increasing. Physicists, electronics and computing people particularly were being seduced to the States with plum star wars contacts. Worse still they said that given the current climate of financial restraint in Britain they were more likely to accept such offers.

The Brain drain is about the loss of skills rather than numbers of people. Senior researchers leaving British industry (19%) are not being replaced by those coming from overseas.

Seniority of emigrants	from UK Number	from UK per cent	to UK Number	to UK per cent
Senior	22	19	1	4
Middle	40	35	12	43
Junior	45	39	6	21
Others	7	6	9	32

Senior: professors, readers, Middle: senior lecturers, Junior: lecturers, assistants, Others: research fellows.

Reasons for leaving	University Number	University per cent
Rates of pay	95	14
Status of science	33	5
Scientific vigour	44	6
Standard of living	41	6
Political climate	2	21
Facilities	92	13
Personal	30	4
Career opportunities	125	18
Carrer limitations	122	18
Working conditions	14	2
Widen experience	86	12
Others	7	1

CIRCUIT IDEAS

Double-sideband s.c. demodulator for 455kHz

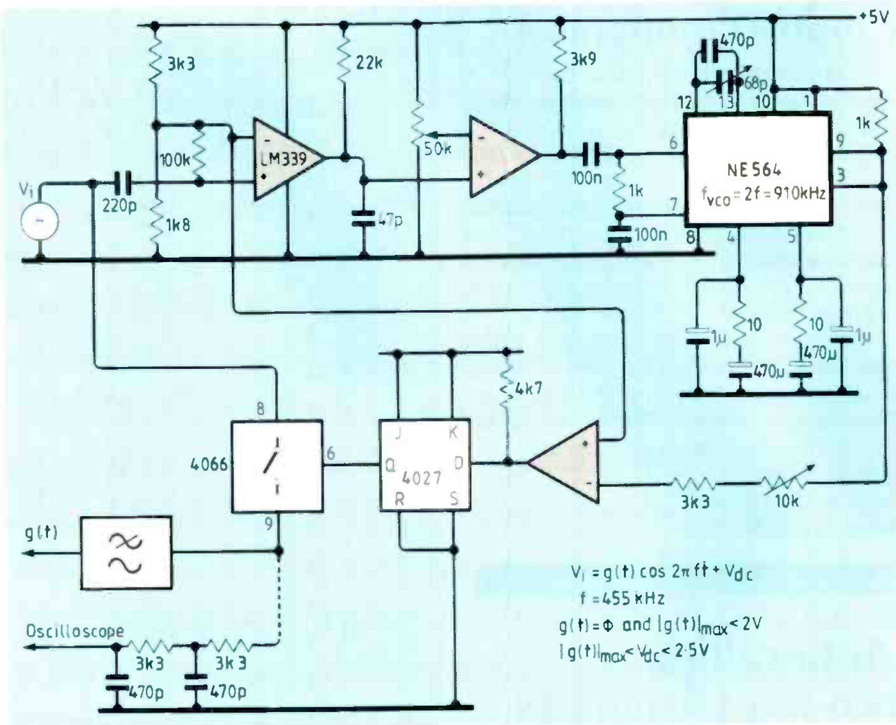
This suppressed-carrier double-sideband detector – an enhanced version of the p.l.l. detector shown on page 35 of the January issue – is suitable for an i.f. of 455kHz.

Two comparators at the input form the duty-shaper block. The first comparator acts as a high-gain half-wave rectifier. Resistor/capacitor loading on its open-collector output turns the signal into triangular pulses with a long rise time and short fall time. By varying the potentiometer at the second comparator input, squared pulses driving the p.l.l. can be adjusted for 25% duty cycle.

Free-running frequency of the v.c.o. must be 910kHz. From the data sheet, $f = 1/16RC$ where value $R = 100\Omega$ but my circuit used $R = 130\Omega$ which produces a C_{vco} of 680pF. Output of the v.c.o. is delayed and inverted by a third comparator, the potentiometer at its input being adjusted for maximum audio output.

As in the previous detector, the synchronized signal is taken from a JK bistable i.c. driving an analogue gate.

Kerim Fahme
Aleppo
Syria



Electromechanical d.c. Ah meter

An ampere-hour meter is useful for determining a battery's state of charge provided that battery age and temperature are taken into account. This meter is relatively inexpensive.

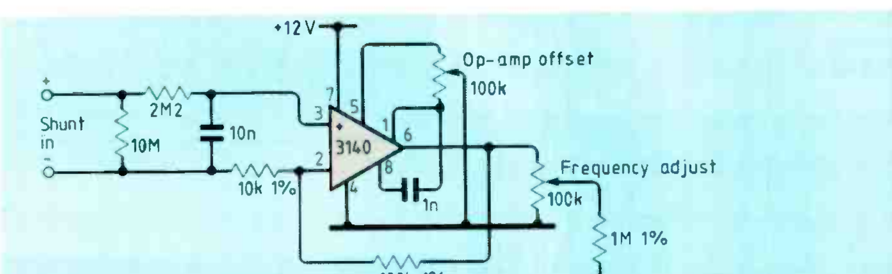
The shunt (not shown) is selected to drop 100mV at full-scale load current which with the values shown is 500A. Output of the ×10 amplifier feeds a voltage-to-frequency converter, divider and pulse stretcher.

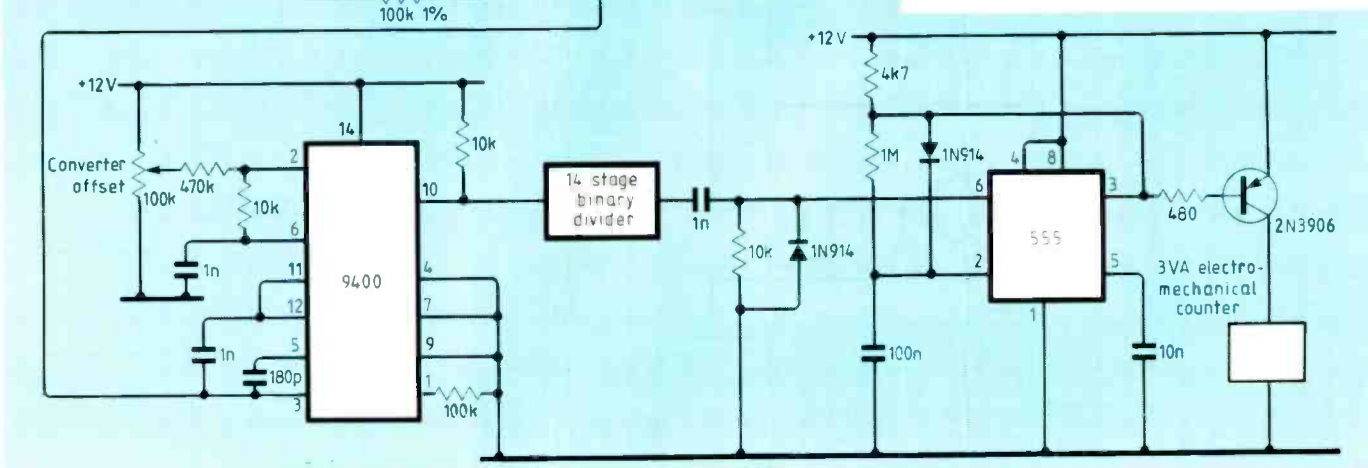
At 500A converter frequency is 2275.56Hz and frequency at the divider output is 0.1388Hz (i.e. 500/3600), which is slow enough for the electromechanical counter. Pulses are stretched to suit the counter using a simple timer i.c.

To calibrate the meter, connect the shunt input terminals together and adjust the op-amp offset potentiometer for 0V at the op-amp output, pin 6. Still with the input shorted, but with the frequency-adjust potentiometer set to maximum, set the converter offset potentiometer so that pin 10 of the v-to-f converter is 0Hz. Finally with 100mV on the shunt input set the frequency-adjust potentiometer so that frequency at output of the converter is 2275.56Hz.

I used an electromechanical counter because it inherently provides non-volatile memory but the circuit can easily be modified to suit other counters and full-scale readings: v.c.o. frequency must not exceed 10kHz.

Dennis Eichenberg
Parma Heights
Ohio





CIRCUIT IDEAS

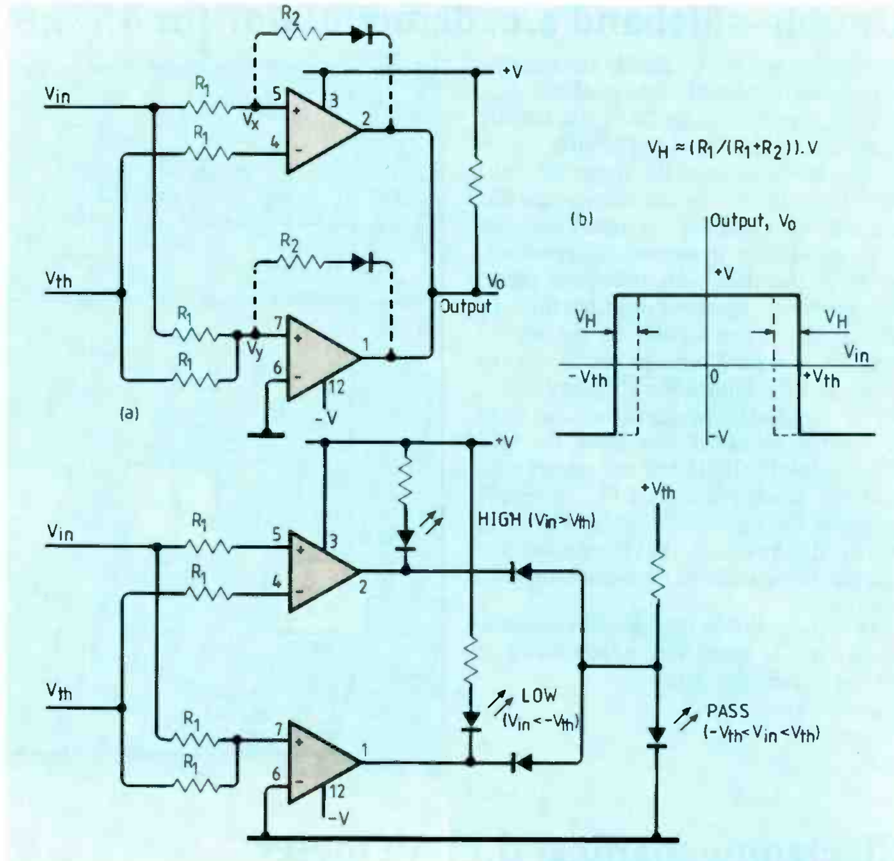
Single-reference window comparator

Two open-collector comparators from a quad i.c. form a window comparator needing only one reference voltage, which is particularly advantageous in variable-threshold applications.

When input voltage is within the window, outputs of both comparators are off and output is positive. Comparator output-sink capability is 16mA so leds or small relays can be driven directly.

Addition of feedback resistors and diodes shown dotted introduces hysteresis that can be varied without altering the trip level. Modifications shown in the second circuit provide high, low and pass indications.

S. Murugesan
ISRO Satellite Centre
Bangalore, India



Auto-calling two-way telephones

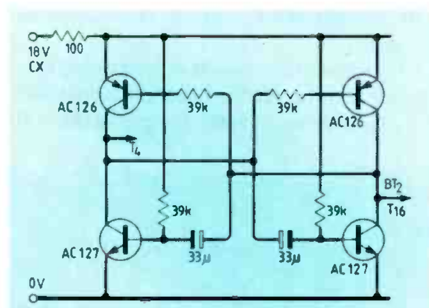
These circuits are for a simple automatic caller using two surplus BT706 telephones. One circuit is a simple d.c. driven oscillator providing d.c. ring signal for intercom-type applications.

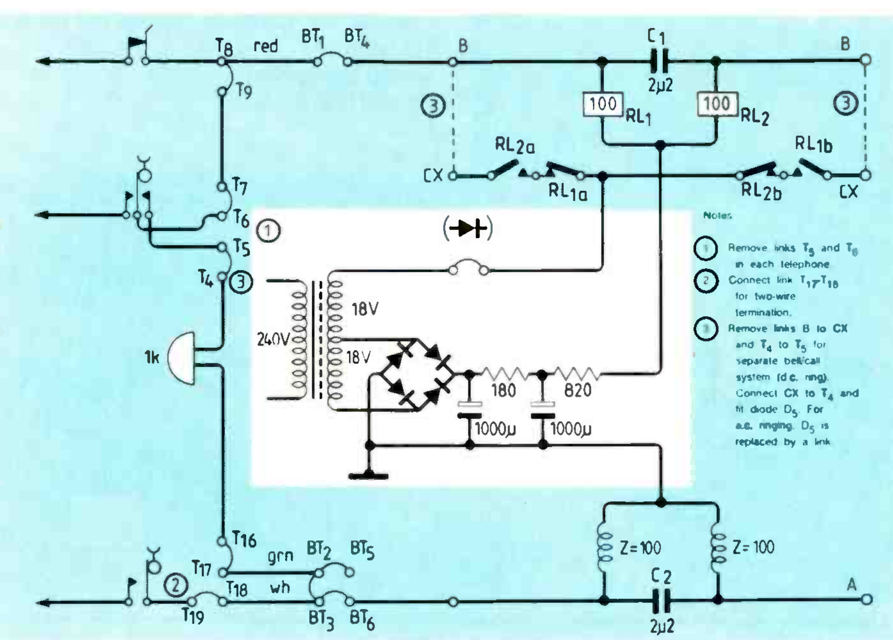
Switching for a simple two-way telephone system with automatic calling is shown in the second circuit. When the caller's handset is lifted, the other telephone rings.

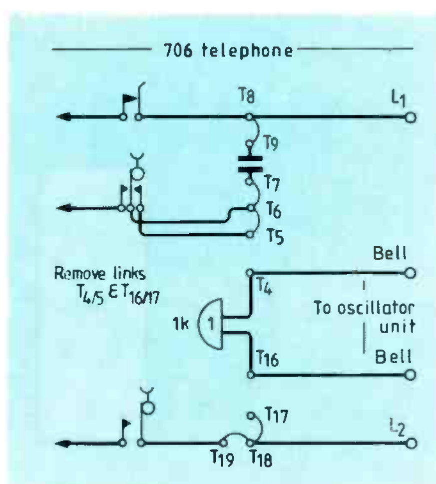
In the switching circuit, two relay coils and two impedances form a central battery-type telephone-transmission bridge. When the first station's handset is lifted, a loop is extended causing relay RL_1 to operate. Alternating ring current passes to the second station through contacts RL_{2b} and RL_{1b}, causing the second station's bell to ring.

When station two answers, relay RL_2 disconnects the station's a.c. ring current and contact RL_{2a} operates to prevent ring current from reaching station one. Capacitors $C_{1,2}$ link the two loops together, completing the audio path.

N. Cook-Abbott
Ipswich
Suffolk







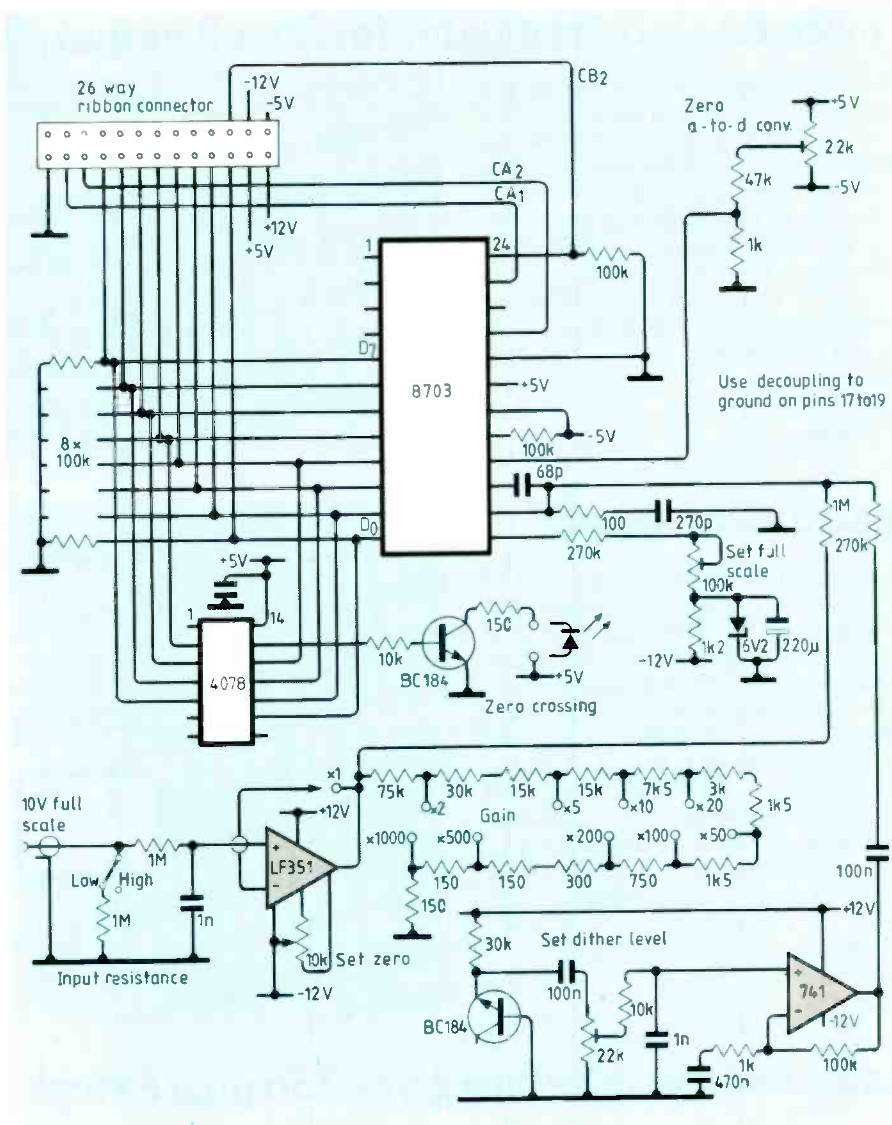
A-to-D converter using dither

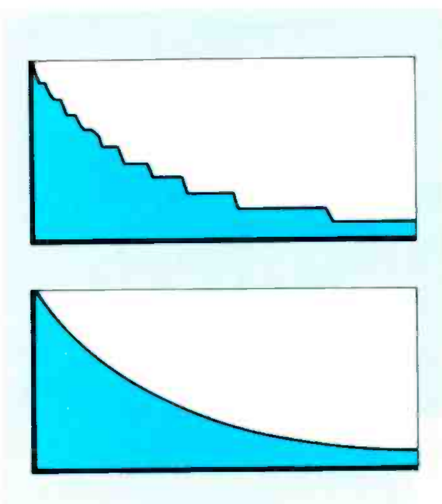
Adding dither, i.e. an impressed signal at around one l.s.b., to the input of an a-to-d converter allows resolution to be improved by averaging. This circuit was developed for an Apple II with 6821 interface chip.

Band-limited noise from a noisy zener diode – the reverse-biased e-b junction of a BC184 – provides the dither signal. Noise dither prevents possible aliasing with the sampling or signal frequencies.

Resolution of the 8703 converter is eight bits but as the graphs show, dither produces considerable improvements in resolution with slowly-varying signals.

G.P. Ormiston
Luton
Bedfordshire





Bridge amplifier with common driver

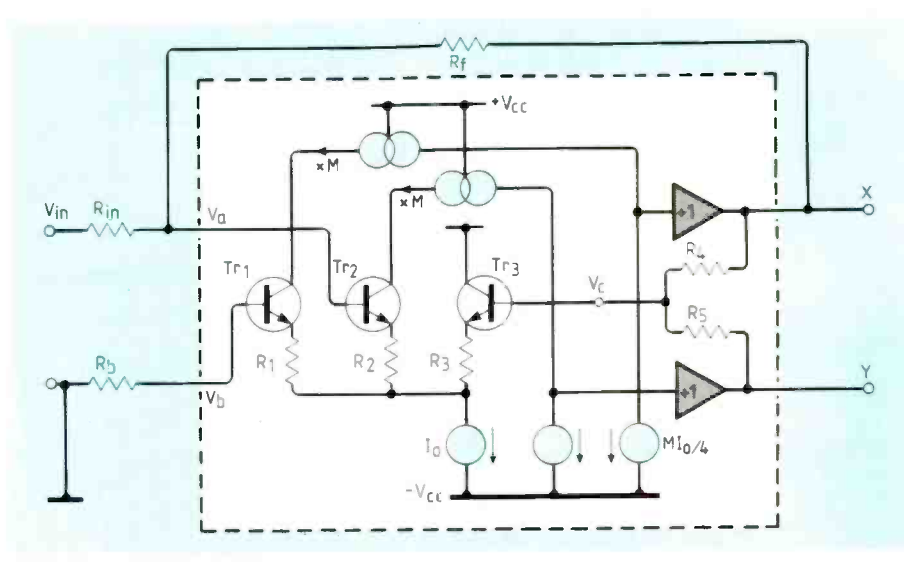
Replacing the differential pair commonly found in bridge circuits with an input triple of transistors reduces the number of components required.

Extra transistor Tr_3 provides common-mode feedback which, when $R_4=R_5$, keeps differential outputs X and Y symmetrical about ground. Emitter resistor ratios are chosen as $R_1=R_2=2R_3$ so that differential gain (times V_a-V_b) is equal to single-ended gain (times V_c).

Mirrors multiply collector currents by factor M and drive the active current-source loads as in a conventional amplifier (other current gain stages could replace the mirrors). Unity-gain voltage followers provide current gain. In the feedback network, R_f with $R_b=R_{in}||R_f$ gives voltage gain of approximately $2R_f/R_{in}$ when suitable compensation components (not shown) are used.

In some respects, this driver is similar to one described by Linsley Hood (80-100W mosfet audio amplifier *WW* July 1982, p65). In that design the current source of a standard-input differential pair was modulated by d.c. feedback from one of the differential outputs and overall negative feedback was taken from the other. My differential-triple configuration is simpler and, I believe, more elegant.

T.G. Thomas
Manchester



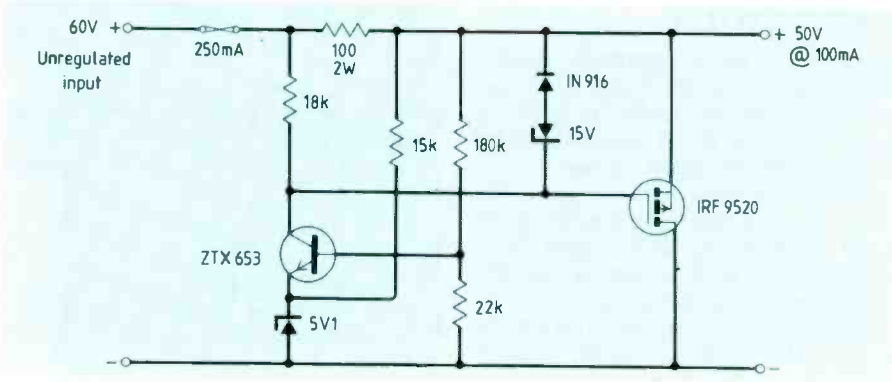
CIRCUIT IDEAS

Power-fet shunt regulator for 50volt output

Modern power fets, with their high g_m and input impedance, make simple but effective shunt regulators. Load regulation of this example for shunting up to 100mA at 50V is 0.1%; nominal d.c. input is 60V.

Since g_m of an IRF9520 is typically 0.9S only very small changes in the bipolar collector, and hence zener current, occur as the load is varied. Off load, 100mA fet current results in dissipation of around 5W so a heat sink is needed.

G.C. Loveday
Uckfield
East Sussex

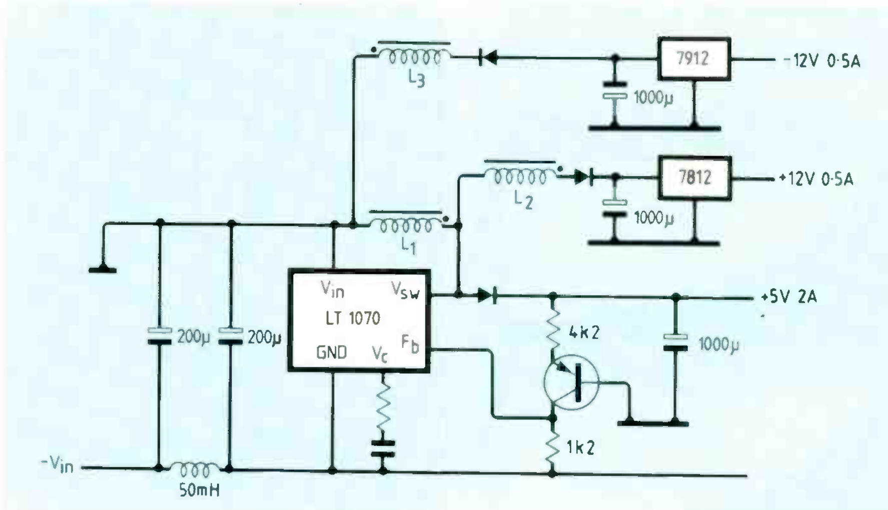


Instrument supply

Supply requirements of a portable instrument were ±12V at 500mA each and 5V at 2A but only a −48 to −52V telephony supply was available. An LT1070 in flyback mode with a 50W core and post regulators provides these supplies with excellent performance.

Windings should be bifilar; for the three output voltages above, L_1 has n turns, L_2 has 1.8n turns and L_3 has 2.8n turns. Any fixed or variable regulator can be used, provided that there is a 3V or more drop across it. Fast switching diodes and a V_{cb} of at least 60V for the p-n-p level-shifting transistor are needed.

G.R. Nimmo
Basingstoke
Hampshire



Mains control interface gives 256 phase steps

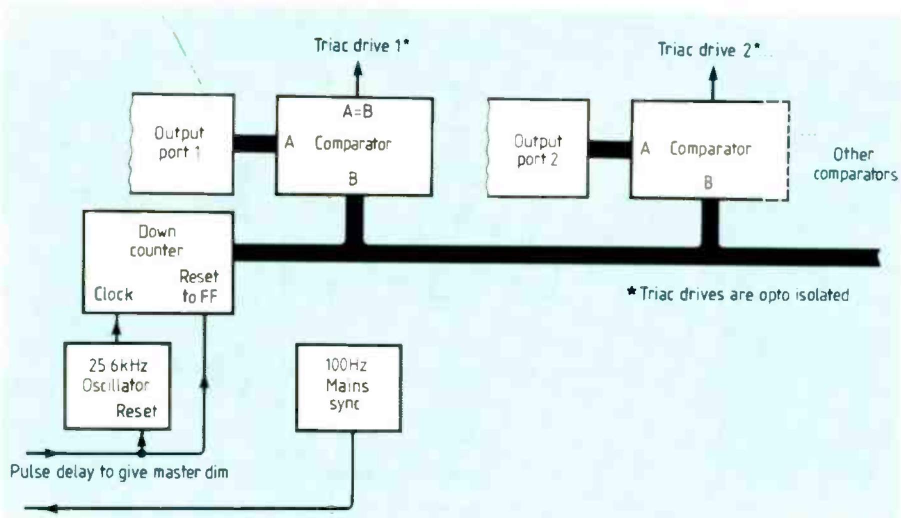
Under control of latched eight-bit microprocessor ports, counters and comparators produce 39μs pulses whose phase can be varied relative to the mains cycle. Having phase delay proportional to the binary value on the output port, these pulses are ideal for triac driving through opto-isolators in mains control applications.

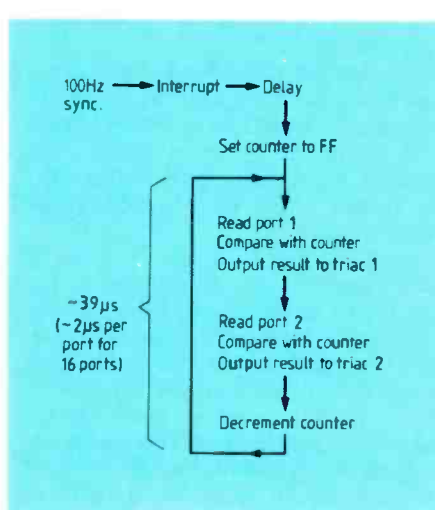
Mains half cycles are split into 256 steps by a down counter and a comparator for each triac compares the output port value with that of the counter. An FF output-port value fires the triac near the start of the mains half-cycle whereas zero leaves the triac off.

Delaying phase of the 100Hz mains signal either under computer control or using a monostable multivibrator, produces a master-dim function. If comparator A<B and A>B outputs are available they could provide a p.w.m. output.

Equivalent software flow suitable for a high-speed digital signal processor is shown.

Graham Hardy
Nottingham





Simple voice-control for the IBM PC

Taking advantage of a useful, undocumented one-bit i/o line to switch keyboard mode with simple 'stop' 'go' commands.

B.J. SOKOL

My word processor (New Word – which is just like Wordstar) requires extensive use of the control key in combination with other keys on the left hand side of the keyboard, which greatly slows typing. I cured this by writing a program to allow a footswitch to function as an additional control key. Later I replaced the switch with a simple voice recognizer that changes the keyboard action according to the last command spoken.

This simple circuitry allows four common i.cs to detect and remember the difference between two spoken words. Saying "stop" puts my word processing keyboard into the control mode, where it remains until I say "go" and resume normal alphabetic typing.

The switch-responding program has to be memory resident so that it can function in the background while the word processor is also running. As PC-DOS does not allow proper multi-tasking, my program uses the timer tick interrupt implemented by DOS on IBM PCs and compatibles. Eighteen times each second this hardware interrupt passes control to a routine which is pointed to by the vector stored at memory locations 00070-73. PC-DOS initially points this vector to an interrupt return instruction. My program changes the vector to point to code that scans a switch, reacts, and then returns control to the main program flow.

When it is first run my program must therefore change the interrupt vector to point to code in memory, and it must install this code in memory in a way that preserves it against overwriting after the program is terminated. PC-DOS provides functions to do these tasks, allowing the creation of t.s.rs, or 'terminate and stay resident' programs.

The program is called VOX.EXE. It is assembled from the source code shown in the listing, and should be executed before any other t.s.r. is installed (usually from an AUTOEXEC.BAT file). Some t.s.rs interact badly, but VOX seems to work happily together with the Turbo Lightning spelling checker t.s.r. which I normally use, and also with the popular t.s.r. Sidekick.

Once installed VOX responds to switch closure by changing the cursor shape as well as changing the key meanings, so that you can see which of the two possible states the keyboard is in. It also allows normal use of the control key; the program flow that achieves this is shown in Fig.1.

There is a way to connect a foot switch or voice switch to a p.c. (IBM or near-clone) without the need for any special hardware to plug into the i/o channel or backplane. This

This code reads a spare line on the printer port. In use, it is protected by DOS.

```
DATA     segment AT 0000

         org      408h      Word at 0000 0408 in absolute memory
PORT     label    word         stores printer LPT1  base address
         org      417h      Byte at 0000 0417 absolute
FLAG     label    byte         stores keyboard flag- bit 2 is cntrl
DATA     ends

CODE     segment
         assume cs CODE  ss STACK

          ..      Executable initialiring code

START      .     First change interrupt vector

         mov      AX 251Ch   .to prepare to change tick irpt
         mov      DX offset HANDLER
         push     DS
         push     CS
         pop      DS        so DS DX points to HANDLER
         int      21h       DOS fn call (change irpt)

          .      Then free memory allocated for copy of DOS environment

         pop      DS        .restore DS to point to Program Prefix
         mov      DI 00    .get into ES
         mov      ES [DI+2Ch]  segment address of unneeded  environment
         mov      AH 49h   .prepare to deallocate memory
         int      21h      .        do it

                 Finally TSR

         mov      AH.31h   prepare to terminate & stay resident
         mov      AL 03    dummy return code
         mov      DX 20h   .resident prog size in paragraphs
         int      21h             do it (TSR)

         ...  ..  ..Resident interrupt handling code

HANDLER
         push     AX        save registers
         push     DX
         push     DS
         push     CX

         mov      AX 0000  .to address PORT
         push     AX
         pop      DS

         mov      DX DS PORT
         add      DX 2          giving base + 2
         in       AL.DX         read hardware
         and      AL.02h        mask for bit 1 (pin 14 inverted)
         jnz      PRESSED       bit closed
         cmp      CS FOOT.1     now open -- so check last state
         jne      END       .    and either end since no change
         mov      CS FOOT.0            or if changed since last scan
         and      DS FLAG.0FBh.          use mask to turn off cntrl bit
         mov      CX.0B0Bh               and change cursor shape
         mov      AH.1
         int      10h                             using interrupt

END      pop      CX            restore registers and fini
         pop      DS
         pop      DX
         pop      AX
         iret

PRESSED  cmp      CS FOOT 0     now closed -- so check last state
         jne      END            either end since no change
         mov      CS FOOT 1            or if changed since last scan
         or       DS FLAG.04h            use mask to set cntrl bit
         mov      CX 000Eh               and change cursor shape
         mov      AH 01h
         int      10h                             using interrupt
         jmp      END

FOOT     db       0             stores last state of switch
CODE     ends

STACK    segment stack
         assume ss STACK
         dw       64 dup(")
STACK    ends

         end      START
```

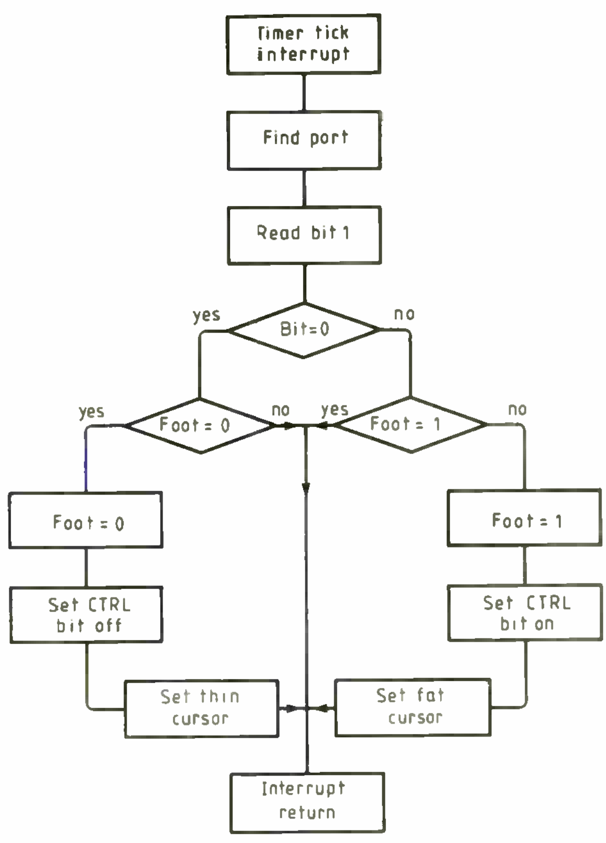


Fig.1. In this resident code flow, the flag Foot controls the function of the Ctrl key. Initially it is set to 0.

is because a spare line is available on the parallel printer port. It is only necessary to connect two wires to the p.c. end of a parallel printer cable, one to pin 14 of the DB25 conneector and the other to an earthed pin (any one, 18 to 25). Be warned, though, that some multifunction cards do not connect pin 14 at all, although IBM printer cards, and monochrome-video-plus-printer cards, do.

The data state at pin 14 of the DB25 appears in the PC in inverted form at bit 1 of the i/o port numbered two above the base address of the parallel printer interface. The base address can always be found at absolute memory location 00408 (for the first printer, LPT1: – any other printers follow at 40A, 40C, 40E). By the way, the bit in question can be written as well as read by i/o instructions, so this trick makes available an undocumented one-bit interface to any PC.

The speech recognition circuit can replace the open-circuit switch connected to pin 14. It distinguishes the words "stop" and "go" or "yes" and "no" to produce two logic states. These word pairs are differentiated by means of frequencies and the duration of speech energy. Sibilant sounds in "stop" or "yes" or "system" produce energy in the high frequency portion of the spectrum. The problem is that this energy is noise diffused across a wide band and has a very low amplitude compared with the average amplitude of speech. Moreover the transient portion of vowel sounds, and some vowels' higher overtones (especially the higher so-called formants of the sound "ee" when pronounced by women or children), put considerable energy into the sibilant region.

The problem is worse if we require the circuit to work with cheap electret microphones that lose part of the high end of the spectrum and also have no noise-cancelling capabilities to eliminate background transients. Nevertheless a reliable circuit using such microphones is possible (Fig.2).

Sibilant energy is first emphasized by a multi-pole high-pass filter cutting off below 5.5kHz. The output of the filter is passed to a level detector and digitizer, and then to a frequency counter. The count is assessed over 10ms to eliminate the effect of brief transients passing through the filter.

The counter is realized very simply because only a logic output indicating an input stream at greater than some frequency is required; the high-order bit of the count is used to indicate whether a sufficient count has been reached. This bit actuates a retriggerable pulse stretcher and so any overrun of the count (by more than a factor of two) that would reset the high bit is ignored, eliminating the need for an input inhibit at maximum count; and the effect of vowel energy following sibilant detection is locked out for a certain period after the sibilance subsides.

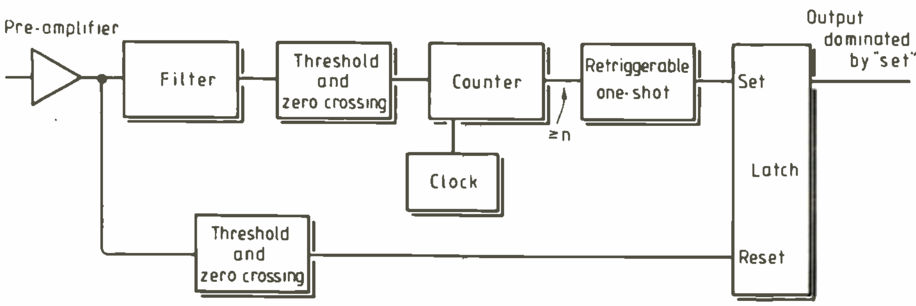


Fig.2. Essentially the function of the circuit is to differentiate between words containing sibliants and those without.

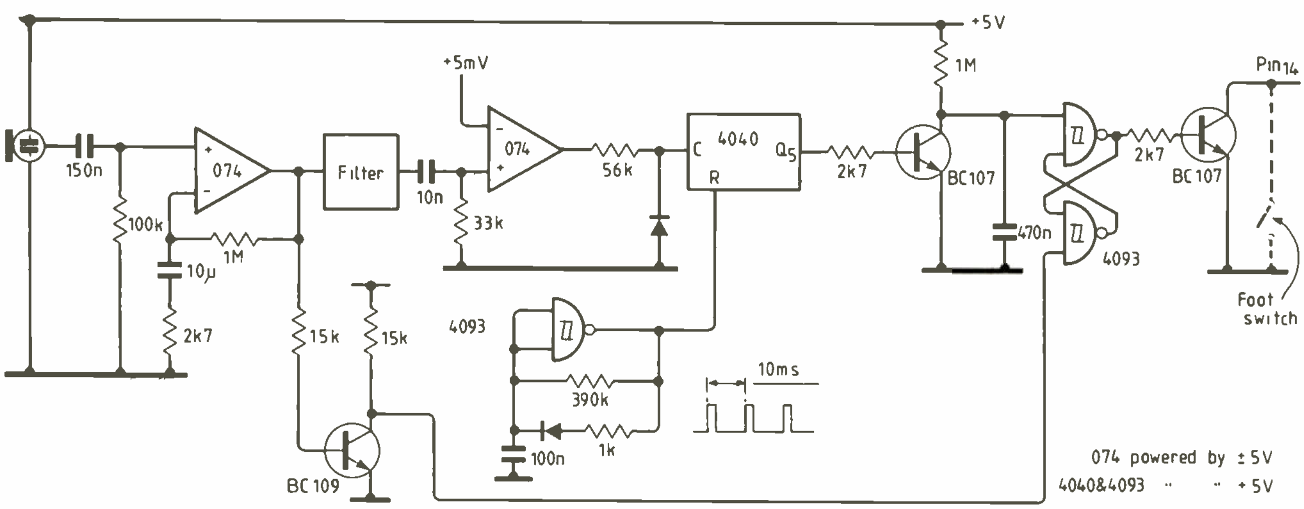


Fig.3. In this speech detector the one-bit output duplicates the action of the Control key; it could equally well duplicate the Shift or Alt Keys.

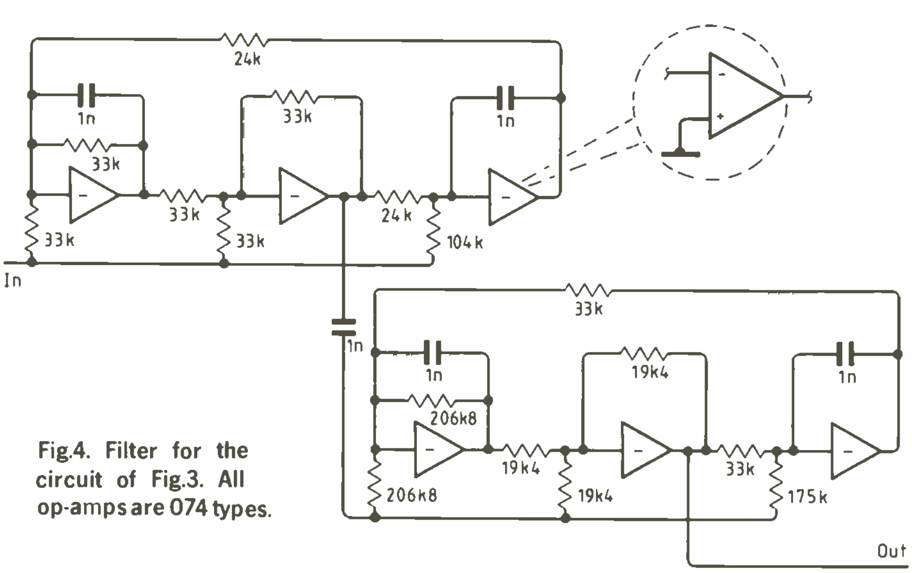


Fig.4. Filter for the circuit of Fig.3. All op-amps are 074 types.

The second action is achieved because the monostable drives a set-reset flip-flop arranged to favour the sibilant state: if a vowel and a sibilant are detected simultaneously, the sibilant wins.

Circuitry is minimal (Fig.3). The vowel detector uses the base junction of a transistor as a level detector. The output of this odd detector is properly digitized thanks to the Schmitt trigger action of the 4093 inputs, and the cross-coupled set-reset latch ignores the irregular stream of pulses produced by it.

Another transistor, a resistor and capacitor, plus another section of the 4093 very simply produce the required retriggerable monostable action. Finally, an elementary level shifter composed of a diode and resistor plus the Schmitt action at the input of the 4040 counter eases the design of the sibilant energy digitizer.

Jerry Sokol started a design consultancy in the U.S. in the early 1960s. He also lectures in English renaissance literature at Goldsmiths' College, London University.

All about curls and divs

A gentle introduction for those who missed out on vector field theory as undergraduates, which should help dispel the mystery surrounding vector field equations.

'JOULES WATT'

In an earlier discussion[1] I covered a little of James Clerk Maxwell's remarkable work on electric and magnetic fields and how he related his model to the propagation of light. After reading it, a student friend soon took me to task and said that although he had learned that James himself had conjured up the terms *curl* and convergence (nowadays oppositely directed as *divergence*), he still couldn't see the wood for the trees. "You see", he went on, "I'm none the wiser about what the curl and div – to say nothing of *grad* – really mean" In answer I said, "It is all to do with vector and scalar fields; they are the basis." "Oh no!" he replied, "we had a ghastly maths course about them. That course is still a poor one, you know." I knew this observation could be very true, as maths teaching is now somewhat grim in our educational system. Nobody seems to care enough about it.

But what of curl and so on? You do need some knowledge of differential and integral calculus, but most O-level syllabuses contain a little about these topics now, so it isn't too frightening. The only little bit extra you need is a nodding aquaintance with partial differential coefficients[2].

SCALARS AND VECTORS

Nearly everyone knows the difference between a *scalar* quantity and a directed number, or *vector*. You would get some raised eyebrows if in the grocers someone asked for, "A pound of tomatoes, due North please." Or if elsewhere you heard, "I drove my car at 60 mile/h – quite exhilarating." To which a comment was, "Where to?" and you heard the reply, "Oh, anywhere, I just close my eyes and go – it's just the speed that matters!"

Imagine we have entered a region of space; a room, a pond or river, a box in a laboratory – anywhere, to make measurements on some quantity permeating the region. Typically, your measurements might apply to a draught in a room, or the temperature distribution, or the water-flow pattern in the river, or again, the electromagnetic radiation in the box. We call any such region a *field*. It might be small, like the box, bounded by walls of some sort. It could be vast with undefined boundaries, or "go off to infinity" as a mathematician might say.

As an example, consider measuring the temperature in the room. Point by point we record the thermometer reading. Figure 1 shows what might be happening. Eventually the data would apply to the whole volume. We don't say at some position that it is "22°C East of North," or any such thing. The temperature is a *scalar* quality and the whole distribution of our measuring points throughout the volume is the appropriate *scalar field* for this measurement.

The points are distanced apart and we interpolate in between, so that we imagine the field smoothly varying around the region. In fact, the same conditions of 'continuity' and 'differentiability' that interest mathematicians regarding other functions apply here also.

Light a candle. With it we can now investigate the cold draught cutting across our feet. The candle flame bends over pointing to where the draught is going. We judge how strong the draught is by noting the guttering of the flame. So as we crawl about the room, we end up with some idea of how strong the draughts are and the directions in which they are blowing. Plotting all this out, point by point yields the *vector field* of the draught distribution, as Fig.2 shows.

You can think of this type of field as a room full of lines, some crammed together indicating high intensity regions, others widely spaced in the weaker regions. They all stream along in the various directions of 'flow' that meander from point to point. These imaginary lines are the *stream lines* of flux in such dynamic vector fields as fluid flow systems. Victorian river and estuary explorers had a fine old time plotting sources and flows. Modern wind-tunnel technologists engage in the same practices.

James Clerk Maxwell appreciated Michael Faraday's genius in visualizing the 'field lines' in the regions around electrically

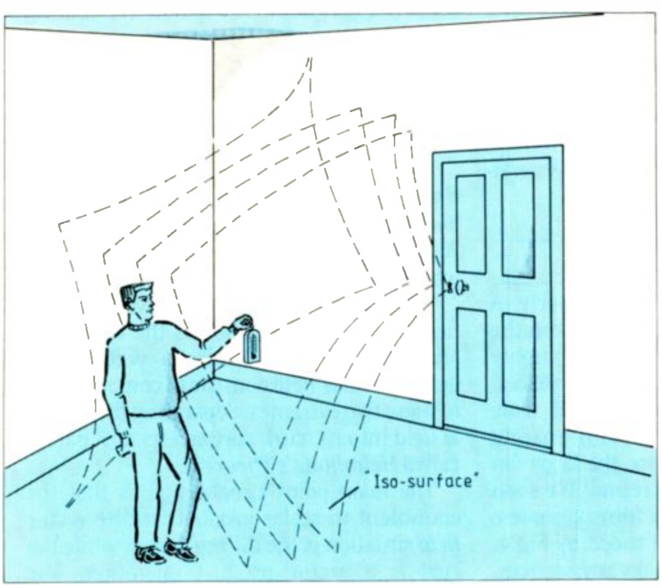


Fig.1. ...invisible surfaces all over your room.

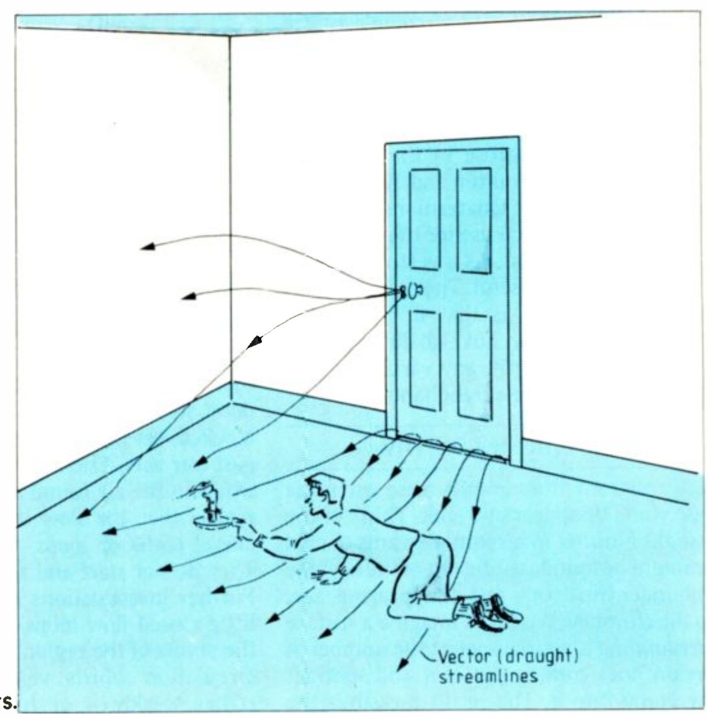


Fig.2. ...crawling about with a vector field roaring about your ears.

charged bodies and around magnets. And as I discussed earlier[1], the whole edifice of the hydrodynamicists with their 'sources and sinks', 'fluxes', 'pressure gradients' (or 'forces'), 'stream functions' and so on, arrived on the electromagnetic field scene with very few changes in terminology. We still have sources and sinks, and fluxes – although no actual flows of electric or magnetic field occur. The one real "flux" situation in our subject is the vector field of conduction current flow.

GRADIENT

If we return to measure the (scalar) temperature distribution all over our imaginary room, we soon discover sets of points at which the thermometer reads the same temperature. We find these points lie on a 'surface' which we might therefore call an *isothermal surface*, which Fig.1 also shows. The iso-surfaces cannot intersect anywhere, or we would have the impossible situation of two different 'constant' values at the same point.

These constant surfaces characterize scalar fields. Another observation soon shows that the temperature changes most rapidly when we move off the isotherm at right angles to it. We could quickly plot all the 'streamlines' of greatest rate of change of temperature, and find they all cross the iso-surfaces at right angles. A vector field results from all this plotting. We have found the *gradient* of the scalar field. We write it as

$$\text{grad}\varphi = \mathbf{A}$$

Alternatively as

$$\nabla\varphi = \mathbf{A}.$$

Here φ is the scalar field *point function*. In other words, it is the magnitude of the field qualtity measured point by point. **A** is the derived vector field distribution point by point. As you now see, we visualize **A** as imaginary stream lines pervading the entire region where the gradient of the scalar field exists. Remember, they arise from the directions of the greatest rate of change in the scalar field.

∇ is the Hamiltonian operator, which has had a chequered history in all the names that people have proposed for it. 'Nabla' was one, another is 'del'. It arose in the theory of quaternions that Hamilton and Tait were so keen on last century. Quaternions have died out because not much use for them arose in applied mathematics[3]. As a vector operator ∇ has proved very useful. The main thing to remember about it is that it has all the properties of a vector, but also differentiates with respect to length, any variables upon which it operates on its right hand side.

VECTOR FIELDS: DIV

Vector stream lines might arise on some source and disappear at a sink. Think of the draught blowing in a room. Streams of cold air might be found issuing out of the keyhole and under the door – and disappearing, say, up the chimney. We could imagine a surface surrounding a 'source', count the number of stream lines coming out of it and subtract any going into it. The result measures the

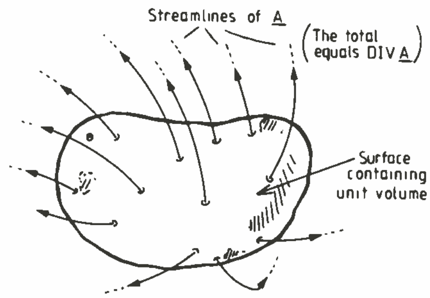


Fig.3. The excess of vector field lines issuing out of unit volume at a point in a field over those going in, is the measure of divergence.

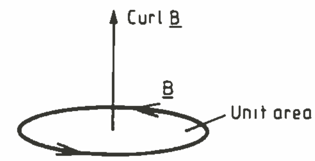


Fig.5. The measure (per unit area) of the circulation of the field lines at a point is the curl of the vector.

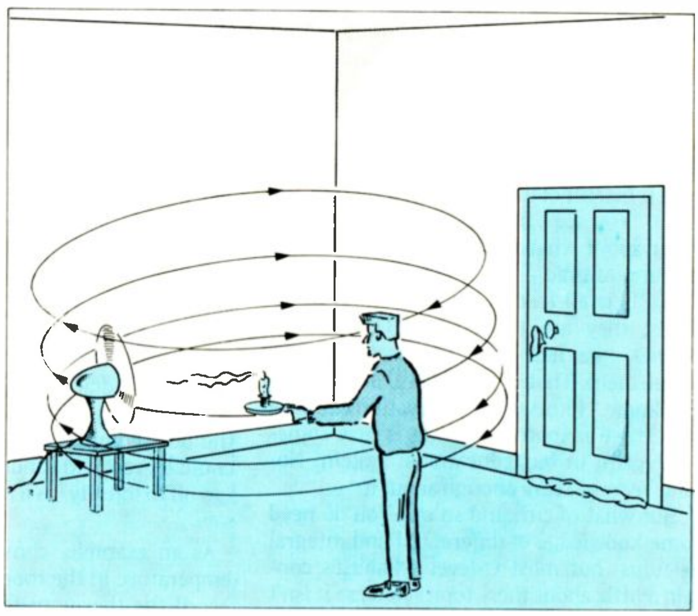


Fig.4. Completely closed stream lines still means a vector field – but one in which there are no sources or sinks.

strength of the source of the vector. The generating source 'material' is a scalar. It might be concentrated at definite locations or distributed around the region as a scalar field. Measuring the vector field lines generated in this way coming from unit volume at any point is called finding the *divergence* of the vector field, and it is written

$$\text{div}\mathbf{D} = \rho \text{ or } \nabla.\mathbf{D} = \rho$$

where **D** is the vector and ρ is the source scalar quantity. ∇ is the differential vector operator again. ∇.**D** measures how rapidly **D** is appearing per unit volume at a point, in other words how concentrated the generating source quantity is there.

VECTOR FIELDS: CURL

Vectors can possess a different property. A second vector field can be derived from the first one. Imagine we are in the draughty room again. All the keyholes, fireplaces, door surrounds might be well and truly blocked, yet here is a huge draught roaring past our ears. Then we notice the large fan whirling the air round and round. We soon realise that the flow lines form complete closed paths or loops, like those in Fig.4. They do not start and stop on any sources. Further investigations show that there are little closed flow loops distributed all over the points of the region. At some points the circulation whirls vigorously, at others rather weakly – or hardly at all. These vortices rotate in planes whose orientations vary from point to point.

We can draw an imaginary line through every little plane loop according to the strength of the vortex per unit area at each location. The lines point away at right angles to the circulation planes in such directions that the rotations go round them in the sense of a corkscrew, as Fig.5 shows. Joining all these new lines point by point gives another vector field. This is the *curl* of the first one. It measures the vorticity per unit area:

$$\text{curl}\mathbf{B}=\mathbf{A} \text{ or } \nabla\times\mathbf{B}=\mathbf{A}.$$

You might notice the significant result about the curl airising from this discussion. **A** and **B** are always at right angles everywhere.

The divergence operation gives a scalar field from a vector, whereas the curl gives another vector field from a vector. The general vector field consists of combinations of these two extremes. Separating the general field into its 'curl' part and its 'div' part is called *Helmholtz's Theorem*.

The main point I make now is that the equivalent to scalar products in the vector *field* situation is the div operation, while the curl is a vector product operation. The meanings of div and curl might now appear a little less daunting.

You might have already noticed that as curl fields start and end on themselves, you can never have a divergence of such a field.

Fig.6. Work done by the component of a force shows a typical example of the scalar product of two vectors.

We can write this as

$$\text{div curl}\mathbf{A} \equiv 0.$$

Again, div fields, and grad of scalar fields never have lines that loop round and end on themselves. This mean that

$$\text{curl div}\mathbf{D} \equiv 0$$

or

$$\text{curl grad}\varphi \equiv 0$$

always.

VECTOR DIFFERENTIAL OPERATOR

The vector differential operator ∇, is admittedly hard to visualize. It obeys the vector rules for products etc., but also it is as we have seen, a differential operator and works on variable and functions 'to the right'. In other words, $\nabla.\mathbf{A}$ is not the same as $\mathbf{A}.\nabla$, where in the second expression ∇ is looking for something to operate on to the right of it. ∇ might be asked to operate on (that is, differentiate) a product – such as $\nabla.(\mathbf{A}\times\mathbf{B})$ or $\nabla\times(\mathbf{A}\times\mathbf{B})$. The rule for differentiating a product has to be obeyed *and* the rules for scalar and vector product expansion at the same time. For example[4]

$$\text{curl curl}\mathbf{A} = \text{grad div}\mathbf{A} - \nabla^2\mathbf{A}$$

where ∇^2 is a second-order or double differentiation. Or again

$$\text{div}(\mathbf{E}\times\mathbf{H}) = \mathbf{H}.\text{curl}\mathbf{E} - \mathbf{E}.\text{curl}\mathbf{H}.$$

Both these expansions give valuable and concise results and descriptions in the mathematical modelling of the electric and magnetic vector field distributions that occur in e.m. theory.

CONCISE NOTATION

The value of vector notation lies in its conciseness. A number of results, like the above two, give a succinct view of what is going on. Nevertheless, we usually return to old René Descartes 'scaffolding' – the x, y and z axes, when doing real life problems. This applies especially to engineering situations with rectangular symmetry, for example rectangular waveguides. If the waveguide is a circular one, the coordinates might be the cylindrical set r, θ, z. If an aerial is radiating into a sphere, we might choose the spherical coordinates r, θ, φ.

All of these coordinate systems have axes which are at right angles to each other at any

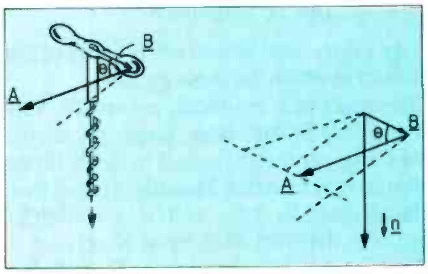


Fig.7. The turning force at the end of an arm – like that on the corkscrew shown, constitutes an example of the vector product.

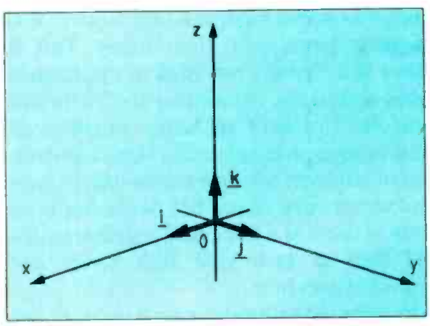


Fig.8. The cartesian axes form the most common 'scaffolding' upon which we erect the dimensions and boundaries of real technical and engineering problems. When we want to show the vector properties in particular, the unit vectors i, j and k are used to point the way.

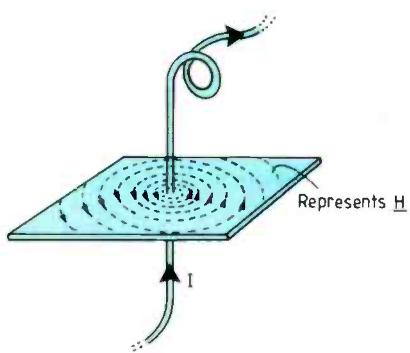


Fig.9. Although the iron filings in this famous old experiment are not curlH, nevertheless they lie along the lines of circulation of the magnetic field. Then if you imagine the amount of this circulation per unit area in the region, then you have the idea of curlH there.

Vectors

Running away into the above discussion, I have put the cart before the horse, at least by assuming everybody knows about ordinary vectors and how to multiply them. Quite a number of people probably don't.

Adding two vectors is simple. We use the 'parallelogram' or 'triangle' rule that most people no doubt did learn. Products of vectors give rise to a little more thought. The results all depend on how we define the multiplication and this can be done in a number of ways. Over the years, it has all boiled down to two different products – one producing a scalar result, the other giving a new vector. These products have survived, indeed have developed into 'standards' because they fit well into how physics, engineering etc. describes things.

The first kind, Fig.6, known as the *scalar product* – or 'dot' product as some people call it, is simply

$$A.B = AB\cos\theta$$

where A and B are the two vectors with magnitudes A and B and an angle θ between them. This mens that if the vectors are at right angles there is no product, because cos90° is zero. Of course, this product is the multiplication of one magnitude by the magnitude of the *resolved component* of the other vector along the direction of the first. For example, also in Fig.6, it gives the work done by a force (A, say) moving along B, (The direction of A in general being at angle θ to B). However, the greatest value of A.B occurs when the vectors are parallel.

The other product, illustrated in Fig.7, we call the *vector* or 'cross' product. It is

$$A\times B = NAB\sin\theta$$

Now you see that the resolution takes the other component, the 'sine' one and the result is greatest for normal, or 'orthogonal' vectors this time. N is the *direction vector* or *unit vector* such that if A is turned towards B, N goes in the direction of an ordinary corkscrew.

If we consider B×A instead, then N points the other way. This means A×B is *not* equal to B×A. In other words, A and B do not commute in the cross product. Often this is the first time students come across a non-commutative algebra, (and some of them come to grief at first). In fact,

$$A\times B = -B\times A$$

At this stage in proceedings, if you look into a book dealing with vectors[4], you can have an entertaining time working out some of the multiple products like

$$A\times(B\times C)$$

or

$$A.(B\times C)$$

Nobody has give a meaning to *division* by a vector, so you won't come across that operation. This means that the denominator of differentiations always contain scalars, or scalar components of a vector, and so on.

It is normal practice to typecast vectors in bold face or, as an alternative to underline the characters, as in our drawings. Here they are in light face as the text is in bold.

point in space: in other words they form orthogonal sets. Admittedly, as Fig.8 might remind you, the rectangular set x, y, z is the simplest.

If we put the properties of scalar and vector fields into cartesian coordinates, we get the three sets of equations that describe the three components of each field.

$$\nabla \text{ is equivalent to } \mathbf{i}\frac{\partial}{\partial x}+\mathbf{j}\frac{\partial}{\partial y}+\mathbf{k}\frac{\partial}{\partial z}$$

in cartesians. This shows the three components explicitly. **i**, **j** and **k** are the unit vectors along the x, y, and z axes.

Therefore gradφ, which is $\nabla\varphi$, has the three components

$$\mathbf{i}\frac{\partial\phi}{\partial x}+\mathbf{j}\frac{\partial\phi}{\partial y}+\mathbf{k}\frac{\partial\phi}{\partial z}$$

in cartesians and is a vector.

div**A**, also written $\nabla.\mathbf{A}$, is

$$\left(\mathbf{i}\frac{\partial}{\partial x}+\mathbf{j}\frac{\partial}{\partial y}+\mathbf{k}\frac{\partial}{\partial z}\right).(\mathbf{i}A_x+\mathbf{j}A_y+\mathbf{k}A_z)$$

which, when we notice **i.i**=1 and **i.j**=0 etc., is

$$\frac{\partial Ax}{\partial x}+\frac{\partial Ay}{\partial y}+\frac{\partial Az}{\partial z}.$$

curl**B**, alternatively $\nabla\times\mathbf{B}$, is

$$\left(\mathbf{i}\frac{\partial}{\partial x}+\mathbf{j}\frac{\partial}{\partial y}+\mathbf{k}\frac{\partial}{\partial z}\right)\times(\mathbf{i}B_x+\mathbf{j}B_y+\mathbf{k}B_z)$$

Keep a sharp eye on the definition of the vector product and you will see that **i**×**i** etc = 0, but **i**×**j** = **k**, **i**×**k** = −**j** and so on, which yields

$$\mathbf{i}\left(\frac{\partial B_z}{\partial y}-\frac{\partial B_y}{\partial z}\right)+\mathbf{j}\left(\frac{\partial B_x}{\partial z}-\frac{\partial B_z}{\partial x}\right)+\mathbf{k}\left(\frac{\partial B_x}{\partial x}-\frac{\partial B_z}{\partial y}\right)$$

for the three components of the vector curl**B**.

The curl expansion, definitely the most complicated, has a determinant expression so that you can remember it easily

$$\text{curl}\mathbf{B}\ \begin{vmatrix}\mathbf{i} & \mathbf{j} & \mathbf{k}\\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ B_x & B_y & B_z\end{vmatrix}$$

MAXWELL'S EQUATIONS AND E M WAVES

With our little nibble at vector fields, we arrive at one of the most famous sets of equations to grace the table of science and engineering. Öersted showed that a magnetic field **H** amps per metre sprang up round a current flow in a conductor. You may remember the science master demonstrating this with a card and iron filings, Fig.9.

Ampère wrote down a mathematical statement about what might be going on. Using our modern notation and units, together with the idea of the current flow paths as a vector field distribution, like that in Fig.10, Ampère's description amounts to saying that the curl of the magnetic force at any point is equal to the current density **J** streaming through

$$\text{curl}\mathbf{H}=\mathbf{J}\ \text{amps m}^{-2}.$$

Michael Faraday found the inverse effect, namely his Law of Electromagnetic Induction. A *changing* magnetic flux field linking a circuit causes a voltage round it. In vector field terms we can write this as a changing flux density **B** webers per square metre* at any point sets up the curl of an electromotive force field **E** volts per metre to circulate round it. So Faraday's Law says that the curl of **E** is equal to the negative of the magnetic displacement current density threading the region, see Fig.11

$$\text{curl}\mathbf{E}=-\frac{\partial\mathbf{B}}{\partial t}\ \text{volt m}^{-2}$$

An electric force field **E** sets up an electric flux field **D**, usually called the *electric displacement*, in a kind of 'stress and strain' relationship.

$$\mathbf{D}=\epsilon\mathbf{E}\ \text{coulomb m}^{-2}$$

where ϵ is the well known permittivity of the medium in which the fields occur.

The units of ϵ are farads per metre. You can see that in the above, farads per metre times volts per metre is equal to farads times volts per square metre. You might recall that a farad multiple by a volt is a coulomb. Similarly the magentic force **H** sets up a strain, the magnetic flux density **B**, so that

$$\mathbf{B}=\mu\mathbf{H}\ \text{weber m}^{-2}\ \text{or tesla}$$

where μ is the permeability in henrys per metre.

The ϵ and μ look like 'stress and strain' moduli of some kind, relating electric and magnetic forces with their fluxes. This is rather like Young's modulus in mechanical stress and strain. No wonder the Victorians struggled to invent an Aether in which all these goings-on could occur. Many a generation of students say how perplexing to have four vectors describing EM fields, but if we think of them as a force field together with a flux field in each case (the 'stress and strain'), it does help.

In our modern units, even a vacuum has values for ϵ and μ. They are

$$\epsilon_0=\frac{1}{36\pi\times10^9}\ \text{farad m}^{-1}$$

$$\mu_0=4\pi\times10^7\ \text{henry m}^{-1}$$

Electric charge gives rise to the flux field **D**. If there is a concentration ρ coulombs per unit volume distributed in a region, then

$$\text{div}\mathbf{D}=\rho\ \text{coulomb m}^{-3}.$$

Nobody has found isolated magnetic charge yet, although people are looking. Therefore

$$\text{div}\mathbf{B}=0.$$

This means magnetic vector flux lines always close on themselves.

We say they are *solenoidal*. And in some discussions, authors write the magnetic flux density in terms of another vector as **B** = curl**A**, where **A** is called the *vector potential*. Because of this, the only magnetic current that can flow is magnetic displacement current – as we saw in Faraday's Law.

We have one last result, not usually included in Maxwell's equations, which relates the current flow lines coming out of a region to the rate of change of charge per unit volume at each point in it. This is the 'equation of continuity'

$$\text{div}\mathbf{J}=-\frac{\partial\rho}{\partial t}\ \text{coulomb m}^{-3}\text{s}^{-1}\ (\text{or amp m}^{-3})$$

Now here is an interesting conundrum, a problem Maxwell solved although not quite this way. From your knowledge of vectors, and the equation of continuity, you might try getting the continuity result from the curl**H** equation by taking its divergence

$$\text{div curl}\mathbf{H}=\text{div}\mathbf{J}=-\frac{\partial\rho}{\partial t}$$

This looks alright – but hold on, div of a curl is *always* zero. Apparently we can never have a charge changing with time! Maxwell got out of this difficulty by looking at the other

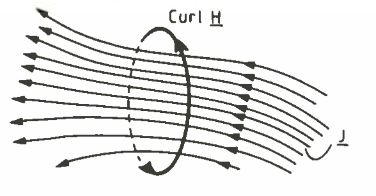


Fig.10. CurlH goes round flux of current J something like this.

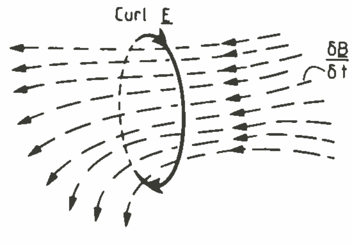


Fig.11. Similarly for the rate of change of flux density B. But notice the direction of curlE in this case.

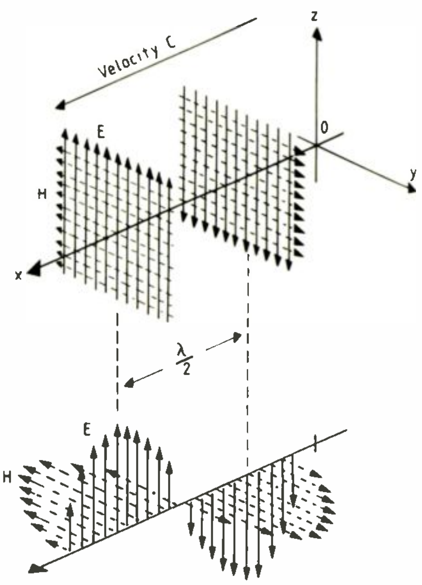


Fig.12. The EM wave advances somewhat like this diagram suggests. The E and H field lines cross at right angles to each other and with the direction of travel. For a single frequency, the lines distribute along the propagation axis in strength and with reversal's depicted in the lower part of the diagram.

*The S.I. Committee asks us to call a weber m^{-2}, a *tesla*.

curl equation (the one for **E**) and by analogy adding on to curl**H** a separate flux change term which he called the *electric* displacement current. So this equation with Maxwell's revolutionary bit of addition, reads

$$\mathrm{curl}\mathbf{H}=\mathbf{J}+\frac{\partial \mathbf{D}}{\partial t}\ \mathrm{amp\ m}^{-2}.$$

Now try the continuity equation

$$\mathrm{div\ curl}\mathbf{H}=\mathrm{div}\left(\mathbf{J}+\frac{\partial \mathbf{D}}{\partial t}\right)=0$$

$$\therefore\ \mathrm{div}\mathbf{J}=-\mathrm{div}\frac{\partial \mathbf{D}}{\partial t}$$

The order of differentiation doesn't matter

$$\therefore\ \mathrm{div}\mathbf{J}=-\frac{\partial}{\partial t}\mathrm{div}\ \mathbf{D}$$

and from the fact that $\mathrm{div}\mathbf{D}=-\rho$ we have directly

$$\mathrm{div}\mathbf{J}=-\frac{\partial \rho}{\partial t}$$

So at last we have Maxwell's equations. For example, out in space, away from currents **J** and charges ρ, the equations are

$$\mathrm{curl}\mathbf{H}=\frac{\partial \mathbf{D}}{\partial t}$$

$$\mathrm{curl}\mathbf{E}=-\frac{\partial \mathbf{B}}{\partial t}\quad \text{with} \begin{cases}\mathbf{D}=\epsilon_0\mathbf{E}\\ \mathbf{B}=\mu_0\mathbf{H}\end{cases}$$

$$\mathrm{div}\mathbf{D}=0$$

$$\mathrm{div}\mathbf{B}=0$$

The two curl equations tell quite a story. If, say, the electric field changes with time, there must be an accompanying magnetic field at right angles to it. If this is changing with time also, then it sets up another electric field – again at right angles. And so on indefinitely. It looks as though **E** and **H** can support each other in space. In other words, a *wave* might exist. Notice the two fields cross everywhere at right angles because of the curl property relating them. The fields also lie across the line of travel, which means that the wave is a transverse type and will polarize. Therefore a plane electromagnetic wave travelling along the x axis might look something like that shown in Fig.12, if we could actually see the lines. This set of results shows Maxwell had written down the transmission line equations for free space.

What we do with them now is to take the curl of the first equation

$$\mathrm{curl\ curl}\mathbf{H}=\mathrm{curl}\frac{\partial \mathbf{D}}{\partial t}.$$

As the order of differentiation doesn't matter and ϵ_0 is a constant.

$$\mathrm{curl\ curl}\ \mathbf{H}=\frac{\partial}{\partial t}\ \mathrm{curl}\mathbf{D}=\epsilon_0\frac{\partial}{\partial t}\mathrm{curl}\mathbf{E}.$$

But from the second curl equation, Curl $\mathbf{E}=-\partial\mathbf{B}/\partial t$, so insert it

$$\mathrm{curl\ curl}\mathbf{H}=-\mu_0\epsilon_0\frac{\partial \mathbf{H}}{\partial t^2}.$$

We know all about expanding curl curl of a vector from our previous discussions, therefore the *pièce de résistance*:

$$\mathrm{curl\ curl}\mathbf{H}=\mathrm{grad\ div}\mathbf{H}-\nabla^2\mathbf{H}=\mu_0\epsilon_0\frac{\partial \mathbf{H}}{\partial t^2}$$

$$\therefore\ \nabla^2\mathbf{H}=\mu_0\epsilon_0\frac{\partial \mathbf{H}}{\partial t^2}.$$

This is the famous wave equation. Here it describes the magnetic field part of the electromagnetic waves Maxwell predicted. The electric field has a similar wave equation. The multiplier of the right hand, or 'time' term is always in this type of equation, which, by the way, is called d'Alembert's equation, where c is the velocity of the wave.

This means that for our derivation with Maxwell's equations. And what is more, c works out to be very nearly 300 000 000 metres per second from the measured values of ϵ_0 and μ_0. This is the velocity of light in a vacuum.

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25 years of space communications

A quarter of a century ago this month the era of international communications through space began. Telstar, the world's first commercial communications satellite, was launched by NASA into low earth orbit on 10 July, 1962, and within days it had successfully relayed television, telephone and facsimile signals across the Atlantic in both directions.

Built in the United States by Bell Telephone Laboratories, Telstar weighed just 77kg and it carried a 2.5W transmitter capable of handling 600 telephone circuits or a single television channel; the uplink frequency was 6.39GHz and the downlink 4.17GHz. The spacecraft orbited the earth once every 156 minutes, at a height varying between 910 and 5875km.

Communication between the US and Europe was possible only when both ground-stations could see the satellite: about three or four useful orbits occurred in every 24 hours, offering transmission periods averaging about 30 minutes. And it was to maximize these that the General Post Office (British Telecom's predecessor) erected its dish close to the western extremity of the UK mainland, at Goonhilly Down.

Geostationary satellites, which would later allow transmission for extended periods, were to come much later – though their principle was by then well known, having first appeared in print in *Wireless World* in February 1945, in a letter from science writer Arthur C. Clarke.

The first night's tv transmissions from Telstar were marred by poor reception: through a misunderstanding, engineers on either side had adopted opposite planes of polarization. But by the following evening, staff at Goonhilly had made the necessary adjustments and live pictures were exchanged between the BBC and US networks. Colour pictures from a 525-line slide scanner provided by the BBC Research Department were sent on 16 July; The US station at Andover, Maine, reported them as "excellent".

Today there are some 130 communications satellites in service, handling traffic between 160 countries. Satellite programme feeds are routine events on radio and television, and the era of direct satellite broadcasting into the home is almost with us. Goonhilly now has ten aerials working to satellites over the Atlantic and Indian oceans; the first of them, the dish used for Telstar, is still operational.

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Electronic organ generator system

Microcomputer-controlled design scans eproms to obtain high quality waveforms.

S. J. KEARLEY

An organ design was required two manuals, a full set of pedals and at least 12 stops, that was capable of playing classical pipe organ repertoire. The pedal notes were to stand out against the rest of the sound, and 'mutation' stops to reinforce the harmonics of the note being played were to be provided.

Conventional pipe organs contain hundreds of pipes, one per note per stop. If these were simulated by the same number of electronic oscillators, the resulting instrument would contain many components and would be difficult to tune.

From one point of view, this is an extremely inefficient way of producing music. It is most unusual for a piece of classical solo organ music to have more than 10 notes playing simultaneously and since a two manual organ has about 150 keys, more than 90% of the generators are idle for the stops selected and all are idle for those stops not selected. The number of generators can be reduced to ten if they are capable of producing notes at any pitch in all the tone colours required. These generators will naturally be more complicated and their linking to the keyboard contacts is not straightforward; nevertheless this system has the potential to cut down on wiring and components. Moreover, the smaller number of generators would make it easier to obtain silence when no note was being played, and make it cheaper to apply measures to avoid start-up thumps and clicks.

A microcomputer would be the best way of interfacing the keyboard contacts to the generators; keyboard contact wiring could be reduced by connecting them into a diode matrix. This would be scanned by the microcomputer which would decide which generators should operate at which frequency, and send them appropriate commands. In this design the microcomputer also provides the coupling between manuals and controls the automatic tuning system. A piggy-back version of a single-chip microcomputer leads to a very compact computer board.

Turning back to the ten generators, a great effort was made to simplify the circuits as far as possible, in the knowledge that each component would be multiplied by ten.

The first method is familiar from the electromechanical Hammond and Compton organs and the *Wireless World* design by A. D. Ryder; usually harmonics up to the tenth are provided. The technique gives natural sounding flutes and diapasons but insufficient harmonics are available for reed or

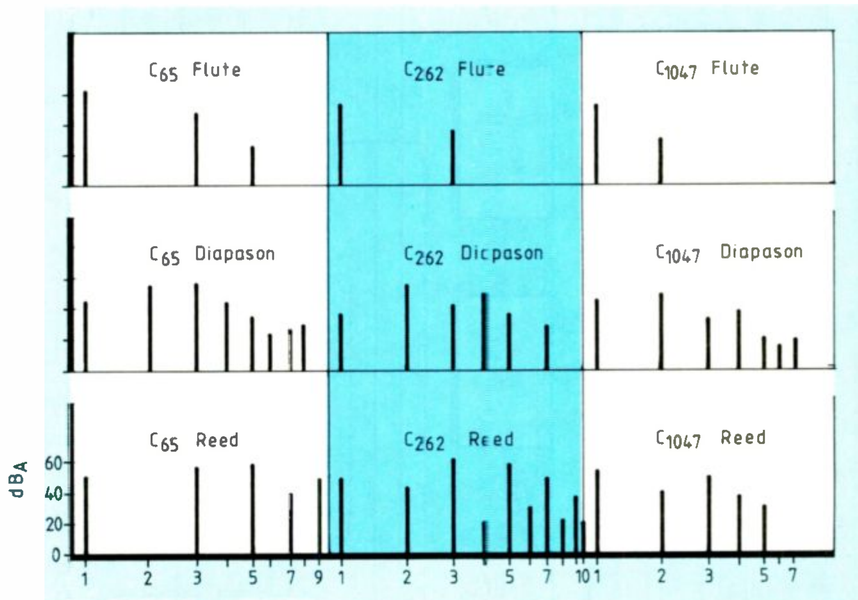

Fig.1. Spectra of pipe organ stops at different frequencies show that the harmonic content changes with frequency, and that diapason and reed stops contain more harmonics the flutes, giving a 'keener' sound.

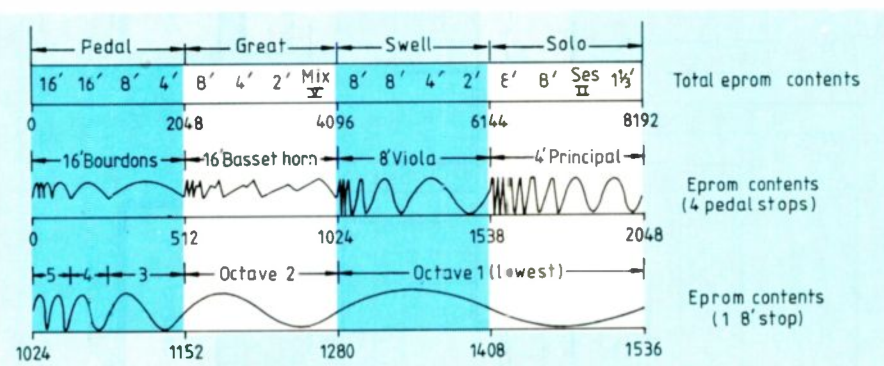

Fig.2. Map of eprom contents, progressively zooming in. There is only room for the positive half of the 16' waveform, so this is inverted for the negative half cycle. A differenct waveform can be stored for each octave.

string tone at the lower frequencies. Furthermore, the simpler forms of the technique synthesize waveforms which have the same harmonic content throughout their frequency range, which is uncharacteristic of both organ reed stops and orchestral reed instruments. Figure 1 shows the harmonic spectrum of typical flute, diapason and reed stops for three different notes recorded from a church organ.

The subtractive filter technique starts with a waveform rich in harmonics and attempts to use filters to cut the harmonic content down to the required amount. It is difficult to make the circuit work over a wide frequency range, since the low-pass filters needed to remove the harmonics from low frequency notes severely attenuate the high frequency notes. Although it is claimed that the change in harmonic content with frequency enables effective reed stops to be simulated with the aid of resonant filters, the author's experiments with this technique have met with little success.

Nowadays it is quite practicable to generate the required waveforms by storing a succession of data points in ram or rom and sending them to a d-a converter at a rate which determines the frequency of the note generated. The fidelity with which the

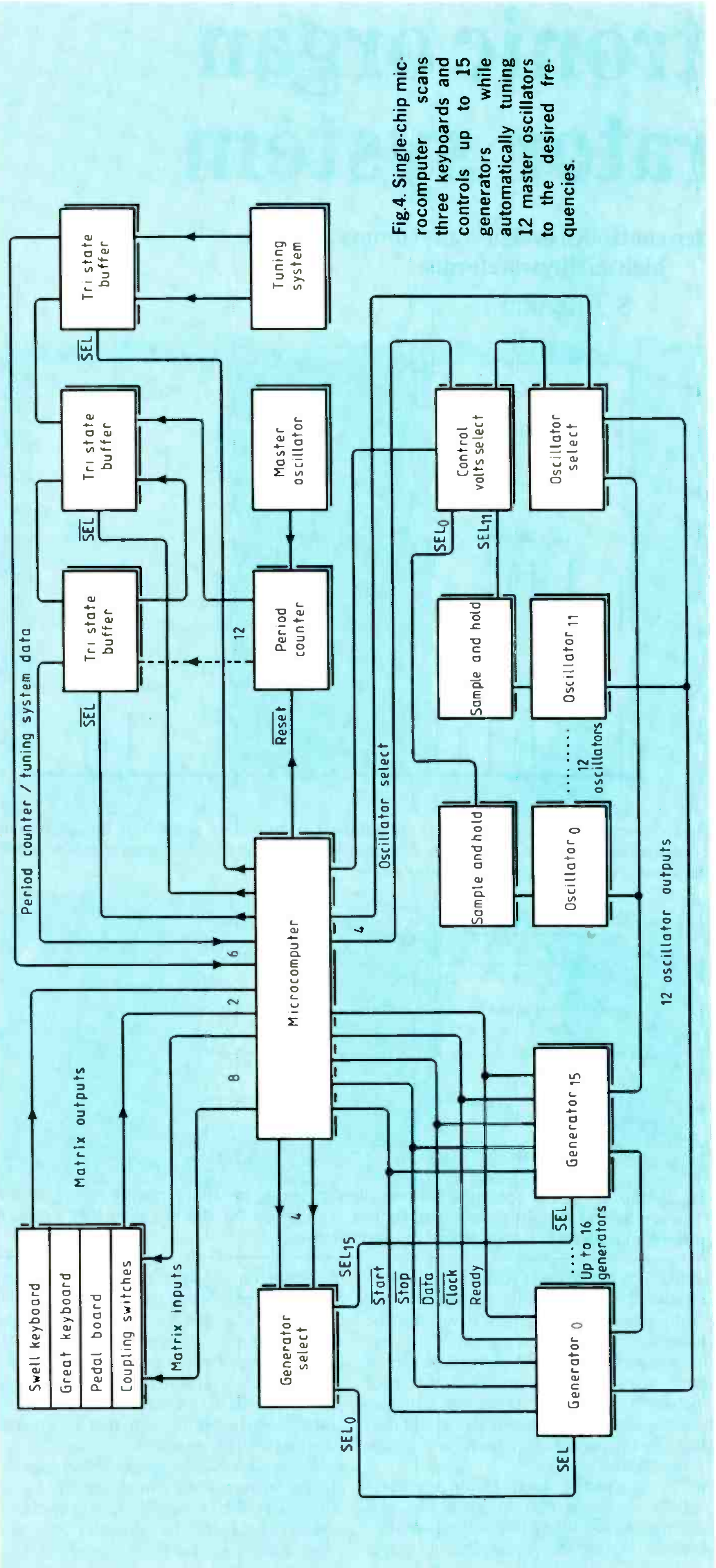

Fig.4. Single-chip microcomputer scans three keyboards and controls up to 15 generators while automatically tuning 12 master oscillators to the desired frequencies.

waveshape will be reproduced depends on the number of points and their resolution; compromises must inevitably be made to keep the cost of the design within bounds.

Further complications result from the necessity to provide realistic attack and decay for the notes; organ notes take several cycles to build up from zero to their maximum amplitude, and some contain starting transients, such as the renowned 'chiff' of some flutes. This problem may be solved by storing suitable starts and finishes for each note and 'splicing' these to the steady state waveform, but this is expensive in memory space and needs high resolution.

A more common technique is to multiply the steady-state waveform by the required start and finish envelopes by either digital or analogue means. If the first, a high resolution d-a converter is required, so I chose a technique employing a multiplying d-a converter. The digital code from the eprom modulates the reference current, which increases slowly from zero at the start of the note to a steady value, then decays back to zero when the note ends. The attack and decay times are made proportional to the period of the note (low notes build up more slowly than high notes). This agrees quite well with measurements of the attack and decay envelopes of organ notes taken with a storage oscilloscope, and gives a much superior effect to circuits which have the same attack/decay times for all frequencies. The effect is important for the very lowest notes, where a slow build up is essential for realism. Three different attack/decay characteristics are available in this design, and a diode matrix enables the constructor to choose whether each stop will be slow, medium or fast.

The output current from the d-a converter contains the waveforms for all 16 stops; this current is steered sequentially to the 16 different stop busbars. Each busbar output is fed to the appropriate amplifier through a stop switch which enables the performer to select which stops he wants, and a potentiometer which adjusts the relative volume of each stop.

The frequency of the note coming from the d-a converter depends both on the number of points per cycle of waveform stored in the memory and also on the speed with which they are clocked. In my design, the clock speed is selected from 12 master frequencies corresponding to the notes C, C . . . B; the different octaves in which a note may sound are obtained by varying the number of points/cycle from 256 in the lowest octave to 16 in the top octave. Different waveforms may be stored for each octave if desired.

The different possible clock speeds means that the sampling frequency of the waveform varies from about 16 to 32kHz. Unwanted beat frequencies of the waveform with the sampling frequency and the clock frequency itself are filtered out by a low-pass filter rolling off at 7kHz.

WAVEFORM GENERATION

The organ output waveforms are generated from a series of eight-bit values stored in memory. I decided that the cheapest suitable

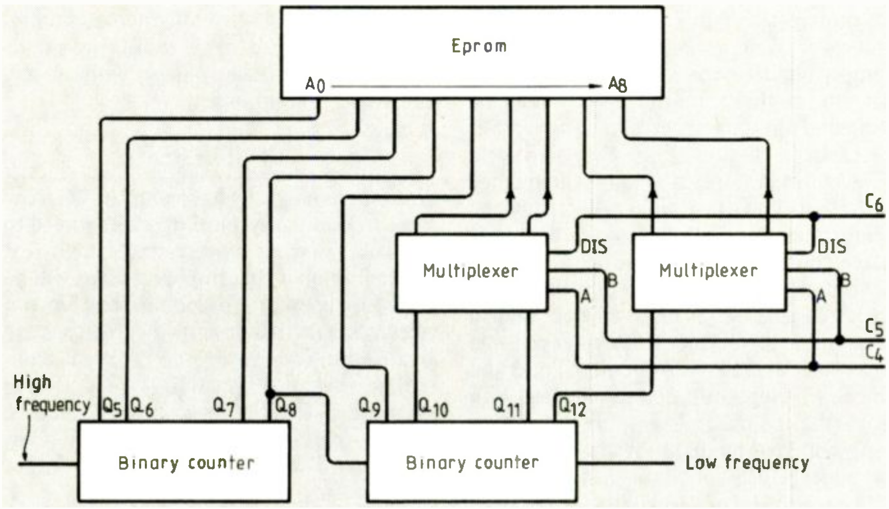

Fig.3. Binary counters increment the eprom address lines. Octave control lines C4 to C6 adjust the high-order addresses to find the section of eprom with the appropriate waveform and to force repetition of codes after the right number of steps.

Table 3 Data selection for eproms

Octave	C4	C5	C6	A5	A6	A7	A8	Address range
1	0	0	0	Q10	Q11	Q12	HI	256 – 511
2	1	0	0	Q10	Q11	HI	LO	128 – 255
3	0	1	0	Q10	HI	LO	LO	64 – 127
4	1	1	0	HI	LO	LO	LO	32 – 63
5	0	0	1	LO	LO	LO	LO	0 – 31

memory was the 2764 eprom which contains 8K × 8-bit words. The number of points available per cycle is proportional to the eprom size, but inversely proportional to the sampling speed and the number of stops. The provision of different waveforms for the same stop at different frequencies also fills up the memory, but I was determined to include this, as it is a characteristic of the pipe organs which the design attempts to mimic. Finally, the scanning speed must be slow enough to enable the samples to be accessed reliably.

After juggling with various combinations, I decided that 16 different waveforms could be stored in the 8K memory and scanned at speeds of between 16 and 32 kHz. This implies an upper cut-off frequency for the organ of about 7kHz, which is acceptable. As 16 waveforms are to be sequentially scanned, the eprom data rate is 16 times the waveform scanning rate; this gives a maximum of about 500kHz, well within the access time capabilities of unselected 2764s.

The problem now is to fit five different waveforms into the 512 words available for each stop. This is achieved by progressively reducing the number of data points stored as the waveform frequency increases. Since the circuit has a fixed upper cut-off frequency, less harmonics are available for high frequency notes than low ones, so nothing is lost by the reduction in data points. The waveform and the number of points are changed for each octave, implying five different waveforms for the five octaves of each stop.

256 points are assigned to the lowest octave of each stop, 128 to the next lowest and so on down to 16 for the highest. For 8′ stops, which sound at normal pitch, one complete cycle of the desired waveform is stored. For 4′ stops, one octave above pitch, two cycles are stored, and $2\frac{2}{3}$, 2′, $1\frac{3}{5}$′ and $1\frac{1}{3}$′ stops required 3, 4, 5, and 6 cycles respectively; 16′ stops present a greater problem as they sound one octave below pitch, and require twice the number of data points. This is a problem faced by conventional organ builders who cannot find space for 16′ pipes (so called because the lowest is about 16′ long.) Their solution is to stop one end of the pipe, getting away with a half-length pipe, at the expense of only being able to generate waveforms with odd harmonics, and I chose an analogous technique. Half a cycle of the waveform is generated, then repeated while the ouput is inverted to complete the cycle. Again, the drawback is that only odd harmonics can be generated. In this design, 16′ tone is restricted to the first two pedal stops by the hardware.

Fig 2 gives a graphical representation of the waveforms in the eprom together with their addresses.

The next problem is to obtain suitable data points to store in the eprom. A computer program reconstructed pipe organ waveforms from their harmonic analyses. The

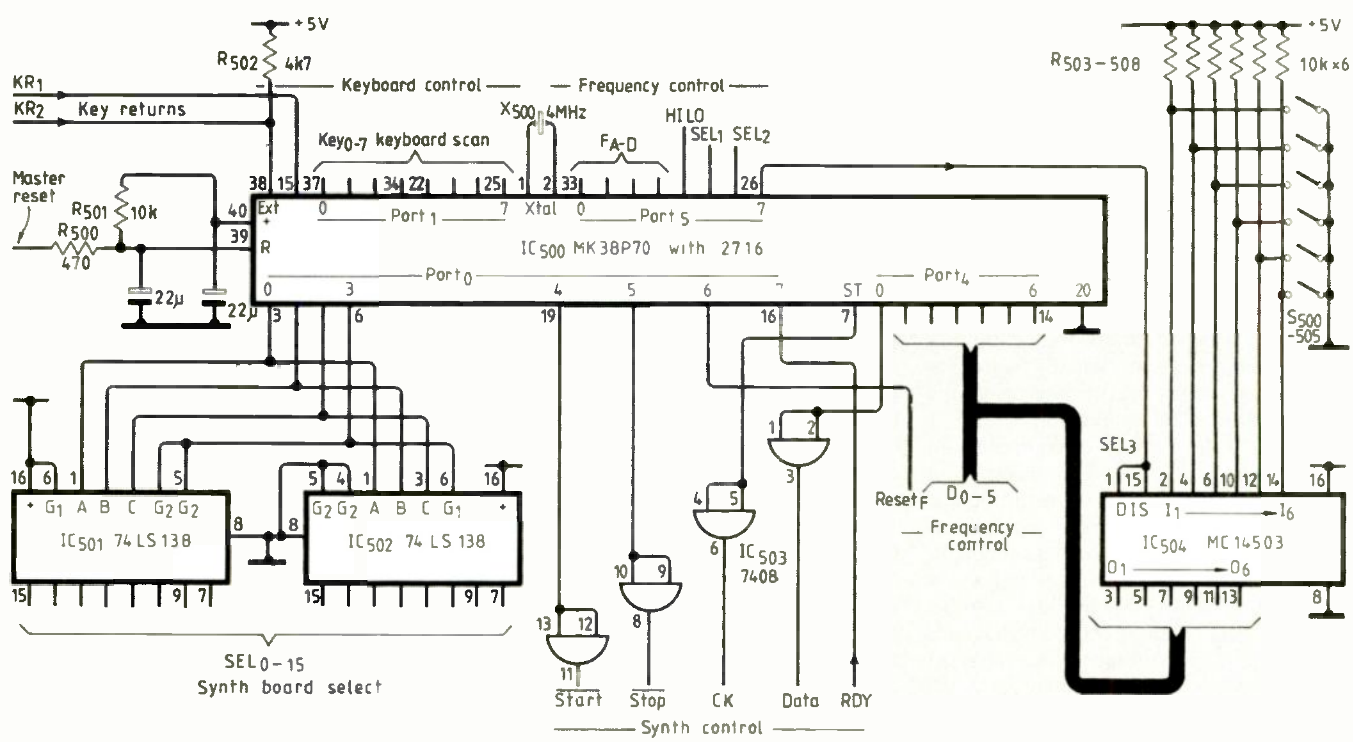

Fig.5. In the microcontroller circuit the switches control which tuning system is selected.

spectra of various pipe organ stops were measured at different frequencies, and a computer programmed to calculate the value of the waveform at the sample points by summing sine waves with appropriate amplitudes. For example, if the spectrum of a flute stop is measured as fundamental 80dB (to an arbitrary reference), the dBs are first converted to linear form (fundamental 10,000 units), third harmonic 1,000 units and fifth harmonic 100 units). The computer is instructed to calculate the value of 10,000sinx + 1,000sin 3x· +100sin 5x for each data point x in the cycle. The answer is then scaled and offset so as to fit into the 8-bit data word. In this circuit the output codes vary from 0 to 255 with zero output at 128, maximum positive output at 255 and maximum negative output at 0.

The scaling should ideally ensure that the waveform with the greatest peak amplitude exercises the full range of the 8-bit d-a converter, as this will give the best possible resolution for the system. The computer program finds the greatest data point value for the five octaves of a particular stop; if this is k, then all the values are multiplied by 127/k, and 128 added. The result is rounded to the nearest integer for the eprom.

The routine described preserves the relative amplitudes of the waveform at different parts of the frequency compass. It is usual for the amplitude of a pipe organ stop to reduce towards the top of its range. A problem occurs for the 16′ stops, where measurements showed that the acoustic power of the pipe organ stops increased greatly in the bottom octave, probably to compensate for the reduced sensitivity of the ear at low frequencies. When the computer program above was applied strictly, the amplitude of the waveform in the lowest octave was so great that very little resolution was obtained at higher frequencies. In addition, a noticeable step in amplitude occured between and adjacent notes B in the lowest octave and C in the next octave. In this case I adjusted the lowest octave amplitude to a value nearer to the amplitude at higher frequencies, and used bass boost in the pedal amplifier to increase the power at very low frequencies.

It must be stressed that there is insufficient resolution in the eight-bit converter to cope with the amplitude differences between different stops. The relative balance between each stop is adjusted by potentiometers on the audio output of each channel. Because the dynamic range desirable for a church or public building is not usually suited to private homes, these potentiometers should be adjusted to suit the application.

Even with the aid of a computer for calculation, the described procedure for waveform synthesis is time consuming and laborious. Experimenters with eight-bit or better digital transient recorders might be able to record the waveforms and obtain the required values directly. In this case, the recorder sampling clock should be adjusted until the required number of samples per cycle of waveform is obtained, and the system gain set for each stop until the note in the octave with the greatest amplitude occupies the full range.

The technique of progressively halving the number of points per cycle for each octave, as well as reducing the size of memory required, has the further advantage that the contents of the eprom may be clocked at the same speed for each octave. For example, assuming one complete cycle of waveform is stored, the output frequency in the bottom octave (256 points) will be 1/256 times the clock frequency. The next octave contains one cycle in 128 points, so the output frequency is 1/128 times the clock frequency, so is twice as high; and so on up to the top octave. This makes possible the simple data selection circuit of Fig. 3 and table 3, which permits octave selection with two dual 1 of 4 multiplexers, the fifth octave being obtained by disabling the multiplexers, under which conditions addresses 0-31 will be scanned. Only 16 points are required here, so two identical cycles of waveform must be stored.

MICROCOMPUTER CONTROL

A block diagram of the microcomputer control system shows that 34 input/output lines are required, Fig.4. Almost any eight-bit microcomputer system with a minimum of 64 words ram, 1K rom, timer interrupt capability and 2μs or better is adequate. I used a Mostek single-chip 'piggy back' MK38P70 with the program held in a 2716 eprom.

The main program scans the keyboard and coupling switch matrix; eight output lines permit up to 256 switches to be monitored. One input tests whether the selected switch is closed and the other whether any one of a group of eight is closed. Four output lines (decoded to 1 of 16) select one of 16 synthesizer boards, for start or stop commands. Four output lines run in parallel to all synthesiser boards, providing start, stop, data and data clock to the selected board and one input monitors whether a selected board is ready or busy playing a note.

A second program operates under timer interrupt at 4ms intervals. This uses four output lines to sequentially select 1 to 12 master oscillators for period measurement. A reset output line resets the period counter at the start of the measurement, which results in a 12-bit word which is fed to six input lines in two words. Three output lines permit the computer to select the low order or high order of the period, or six setting switches, three of which define the tuning system. The period of the master oscillator is compared with the desired value, and an output, Hilo, derived which drives the voltage on the appropriate sample and hold in a direction which corrects the frequency error.

Fig. 5 shows a 3870-based solution. The 3870 ports can be programmed as inputs or outputs, so most ports have measures of inputs and outputs. A strobe pulse is automatically generated every time a port – output operation is carried out, and this is used as a data clock. Circuit IC_{503} buffers those outputs which drive several ports, as the computer outputs are relatively low power, while IC_{504} is a tristate buffer for the setting switches, its output paralleled with two buffers on the frequency locking board. The piggy-back single-chip microcomputer, while relatively expensive, results in a simple layout which operates reliably without special wiring precautions.

COUPLERS

Pipe organs normally have couplers whereby stops from one keyboard may be coupled to another. These are unidirectional, i.e. Great to Pedal implies that the Great stops will be played by operating pedal switches but not vice versa. In this design, the 16 stops are arranged in four groups of 4 – Pedal (controlled by foot pedals), Great (lower keyboard), Swell (upper keyboard) and Solo. The last-mentioned is 'floating' in that it has no keyboard but may be coupled to any of the other three.

When a note is selected, the computer decides which of the four groups should be activated by observing which manual switch has been operated and which couplers have been selected. The final four bits of the serial data stream select the required group. If a coupler switch is altered while notes are still sounding, these notes will not be affected by the change, but succeeding notes will be.

Pipe organs usually have octave couplers which add in the pipes an octave above the pipes being played and sometimes sub-octave couplers which sound one octave below. It would not be difficult to add these to the microcomputer control system, but each note would then tie up two synthesizer boards, and it is likely that, with ten boards as in the prototype, the system would soon run out of available boards when chords were played.

Another possibility is automatic transposition, whereby a tune in one key can be caused to sound higher or lower. All these effects are obtained by adding a fixed displacement to the code for the key depressed. For example, the lowest D switch of the pedalboard has a code of 61. To transpose it down one semitone, 1 is added to the code; to transpose it up, 1 is subtracted. To transpose it up one octave, 12 is subtracted and to transpose it up two octaves, 24 is subtracted.

The code for the high Pedal G is 32; when transposed up by two octaves, 24 is subtracted, leaving eight, which is the code for coupler switch. However, there is no conflict, since the pedal switches are only scanned from 32 to 63. If the keyboards were scanned in the opposite direction (lowest notes = lowest codes) either the low pedal notes would conflict with the coupler switch codes, or the double octave of high pedal notes would have codes exceeding 63 and would play in the Great range.

A novel tuning scheme that allows the selection of different schemes for tuning is described separately, together with details of suitable generator boards. (Available from the editorial office in return for an A4 envelope marked "Organ design".)

Steve Kearley, who is an honours graduate in electronics from Manchester's UMIST, is research officer at the Electricity Council's research centre, and specializes in instrumentation for monitoring imperfections in the mains supply.

Stream encryption

A stream cryptosystem generates key sequences containing roughly equal numbers of ones and zeros with very long periods to appear random to an observer.

BRIAN P. McARDLE

Encryption is the process that turns data into secret form. The original data is known as the plaintext or cleartext and the encrypted data as the ciphertext. If the plaintext is P and the ciphertext is C, then the encryption operation is described by the equation

$$\hat{E}_K(P)=C$$

where K is a parameter called the *key* which is used to vary $\hat{E}$. The effect of a change of key is to generate a different C for the same P. A user chooses a particular key from a set of possible keys (K) and encrypts the plaintext. The ciphertext is stored or transmitted over a channel as illustrated in Fig.1 to a receiver. One must know the particular key in use to recover the plaintext using the inverse or decryption operation

$$\hat{E}^{-1}{}_K(C)=\hat{D}_K(C)=P.$$

From the point of view of maintaining secrecy, it must be assumed that a cryptanalyst (hacker) would have an unlimited ciphertext and would probably know the method of encryption which means $\hat{E}$ without knowing the particular K. To ensure real secrecy, two main tests to assess cryptosystems have evolved over the years:

- the set of possible keys must be large enough to make a search using each key in turn in the decryption operation impracticable. This is called an *exhaustive search* and is based on the fact that only the true key will produce meaningful text;
- deduction of the key from known plaintext/ciphertext pairs should be impossible except by an exhaustive search. This is called a *known plaintext analysis.*

A function is said to be linear it if satisfies the following two conditions:

$$f(x+y)=f(x)+f(y)$$
$$f(ax)=af(x)$$

where a is a constant. Otherwise the function is said to be non-linear. It has been stated that linearity is the friend of cryptanalysts and the enemy of cryptographers. This point should become clear in the next sections.

Euler's Totient Function $\varphi(n)$ is the number of integers less than n that are relatively prime to n, that is have no common factors. For example, $\varphi(31)=30$.

STREAM ENCRYPTION

In electric terms, the plaintext is a binary sequence which consists of 1s and 0s. The encryption operation is a *Boolean exclusive-Or logic operation*, where a bit of the plaintext P_j and a key bit K_j are combined in an exclusive-Or gate to generate C_j. The operation is described mathematically by the equation

$$C_j=(P_j+K_j)\bmod 2.$$

The reasons for using this operation as opposed to an Or or an And are that C_j is 0 or 1 with equal frequency and that the decryption operation only requires the same operation as follows:

$$P_j=(C_j+K_j)\bmod 2$$

The following example for encrypting/decrypting 5 bits explains the procedure.

Encryption		**Decryption**	
P_j	: 1 0 1 0 1	C_j	: 1 1 0 0 1
K_j	: 0 1 1 0 0	K_j	: 0 1 1 0 0
P_j+K_j	: 1 1 2 0 1	C_j+K_j	: 1 2 1 0 1
(P_j+K_j) mod 2	: 1 1 0 0 1	(C_j+K_j) mod 2	: 1 0 1 0 1

To summarize, a stream cryptosystem is essentially a deterministic process for generating a key sequence (K_j) which should have approximately equal numbers of 1s and 0s and have a very long period, so as to appear random to an observer.

LINEAR FEEDBACK SHIFT REGISTERS

A linear-feedback shift register is illustrated in Fig. 2. Each stage is a J-K flip-flop, the output being taken from the last stage. The feedback function generates successive states from an initial state or seed as follows:

$$K_j=f(K_{j-1},K_{j-2},\ldots,K_{j-r})\text{ for } j>r$$

which for a linear-feedback arrangement can be rewritten as

$$K_j=\sum_{i=1}^{r} L_iK_{j-i}\bmod 2\text{ for } j>r$$

$$L_i=1\text{ for latch i closed}$$
$$=0\text{ for latch open}$$

To ensure that K_j has approximately the same number of 1s and 0s, latch r is usually left closed. Consider an example for r=5 with L_3 open and the other latches closed. The linearity of f can be shown by the following results:

$$f(1,0,1,0,1)=0$$
$$f(1,1,1,1,0)=1$$
$$f(0,1,0,1,1)=1$$

The third state on the left can be generated from a modulo-2 addition or an exclusive-Or between the other two states. The same result can be obtained on the right side. Thus the arrangement satisfies the first condition for a linear function. There is no need to consider the second, since a is 0 or 1 in modulo-2 arithmetic.

In the operation of the shift register, each state has a unique predecessor and a successor. The total number of possible states for r stages is 2^r, but the state "all 0s" is never used, which means that the maximum possible period is 2^r-1. In the previous example, the key sequence from a seed (1,0,1,0,1) is (1,0,1,0,1,0,0,1,0,0,0,1,0,1,1,1,1,1,0,1,1,0,0,1,1,1,0,0,0,0,1) and has a period 31, which means that the choice of latches results in maximum period. Obviously, every arrangement of the latches does not produce maximum period. There are $\varphi(2^r-1)/r$ different arrangement where φ is Euler's Totient function. For r=5, this gives $\varphi(2^5-1)/5=6$.

In encryption applications, the question of secrecy must be examined. If a cryptanalyst knows the value of r and the last 10 bits of the key, then

$$0=(1,1,1,0,0)$$
$$0=(0,1,1,1,0)$$
$$0=(0,0,1,1,1)$$
$$0=(0,0,0,1,1)$$
$$1=(0,0,0,0,1)$$

and the five equations

$$0=(L_1+L_2+L_3)\bmod 2$$
$$0=(L_2+L_3+L_4)\bmod 2$$
$$0=(L_3+L_4+L_5)\bmod 2$$
$$0=(L_4+L_5+L_6)\bmod 2$$
$$1=L_5\bmod 2$$

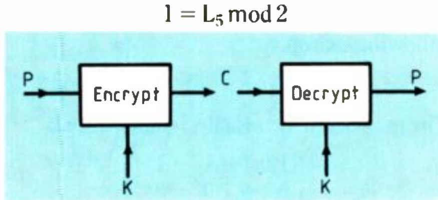

Fig.1. The encryption/decryption operation

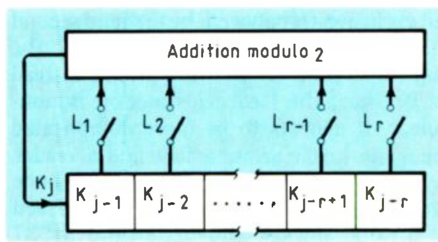

Fig.2. Linear feedback shift register

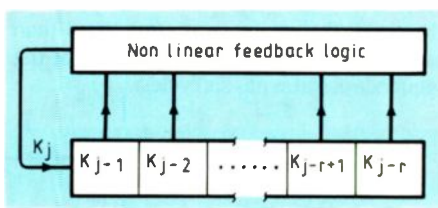

Fig.3. Non-linear feedback shift register

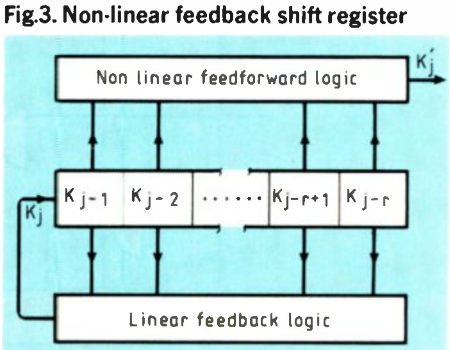

Fig.4. Non-linear feedback shift register with non-linear feedforward

From the last equation, $L_5 = 1$. Therefore the previous equation can be re-written as

$$0 = (L_4 + 1) \bmod 2$$

Continuing in this manner gives $L_3 = 0$ and $L_1 = L_2 = 1$. The mathematical problem can also be formulated in matrix form such that the solution requires the calculation of the inverse matrix. This method is more suitable for large values of r because a cryptanalyst could make use of computer packages. But once a latch arrangement and a state for the shift register are known, the full sequence can be generated. Consequently, the linear function, irrespective of the value of r, is too predictable for secrecy and does not satisfy Test 2.

SHIFT REGISTERS WITH NON-LINEAR LOGIC

A shift register with non-linear feedback logic is illustrated in Fig. 4. The incoming bit is generated according to:

$$K_i = f(K_{j-1}, K_{j-2}, \dots K_{j-r}) \bmod 2$$

where f is a non-linear function. Normally f is chosen such that

$$K_i = [f'(K_{j-1}, K_{j-2}, \dots K_{j-r+1}) + K_{j-r}] \bmod 2$$

which ensures that (K_j) has approximately equal numbers of 1s and 0s. The new function f′ is also non-linear. Consider the following example.

$$K_j = (K_{j-1}K_{j-4} + \overline{K_{j-2}}\,\overline{K_{j-3}} + K_{j-5}) \bmod 2$$

The non-linearity is easily demonstrated:

$$f(1.0.1.0.1) = 1$$
$$f(0,1,0,1,0) = 0$$
$$f(1,1,1,1,1) = 0$$

An exclusive-Or between the first and second states on the left gives the third, but the same operation on the right gives 1 instead of 0. Thus, the feedback function is non-linear. It appears to be more complicated than the linear arrangement and a reader would be justified in assuming at first glance that it is also more secure. For a seed (1,0,1,0,1), the key sequence for the first 31 terms is: (1,0,1,0,1,1,1,1,1,0,1,0,1,1,1,1,1,0, 1,0,1,1,1,1,1,0,1,0,1,1,1). But the period is short and the sequence repeats more than once. A more detailed study shows that the sequence of states has six cycles:

00000-10000-11000-01100-00110-00011-00001

00010-10001-01000-00100

10101-11010-11101-11110-11111-01111-1011 -01011

01101-10110-11011

00101-10010-01001-10100-01010

11100-01110-00111-10011-11001

An interesting point is that the state (0,0,0,0,0) does not generate itself. From the point of secrecy, the key sequence has period 8 and repeats three times within the 31 terms. Thus, non-linear functions are not necessarily more secure than the linear variety. But no such cryptosystem, irrespective of the period, offers any real secrecy. If a cryptanalyst knows the feedback function, he can generate the balance of the sequence following known bits. Consequently, this arrangement also fails Test 2.

The arrangement of Fig. 5 attempts to eliminate the two main weaknesses. The linear feedback function generates the incoming bits to the shift register and consequently determines the period of the entire system. The non-linear feedforward function generates the key bits and protects the shift register from an analysis using known key bits. The two previous examples combined result in:

$$K_j = (K_{j+4}K_{j+1} + \overline{K_{j+3}}\,\overline{K_{j+2}} + K_j) \bmod 2$$
$$K_{j+5} = (K_{i+1} + K_{j+3} + K_{j+1} + K_j) \bmod 2.$$

For the seed (1,0,1,0,1) the key sequence is (1,0,1,0,1,0,1,0,0,0,1,1,1,0,1,0,0,1,0,1,1,0, 0,1,0,0,1,0,0,1,1) and has period 31. The secrecy depends on not being able to deduce K_j to K_{j+4} from K'_j to K'_{j+4} (assuming a worst-case analysis where both functions are known). In this simple example, such a deduction is turgid rather than impossible. But an actual commercial system would have r=128 or 256. In designing such a system, the feedback logic would be one of $\varphi(2^r-1)/r$ latch arrangements that produce a maximum period of 2^r-1. The non-linear logic could be chosen using a variety of methods, but the following is simple and straightforward. The output or inverted output of such stage (flip-flop) is connected to an And gate with the constraints:

- each gate has only two inputs;
- the span of the inputs does not exceed
- the number of stages.

For example, the pairs (1,4), (2,6), (3,8) and (5,7) satisfy these conditions. The resulting function is not necessarily non-linear in the strict mathematical sense, but for a large value of r would be quite complicated. A cryptanalyst would have to discover a method of solving equations which have non-linear operations or use an exhaustive search. For r=256 this would be impractical. Therefore this arrangement is reasonably secure. A useful hint for designers is to include a facility to vary the logic arrangement such that the same functions are not used too often.

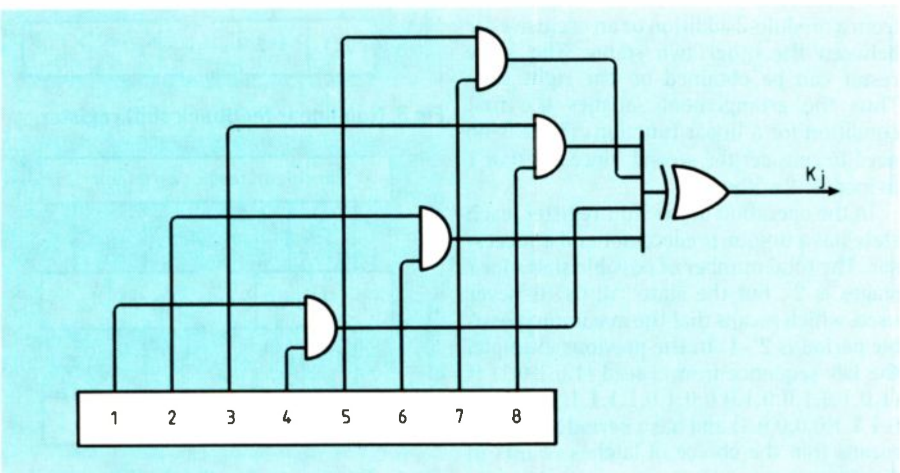

Fig.5. Non-linear feedforward loop for r=8

CONGRUENCE GENERATORS

This method is essentially a computer algorithm for generating a sequence of numbers from a seed X_0 as follows.

Number sequence $X_j = (AX_{j-1} + B) \bmod M$
Binary sequence $K_j = X_j \bmod 2$

Thus K_j is 0 or 1, depending on whether X_j is even or odd. The modulus M is the largest prime that can be fitted to the processor's word size and A and B are integral powers of some prime factor. The generated sequences are periodic because, once the seed is reproduced, the complete succession of results after the seed also repeats. For example, $X_0 = 8191$, $A = 13077$, $B = -6925$ and $M = 32767$ has period 1050. But the simplicity of the operation is also its weakness. Generally, A, B and M are machine constraints, which means that X_0 is the only parameter to be varied. In addition, some seeds have short periods which, in turn, limits the choice of seed. In applying Test 2, it must be assumed that a cryptanalyst would have all the details except the seed. Thus, the secret depends on the difficulty of deducing X_j from K_j. For example, if $K_j = 1$, then for a 16-bit word X_j is an uneven number between 1 and $2^{16}-1$. An examination which would try each possible number in turn would *not* be impractical. Consequently, this system implemented on the standard desk-top would not satisfy Test 2.

X^2 MOD PQ GENERATOR

A sequence of numbers (X_j) is generated from a seed X_0 as follows.

Number sequence $X_j = X_{j-1} \bmod N$
Binary sequence $K_j = K_{j-1} \bmod 2$

The modulus N is the product of two large primes P and Q that are congruent to 3 mod 4 and mod $(X_0, N) = 1$. Therefore K_j is 0 or 1, depending on whether X_j is even or odd. The set of possible seeds has $0(N) = (P-1)(Q-1)$ elements, where φ is Euler's Totient Function. The main difficulty is implementation of desk-top microcomputers which normally handle 12 digit numbers. For secrecy, P and must be very large primes in the order of 100 digits. The method is therefore considered to be suitable only for Public-key Encryption, which is not covered in this article.

Data capture for Fourier analysis

In coverage of computer FFT analysis, little has been said about getting data into memory. This capture system digitizes in $10\mu s$.

PETER FINCH and DAVID TAYLER

Biomedical engineers use Fourier transforms to characterize and analyse a variety of signals such as electrocardiograms, electroencephalograms or respiratory waveforms. If the transform and its reverse can be performed rapidly, then selective attenuation of frequency components provides a versatile filter.

Dedicated components are available for the Fourier transform, but microcomputers can also perform satisfactorily once the data is in digital form. Speed limitations of the software option necessitate use of the fast Fourier-transform algorithm.

The widely used fast-Fourier-transform algorithm requires a predefined number of samples of 2^n; n is the number of computation arrays, and hence passes through the data, produced by the calculation[1]. Running machine language on an eight-bit computer it is convenient to have $n=8$, i.e. 256 samples.

Another requirement is for an integral number of waveforms in the sample window to be analysed. If this condition is not met, a discontinuity will be introduced and this can have a profound effect upon the frequency spectrum, causing erroneous non-existent components[2]. Furthermore, sampling frequency must be high enough to avoid aliasing.

These constraints make real-time sampling of biological signals difficult since the periodicity of the waveform may not be known prior to sampling, and indeed may change from beat to beat. It may not prove possible to set the sampling interval in order to generate the required number of data points in an integral number of waveforms prior to sampling. This data-capture system for a BBC B microcomputer was developed to sample real-time electrocardiographic signals so that they can be analysed in frequency domain.

HARDWARE

Circuit Fig. 1 gives you control over the trigger point by setting signal polarity, gain and offset with a choice of peak or level detection. The number of cycles of the waveform can be selected and the starting point for sampling may be delayed from the trigger point. An input to the data capture system starts sampling, PB$_0$, and an output from it, PB$_1$, flags the sample waveform's beginning and end.

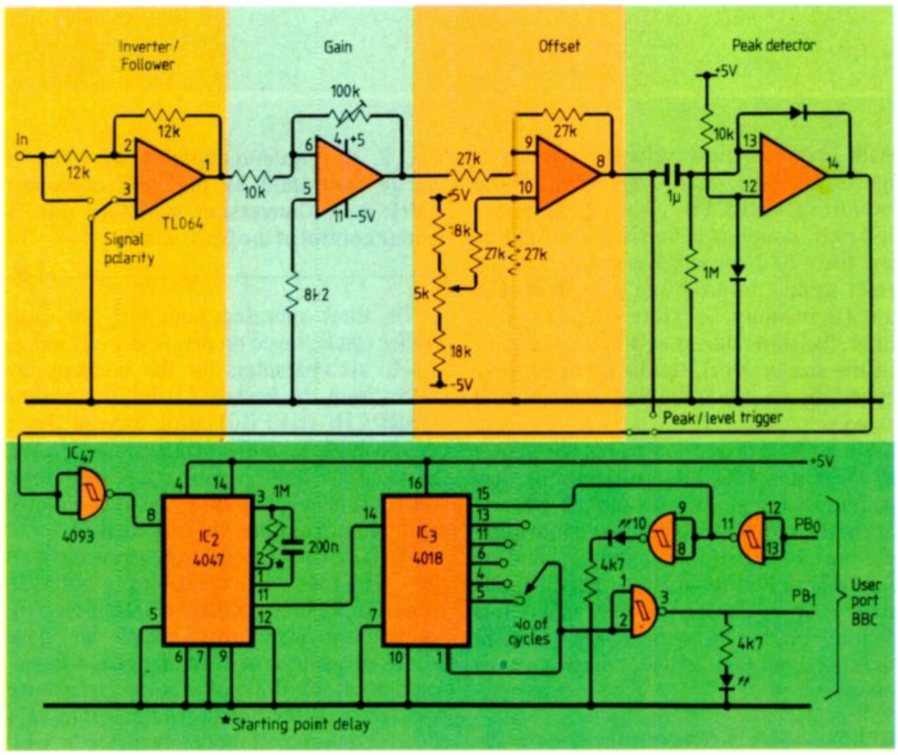

Fig. 1. Counter and analogue circuits for data capture. Line PB$_0$ from the computer starts sampling and input PB$_1$ flags the conversion beginning and end.

Conversion time of the ZN448 analogue-to converter is $10\mu s$; it is clocked by the 1MHz bus and software controlled, Fig. 2.

SOFTWARE

Four menu options are provided by the software. In order to free the maximum amount of memory for a data buffer, the program runs in mode seven and has a simple screen display, indicating the option selected by a solid box next to the menu item. Options are;

- setting sampling interval, in μs
- manual setting of PB$_0$ high for setting trigger level and data-capture system sensitivity
- waveform sampling
- saving the compressed sampled waveform as a disc file.

Waveforms are sampled by the a-to-d converter at a rate dermined by timer one of the 6522 versatile interface adaptor. All interrupts on the microcomputer are disabled during sampling (by setting the interrupt flag), which avoids intermittent stretching of the sampling interval by unexpected interrupts. Free running mode is used for the v.i.a. timer, and the time interval is loaded into the timer latches. By continually polling the appropriate bit of the interrupt-flag register (set for no interrupts), a time-out is detected whereupon a sample point is read from the a-to-d converter latch at address FCF3. Another conversion is immediately initiated by a write operation to address FCF5 so that the data may be ready at the next time out.

Data capture requires two control lines, provided by the two low-order bits of port B of the computer's 6522 v.i.a. When you

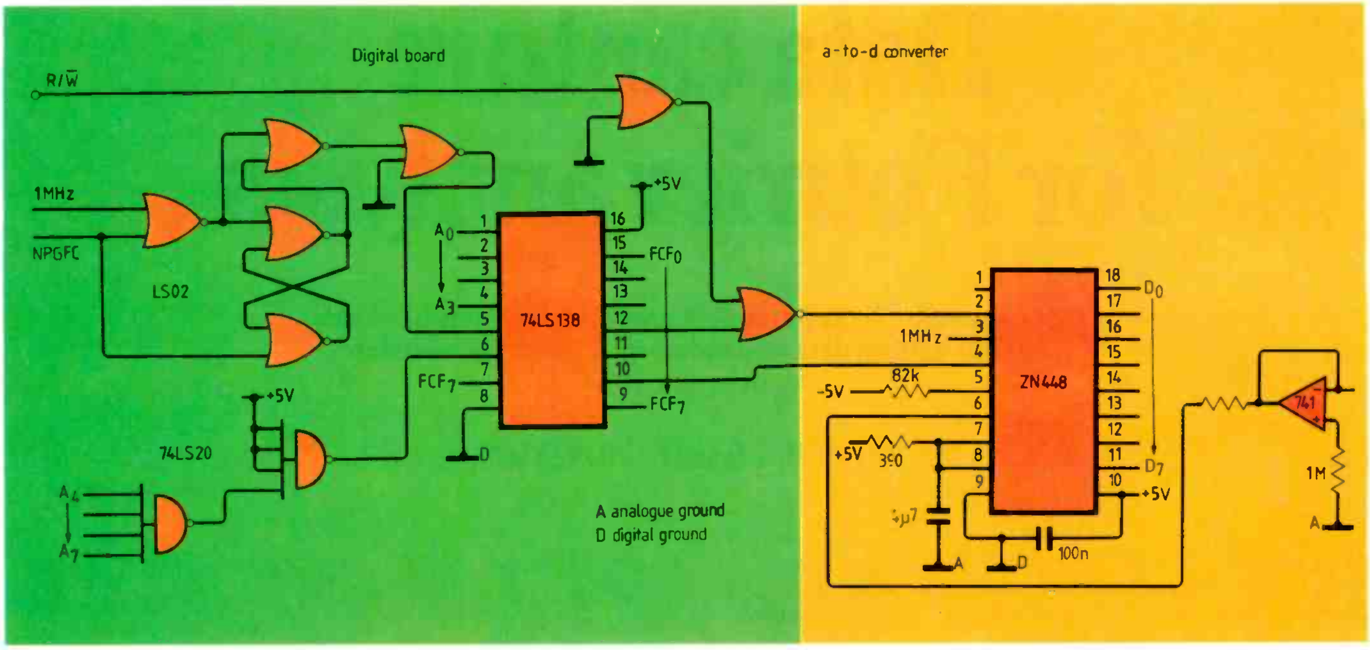

Fig. 2. Analogue-to-digital conversion is partly controlled by the BBC computer 1MHz bus. Conversion sampling rate is under control of the 6522 v.i.a.

decide to sample the waveform PB_0 is driven high, enabling IC_3. At the trigger point of the waveform selected, PB_1 goes high and stays high until sampling is finished. During this time the a-to-d converter is sampled at the preset sample interval and data from it is stored in memory. Data is now held in a ram buffer, the start address of which is constant but the size of which can be up to 20Kbyte depending on the sampling interval and period.

When PB_1 is driven low by IC_3 to indicate the end of sampling, PB_0 is programmed low again ready for another sampling cycle, and data in the ram buffer is crammed into a 256 byte page buffer so that it can be saved on disc for later Fourier analysis. This requires taking every n/256 sample point where n is the total number of sample points stored in the ram buffer. List 1 shows how this can be done.

LIST 1. Basic and its machine-language equivalent

```
10  REM Waveform in RAM between BUFFSTART and
    BUFFEND
15  REM Result in buffer from PAGE to PAGE+256
20  Y=0                        :REM LDY #0
25  Index=buffstart            :REM  LDA buffstart
                               :LDX buffstart+1
30                             :REM  STA index
:                              STX index+1
35  counter=buffstart          :REM STA counter
                               :STX counter+1
40  POKE (page+Y).             :REM  .assign LDX #0
    PEEK (index)               :LDA (index.X)
    [MBasic]
45  REM (page)?Y=?             :REM  STA (page).Y
    (index) [BBC Basic]
50  index=index+1              :REM  .1p INC index
                               :BNE skp :INC index+1
55  counter=                   :REM .skp INC counter+1
    counter+256
60  If counter<buffend         :REM  SEC :LDA counter
    THEN 50                    :SBC buffend
65                             :REM  PHA
                               :LDA counter+1
                               :SBC buffend+1
70                             :REM TAX :PLA
                               :BCC 1p: CLC
75  counter=counter-           :REM  ADC buffstart
    buffend+buffstart          STA counter :TXA
80                             :REM  ADC
                               buffstart+1
                               :STA counter+1
85  Y=Y+1                      :REM  INY
90  IF Y<256 THEN 40           :REM  BNE assign
```

To allow repeated sampling, the page buffer can be saved on disc under any name. Up to six characters for the filename are taken from the keyboard using the routine OSRDCH (&FFE0) and stored in a command-line buffer containing "*SAVE xxxxxx 7800 7900". Command line interpreter routine OSCLI (&FFF7) is then pointed at the command-line buffer and called.

We have used this data capture system on both BBC model B and Master computers to generate 256byte arrays of real time electrocardiogram waveforms, which we have analysed using a machine-language implementation of the fast Fourier transform written by Peter Finch. The program uses floating-point arithmetic, executes in typically three to four seconds, and is capable of reverse transforms. Using our implementation of the FFT and its reverse transform, we have demonstrated the advantages of linear-phase high-pass filtering to stabilize the baseline of electrocardiograms without introducing insignificant waveform distortion[3].

References

1 Oran Brigham, E., The Fast Fourier Transform, Prentice-Hall 1970.

2 Omer, W., Faster Fourier transforms. *Electronics and Wireless World*, June 1986 pp.23-5.

3 Tayler, D., Finch P. and Vincent, R., Linear-phase filtering — a new approach to distortion free electrocardiograms. Computers in Cardiology, IEEE 1985, pp.283-6.

David Tayler B.Sc., B.M. is a G.P. and clinical assistant in cardiology in Sheffield, currently investigating the effects of electrical distortion on e.c.g. waveforms. Peter Finch B.M., B.S. is registrar in gastroenterology in Liverpool with an interest in programming for gastroenterology data management.

CONTROL SOFTWARE

Peter Finch and David Tayler's listings for grabbing data from the a-to-d converter, drawing a saved page and dumping a mode-four screen are available. Send either an Acorn-format disc (preferably 80-track double sided) and return postage or a large s.a.e. to *E&WW* Editorial, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Please mark FFT-TF on your envelope.

Risc card for PCs

Besides launching the Archimedes computer (see page 839). Acorn has also made its risc architecture available in a single-board computer to plug into the expansion slots of IBM PC-compatibles. The so-called Springboard contains the full risc chip set with the exception of the display controller and comes with 1Mbyte of ram (at £1000) or 4Mbyte (at £2000). The processor's design avoids the need for costly high-speed static ram.

Up to four Springboards can be used simultaneously, each running independently of the others and of DOS, though the PC can be used as a terminal. A bus connector is provided on the board to eliminate delays in passing i/o via the host computer's bus. Development software for the card includes an assembler, utilities and other tools. High-level languages are an Arm C compiler, Fortran, Prolog and Lisp. Details from Acorn Computers on 0223 214411.

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AD161	0.50
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AF116	3.50
AF117	4.00
AF139	0.55
AF186	0.75
AF239	0.65
AFZ11	3.75
AFZ12	5.00
ASY26	1.40
ASY27	1.00
ASZ15	2.20

ASZ16	2.00
ASZ17	1.60
ASZ20	4.50
ASZ21	4.75
AUY10	3.50
BA145	0.13
BA148	0.15
BA154	0.06
BA155	0.11
BA156	0.06
BAW62	0.05
BAX13	0.05
BAX16	0.06
BC107	0.12
BC108	0.13
BC109	0.14
BC113	0.12
BC114	0.12
BC115	0.12
BC116	0.12
BC117	0.24
BC118	0.32
BC125	0.25
BC126	0.25
BC135	0.18
BC136	0.18
BC137	0.22
BC147	0.12
BC148	0.12
BC149	0.12
BC157	0.12
BC158	0.13
BC159	0.13
BC167	0.10
BC170	0.09
BC171	0.11
BC172	0.09
BC173	0.09
BC177	0.15
BC178	0.28
BC179	0.15

BC182	0.11
BC183	0.09
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.09
BC238	0.09
BC301	0.36
BC303	0.36
BC307	0.09
BC308	0.09
BC327	0.09
BC328	0.09
BC337	0.09
BC338	0.09
BCY30	7.50
BCY31	7.50
BCY32	7.50
BCY33	7.50
BCY34	7.50
BCY39	3.60
BCY40	3.00
BCY42	0.32
BCY43	0.45
BCY58	0.25
BCY70	0.21
BCY71	0.21
BCY72	0.21
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BD115	0.35
BD123	2.30
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BD131	0.42
BD132	0.42
BD135	0.27
BD136	0.27
BD137	0.30
BD138	0.30
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BD140	0.30
BD144	2.00
BD181	0.75

BD183	0.75
BD237	0.35
BD238	0.35
BDX10	0.91
BDX32	2.00
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BDY20	1.50
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BF258	0.30
BF259	0.30
BF336	0.30
BF337	0.30
BF338	3.00
BFS21	4.00
BFS28	2.50
BFS61	0.30

BFS98	0.30
BFW10	1.04
BFW11	1.01
BFX84	0.28
BFX85	0.28
BFX87	0.28
BFX88	0.28
BFY50	0.28
BFY51	0.28
BFY52	0.28
BFY64	0.36
BFY90	0.65
BSX19	0.27
BSX20	0.27
BSX21	0.27
BT106	1.65
BTY79 400R	3.00
BU205	1.70
BU206	1.70
BU208	2.00
BY100	0.42
BY126	0.15
BY127	0.15
BZX61 Series	0.17
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MJE340	0.79
MJE370	0.73
MJE371	1.05
MJE520	0.75
MJ521	0.73
MJE2955	2.25
MJE3055	2.00
MPF103	0.55
MPF104	0.55
MPF105	0.55
MPSA06	0.17
MPSA56	0.17
MPSU01	1.11
MPSU06	1.33
MPSU56	1.71
NE555	0.45
NKT401	4.00
NKT403	3.50
NKT404	4.00
OA5	1.75
OA7	0.75
OA10	0.55
OA47	0.15
OA70	0.22
OA79	0.21
OA81	0.21
OA85	0.21
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OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
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OAZ200	1.50
OAZ201	1.50
OAZ206	1.50
OAZ207	1.50
OC16	5.00
OC20	6.00
OC22	4.00
OC23	10.00
OC24	3.00
OC25	1.75

OC26	1.50
OC28	5.50
OC29	4.40
OC35	4.00
OC36	4.00
OC41	1.20
OC42	1.50
OC43	1.50
OC44	1.25
OC45	0.85
OC71	0.65
OC72	2.20
OC73	1.45
OC74	1.40
OC75	1.40
OC76	1.60
OC77	2.75
OC81	0.90
OC81Z	4.00
OC82	0.95
OC83	1.40
OC84	1.40
OC122	6.50
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OC207	18.00
OCP71	2.50
ORP12	2.40
R2008B	1.95
R2009	2.25
R2010B	2.00
TIC44	0.48

TIC226D	1.20
TI1209	0.29
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TIP110	0.10
TIP117	0.45
TIP125	0.35
TIP130	0.45
TIP131	0.45
TIP132	0.48
TIP135	0.45
TIP137	0.48
TIP140	0.85
TIP141	0.85
TIP142	0.85
TIP2955	0.60
TIP2955T	0.45
TIP3055	0.60
TIP3055T	0.45
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS272	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.14
ZTX303	0.14
ZTX304	0.14
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.14

ZTX503	0.14
ZTX504	0.20
ZTX531	0.20
ZTX550	0.25
IN914	0.03
IN916	0.03
IN4001	0.04
IN4002	0.04
IN4003	0.03
IN4004	0.04
IN4005	0.04
IN4006	0.04
IN4007	0.05
IN4009	0.06
IN4148	0.03
IN5400	0.10
IN5401	0.11
IS44	0.04
IS290	0.10
IS921	0.12
2G301	1.00
2G302	1.20
2G306	1.50
2N404	1.50
2N696	0.30
2N697	0.36
2N698	0.38
2N705	2.50
2N706	0.20
2N708	0.22
2N930	0.25
2N1131	0.35
2N1132	0.35
2N1302	1.80
2N1303	0.90
2N1304	3.00
2N1305	1.00
2N1306	3.00
2N1307	1.20
2N1308	4.00
2N1309	1.50
2N1613	0.30
2N1671	5.00

2N1893	0.30
2N2147	8.00
2N2148	2.75
2N2218	0.32
2N2219	0.32
2N2220	0.22
2N2221	0.22
2N2222	0.20
2N2223	7.50
2N2368	0.23
2N2369	0.23
2N2384	0.24
2N2646	0.75
2N2904	0.30
2N2904	0.30
2N2905	0.30
2N2906	0.22
2N2907	0.22
2N2924	0.12
2N2925	0.22
2N2926	0.12
2N3053	0.30
2N3054	0.55
2N3055	0.70
2N3440	0.60
2N3441	0.75
2N3442	1.00
2N3614	5.00
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.11
2N3709	0.11
2N3710	0.11
2N3711	0.10
2N3771	1.20
2N3772	1.20
2N3773	1.60
2N3819	0.50
2N3820	0.60

2N3823	0.80
2N3866	1.00
2N3904	0.10
2N3905	0.10
2N3906	0.10
2N405X	0.12
2N4059	0.20
2N4060	0.12
2N4061	0.12
2N4062	0.15
2N4124	0.13
2N4126	0.13
2N4248	0.25
2N4288	0.15
2N4289	0.12
2N4400	0.12
2N4401	0.12
2N4402	0.12
2N5457	0.45
2N5458	0.40
2N5459	0.40
2S017	16.00
2S019	25.00
2S024	35.00
2S025	35.00
2S026	40.00
2S103	2.50
2S302	5.50
2S303	5.50
2S322	5.00
2S325	4.00
2S701	12.50
2S745A	1.75
2S746A	1.75

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	35.00
A2521	25.00
A2900	15.00
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	165.00
BS90	58.00
BS810	60.00
BT5	58.95
BT17	185.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.90
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	27.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	50.00
E80CC	15.00
E80CF	11.27
E80F	14.19
E80L	13.73
E81CC	8.00
E811	13.27
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	10.33
E90CC	9.47
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10
E130L	18.50

E180CC	10.50
E180F	12.05
E182CC	13.25
E186F	11.50
E188CC	8.91
E280F	22.51
E283CC	12.00
E288CC	17.50
E810F	35.48
EA52	110.00
EA76	2.00
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	10.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	462.00
ECC33	4.50
ECC35	4.50
ECC40	5.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	3.50
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	5.00
ECF80	1.50
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00

EF85	1.75
EF86	3.50
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	15.00
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MUL	4.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	3.25
EL91	7.39
EL95	2.00
EL156	30.00
EL360	18.50
EL500	3.00
EL509	10.00
EL821	13.00
EL822	13.97
EL180	25.00
EM34	8.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	25.00
EN91	6.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	3.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
G551K	12.00
G180 2M	17.50
G240 2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	25.00

GU50	20.00
GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.40
GXU4	14.50
GXU50	20.00
GY501	3.00
GZ32	4.00
GZ33	4.75
GZ34	4.00
GZ37	4.75
KT61	5.00
KT66	15.00
KT77 Gold Lion	12.00
KT88 Gold Lion	20.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	10.25
M8091	10.43
M8096	6.80
M8097	8.15
M8098	8.15
M8099	8.00
M8100	10.30
M8136	11.75
M8137	12.25
M8140	6.00
M8141	6.50
M8142	8.75
M9144	7.50
M8149	6.50
M8161	9.35
M8162	11.75
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	115.00
MU14	2.50
MX119	55.00
MX123	86.00
MX145	61.50
MX151	18.30
MX152	150.00
MX161	175.00
MX163	19.50
MX164	26.40
MX166	164.00
MX168	78.50
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB3	2.50
OC2	4.35

OC3	2.50
OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	2.00
PC900	1.50
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.00
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	15.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504 5	2.50
PL508	5.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.50
PY82	1.50
PY83	1.25
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QF451	82.50
QQV02-6	38.00
QQV03-10	26.25
QQV03-20A	48.38
QQV06-40A	46.00
QQV07-50	76.65
QQZ06-40A	62.70
QU37	12.50
QV03-12	6.80

QV04-7	3.50
QV08-100	197.40
QY3-65	63.24
QY3-125	78.48
QY4-250	74.00
QY4-400	87.20
QY5-500	208.00
QY5-3000A	566.80
QZ06-20	46.00
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-1250	59.50
RG3-250A	32.68
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	50.00
TT21	37.50
TT22	37.50
TT100	60.00
TY2-125	78.75
TY4-400	88.20
TY4-500	124.26
TY5-500	272.50
TY6-800	231.00
TY5-4000A	637.20
TY6-5000B	395.00
TY6-5000W	523.00
TY7-6000A	632.00
TY7-6000W	579.00
TZ40	25.00
U18 20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	17.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10

UF80	1.75
UF85	1.75
UF89	2.00
UL41	5.00
UL84	1.75
UM80	2.00
UY41	4.00
UY85	2.25
VLS631	15.00
XG1-2500	100.00
XG5-500	30.00
XG2-6400	185.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	165.00
YD1120	395.00
YD1240	588.60
Z803U	25.00
Z759	25.00
ZM1001	8.00
ZM1020	9.00
ZM1020	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	265.00
2J70A	383.00
2J70B	336.00
2K25	175.00
34007	115.00
35007	100.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.05
3B240M	17.50
3B241M	17.50
3C23	25.00
3C24	12.00
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
4-65A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00

4C35	120.00
4CX250B	58.00
4CX350A	105.00
4X150A	60.00
4X150D	56.00
5I1E12	65.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	2500.00
5R4GY	5.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	5.99
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.02
6AN5	4.75
6AN8A	3.50
6AQ5	3.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BE4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	125.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00

6C16	£3.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H	14.00
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6JE6C	7.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	8.00
6L6G	5.00
6L6GA	3.50
6L6GC (GE)	5.75
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6RHH8 6KN8	10.00
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SL7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	4.25
6X4	3.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75

12AY7A	4.00
12B4A	3.50
12BA6	2.50
12BE6	2.50
12BH7	2.75
12BY7	3.00
12E1TT	28.00
12E14	65.00
12E1	20.00
13E1	170.00
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	6.45
90AG	20.00
90AV	20.00
90C1	6.00
90CG	14.54
90CV	15.45
92AG	20.00
92AV	20.00
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	47.50
813 valve	65.00
833A	193.16
866A	35.00
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.50
4212F	300.00
4212H	300.00
5544	110.00
5545	150.00
5551A	120.00
5552A	165.00
5642	9.00
5654	3.00

5651	4.45
5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	17.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	12.25
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	10.25
6067	11.75
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	12.00
6146B	12.00
6159B	19.00
6189	9.50
6201	11.40
6442	20.00
6550	10.00
6883B	12.50
6973	7.50
7025	4.50
7027A	8.00
7551	6.25
7586	15.00
7587	23.00
7609	56.00
7868	6.00
7895	12.00
8068	16.50
8136	2.50
8417	6.00
18042	11.53
18045	10.49
18046	11.53

Tested Ex-Equipment 4CX250B 8.50
CV Devices
Large stocks
Prices on application

BASES

B8G Unskirted	0.40
B7G Skirted	0.50
B9A Unskirted	0.40
B9A Skirted	0.50
B9D	0.55
Int. Octal	0.40
Loctal	0.55
Nuvistor base	2.00
Valve screening can all sizes	0.40

CRTs

2AP1	8.50
2BP1	9.00
3BP1	20.00
3DP1	5.00
3FG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00
5ADP1	55.00
5CP1	10.00

5CP1A	40.00
5P15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DG7-36	65.00
DH3-91	56.83
DH7-11	113.12
VCR138	12.00
VCR138A	12.50
VCR139A	8.00
VCR517B	10.00
VCR517C	10.00

CRT sockets
Prices on application

IC sockets
Texas
low profile

8	pin	10p
14	pin	10p
16	pin	10p

INTEGRATED CIRCUITS

7400	0.16
7400	0.35
7401	0.36
6402	0.36
7403	0.36
7404	0.42
7405	0.42
7406	0.48
7407	0.55
7408	0.36
7409	0.36
7410	0.36
7411	0.40
7312	0.42
7413	0.36

7416	0.48
7417	0.48
7420	0.48
7422	0.36
7423	0.36
7424	0.36
7427	0.36
7428	0.36
7430	0.36
7432	0.36
7433	0.55
7437	0.36
7438	0.36
7439	0.36
7440	0.36

7441	0.48
7442	1.25
7450	0.30
7451	0.30
7453	0.30
7454	0.30
7460	0.30
7470	0.48
7472	0.30
7473	0.48
7474	0.36
7475	0.65
7476	0.48
7480	0.32
7483	0.48

7484	0.72
7486	0.54
7490	0.72
7491	0.36
7492	0.54
7493	0.54
7494	0.78
7495	0.65
7496	0.60
7497	3.90
74100	0.84
74107	0.36
74109	0.54
74110	0.48
74111	0.51
74116	1.50
74118	1.20
74119	1.50

74120	0.75
74121	0.54
74122	0.70
74123	0.60
74125	0.60
74126	0.54
74128	0.55
74136	0.70
74141	0.46
74143	1.30
74145	0.72
74147	1.50
74148	1.40
74150	1.60
74151	0.36
74154	1.40
74155	0.60
74156	0.48

74159	1.75
74170	1.20
74172	4.00
74173	0.72
74174	0.60
74175	1.00
74176	1.00
74180	1.48
74190	1.20
74191	1.20
74192	1.10
74193	0.60
74194	1.10
74195	0.72
74196	1.00
74197	1.00
74198	2.20
74199	2.20

TAA570	1.75
TAA630S	1.75
TAA700	3.00
TBA480Q	1.50
TBA520Q	1.50
TBA530	1.50
TBA550Q	1.75
TBA560Q	1.75
TBA673	1.75
TBA700	1.50
TBA700Q	1.75
TBA750Q	1.50
TBA800	1.00
TBA920	1.75
TBA990	1.50
TCA270Q	1.00
TCA760A	1.25

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TELECOMMS TOPICS

Quadripartite digital cellular agreement

The UK, West Germany, France and Italy reached agreement on the introduction of a pan-European digital cellular radio service. At a meeting in Bonn, West Germany, on 19 May, the Ministers responsible for telecommunications and their representatives signed a declaration setting dates and targets for the new service which is to be established in these four countries from 1991. British Telecoms Mobile Communications and Racal were among the co-signatories to the Quadripartite Agreement.

An outline specification has already been prepared and there are not thought to be any sticking-points. Consequently, it is expected that the specification will be "firmed-up" within the next 12 months. The total equipment market for Western Europe alone is estimated to be between £500m and £600m per annum. These revenues being divided roughly equally between infrastructure equipment and the mobile phones.

Coopers & Lybrand lead network security study

A number of the leading European companies in information and telecommunications technology have agreed to participate in an EEC study of the security of network systems. The motivation being the increasing recognition of the increasing dependence on information technology. The urgent need being for systems in which owners, operators and users can have confidence in terms of the confidentiality of data; the integrity of data as regards error and fraud; and the availability of the system.

The Europe-wide study, with a budget in excess of £700,000, has been awarded to a consortium of five European member firms of Coopers & Lybrand and Admiral Computing. The results are scheduled for this September. The study is being funded by the European Commission, sponsors, Case-study organizations and C&L itself. Sponsors include the Italian and Dutch PTTs, GEC, Plessey, Olivetti, Siemens, DEC and Hewlett-Packard.

DTI ban on cordless phones

The Department of Trade and Industry has announced legislation to make the import, manufacture, sale or possession of certain unapproved cordless telephones, operating at frequencies below 853MHz, illegal. This will remove the anomaly whereby it was illegal to use such instruments, but legal to sell them.

Unlawful equipment can be seized and offenders face fines of up to £2000. By outlawing these telephones, the DTI aims to remove a considerable source of interference with legitimate radio users, including the emergency services.

BT opto spend in the City

British Telecom is investing £40 million on the second phase of its City Fibre Network (CFN). It will provide major customers with a single access path for all services and will reduce the time taken to provide private circuits to customers. Extra circuits can be switched in immediately from the control centre. Ultimately, control centre staff will be able to reconfigure existing circuits equally quickly and so allow customes to change the use of the circuits at will.

The first phase of the project – a £30 million contract covering the installation of more than 60,000km of fibre – is nearing completion and work starts shortly on installing terminal equipment (customer service modules) on the premises of the 100 customers who will be the first to use CFN. The fibre already installed has been linked to a System X service access switch (s.a.s.) at the main Baynard House exchange in the City of London to provide the cross-connections between different fibre links needed to set up private circuits between customers.

Under Phase two, the CFN will be extended to more than 600 sites and additional switching capacity will be installed. The control centre will give engineers access to BT's computerized fault-finding system for private circuits known as RATES (remote access and test equipment system) which allows circuit faults to be pinpointed quickly.

Nearly 100 Dealerinterlink customers will be the first to use the fibre network. Dealerinterlink was launched in December 1985 as part of BT's preparation for the "Big Bang". Customers rent groups of analogue (non-fibre) circuits which are all connected to a central point. This enables a private circuit to be set up with any other Dealerinterlink user within 24 hours. Other services will then be progressively provided via the fibre connections including telex, packet switched data, digital private circuits and analogue links.

STC, as prime contractor will be supplying the complete system and management of the project, while Plessey will provide varying combinations of telephone and data links on demand as user needs change – and even varied at different times of day. Allocation, reconfiguration and addition of new channels up to the 34Mbit/s capacity of each optical-fibre link is done via its control computer keyboard.

Battle for share of the cells

With the backing of a £5 million advertising campaign, Cellnet has announced that, until August, subscribers joining the system will only have to pay half the normal subscription for a six months period. Vodafone responded by authorizing its dealers to give a £75 discount – effectively the same as Cellnet – to those who join within this period.

Cellnet launched its attack with the objective of gaining the lion's share of the around 100,000 new subscribers expected in the forthcoming year. At present, Vodafone is believed to have 80,000 of the 150,000 users and has been suffering from network congestion in the London area. It has only been partly successful in its attempt to get further channels allocated in the London area on a temporary basis until further channels become available next year.

First System X for Guernsey Telecoms

Guernsey Telecoms has completed the first stage in its modernization plan with the recent official opening of its first System X exchange.

Plessey Major Systems Ltd is the prime contractor for this turnkey project for the island, whose economy depends to a large extent upon off-shore finance. Scheduled to be phased in over a 15 year period, it includes seven digital exchanges and an optical-fibre network to link them. The fibre network has been completed, together with the Castel exchange. This is the first "split-mode" combined trunk and local System X exchange to be brought into service. It carries 5,400 subscriber lines, plus all initial trunk and international traffic. Its initial capacity of 480 Erlangs will reduce to 360 when the second trunk/local exchange is cut over early next year. This will be located just behind GT's headquarters in St Peter Port. (Erlang is a unit of traffic intensity where one permanently engaged circuit has a traffic flow of 1 Erlang).

The remaining exchanges will be progressively replaced by System X and this programme will be supported by the provision of a new optical-fibre cable to the UK that will initially operate at 140Mbit/s. This will be backed-up by a duplicate digital route via the French mainland, employing digital microwaye links to France, via Jersey, and then landlines across France.

At the present time, transmultiplexers have been installed to provide an interface between the existing analogue submarine cables to the UK and GT's growing digital network.

Guernsey Telecoms serves all the islands of the Guernsey Bailiwick: Guernsey, Alderney, Sark, Herm and other, smaller, inhabited islands. Currently there are over 26,000 exchange lines and nearly 50,000 telephones connected to the system. Other services provided by GT include packet switching, wide-area paging and, at the beginning of May, it linked into the Cellnet cellular radio network.

Mercury/ Australia switching deal

A direct international public switched telephone service between the UK and Australia has been initiated by Mercury Communications Ltd and the Overseas Telecommunications Commission (Australia).

Mercury already has public switched service agreements with the USA, Canada, Hong Kong, Bermuda, Bahrain and Belize. Its customers making international calls to these destinations can obtain savings of up to 17 per cent. Mercury currently operates voice and digital private leased lines between the two countries and plans to expand this service during 1987.

Fibre around the world

Pacific Telecom Cable Inc. has been granted a licence by the Federal Communications Commission (FCC) to land a new, high-capacity transpacific optical-fibre cable in Seattle and Anchorage. PTC is 80 per cent owned by Pacific Telecom with UK company Cable and Wireless owning the balance.

The proposed cable will be the first direct fibre link between the USA and Japan and has an estimated cost of $500 million. The venture is fully supported by the US as serving national security interests through providing diverse routing for critical communications and as furthering competition in international telecommunications.

Mr Joe Crouch, C & W director for North America and a director of PTC, pointed out that "In Japan, the Anglo-United States-Japanese consortium (International Digital Communications) is proposed for a second international telecommunications carrier licence. All the partners in IDC see the Pacific cable as central to its business and look forward to the Japanese government expediting its endorsement of the US Government's approval of the new cable and believe that the speedy issue of a licence to IDC as an international telecommunications operator and co-owner of the cable is essential to enable the project to be implemented within the time frame stipulated."

Leased line to Japan

Mercury Communications, in conjunction with the Japanese international telecommunications company KDD, is expected to launch a leased line service to Japan even though its parent company, Cable & Wireless, is still embroiled in the fierce battle between rival consortia fighting for the second Japanese international telecommunications licence.

KDD has recently applied to the Japanese Ministry of Posts & Telecommunications for permission to operate, in conjunction with Mercury, a service to the UK. This is seen as being an important breakthrough for Mercury as it could be the first step in obtaining permission to operate a switched service to Japan.

Paging upheaval

There is growing competition in the wide area paging market. Mercury Paging, a company owned jointly by Mercury Communications (51 per cent) and Motorola, has entered the market where British Telecom has an 80 per cent share. Motorola is providing the pagers and setting up the v.h.f. transmitters, which will be connected via the Mercury backbone optical-fibre network, while Mercury will operate the service.

Initially, the service will operate in the Greater London area, but during the year its coverage will be extended with the target of nationwide coverage by 1989. In a noticeable departure from usual industry practice the company is offering pagers on lease in addition to rental. Managing director, Bob Ure, says that the company aims to be broadly competitive with British Telecom, but believes that he has better designed coverage plans. He went on to say that the UK lags behind the USA and other countries in the use of paging.

In addition, when questioned, Ure said that the software is currently being written that will allow Mercury pagers to be accessed via the Mercury Link electronic mail service.

Even greater competition can be expected before the end of the year with at least one of the other two licencees for national paging services commencing operations. One is Racal and the other a consortium of existing paging operators; Aircall, Digital Mobile Communications, InterCity and Page Boy.

Dialcom extends to Finland

The Finnish PTT has signed a letter of intent to provide the Dialcom electronic mail service which is marketed under the name Telecom Gold in this country. Dialcom will now negotiate a licensee contract to enable the PTT to use the company's software and services.

Finnish PTT manager, Leena Save commented that "X.400 is fast emerging as the international standard in Europe and Dialcom has the lead in X.400 software in the public message handling domain. No progressive telecommunications company can overlook that fact. A second important reason for our choosing Dialcom is because it is the choice of many other PTTs. It is serving the largest community of international licensees with software and techniques that have proven themselves over the years."

Dialcom has 16 other licensees around the world and claims to be the leading international supplier of value-added mail and other services with more than 250,000 mailboxes worldwide, including 76,000 in the UK.

Plessey and Racal link on mobiles

Plessey and Racal have announced the formation of a 50/50 jointly-owned company to undertake the design, development, manufacture and marketing of civil mobile communications infrastructure and subscriber equipment. This follows closely on the heels of the European Quadripartite Agreement on digital cellular.

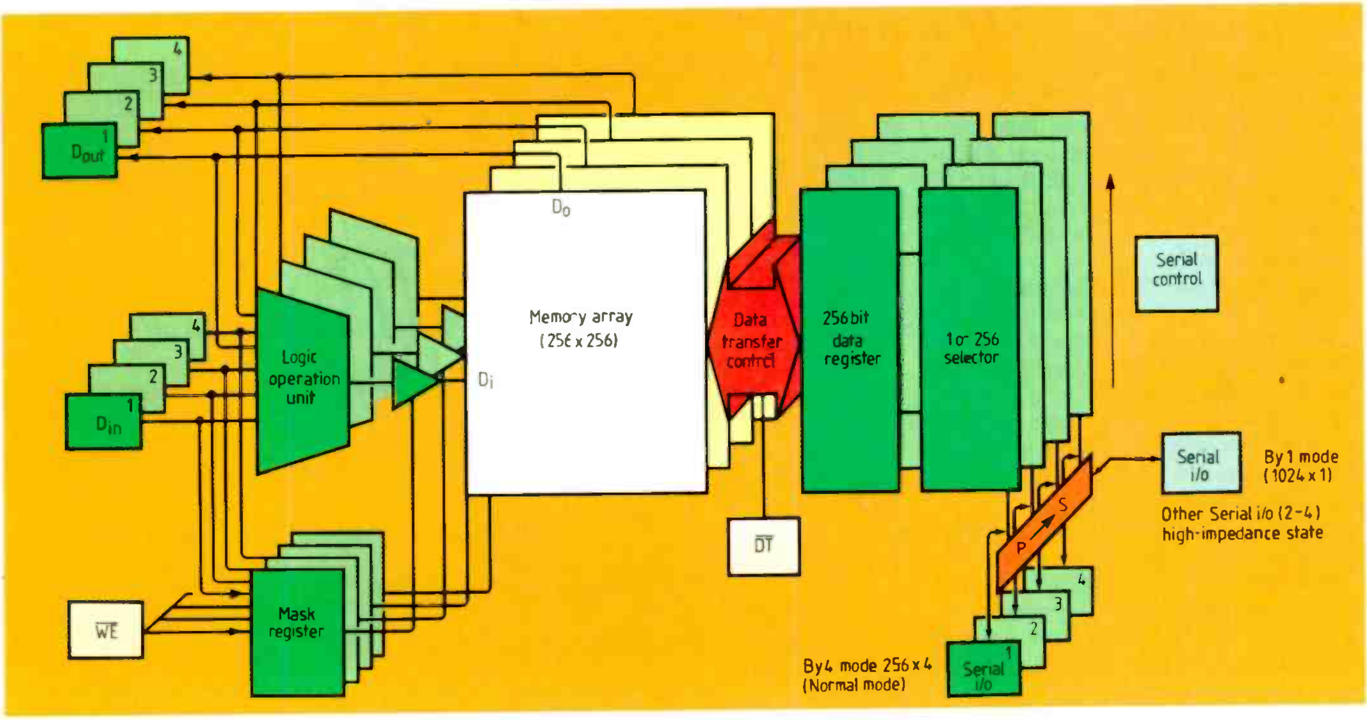
The main objectives of the new company, Orbitel Mobile Communications Ltd, is to develop equipment for the pan-European digital cellular system which is to be introduced throughout Europe in the early 1990s. While the new company will be at arm's length from its parent companies, it will complete existing Vodafone orders for base stations and terminals. This will result in a 1987/88 turnover of some £25million. According to David Dey, managing director of Plessey Telecommunications and Office Systems Ltd and chairman of Orbitel – this latter post will alternate annually between the two companies – the company cannot afford to sit on just one product and service to enable it to meet a 1990/91 target of £100m. In addition to cellular, it will be looking to other areas such as private mobile radio. Consequently, he expects the two parent companies to invest around £30m over three years.

Orbitel intends to be a member of a major European cellular consortium. It is engaged in talks across Europe and aims to join the group which offers the best scope. In addition, it would be interested in a USA involvement – especially if it provided access to the US market.

Dey stressed that customer demand for cellular is proven; digital technology is available; and the pan-European political will is present. The total equipment market, estimated to be between £500m and £600m for Western Europe alone, is expected to grow significantly as the European standard is adopted in other parts of the world.

By Adrian Morant

APPLICATIONS SUMMARY



MULTI-PORT VIDEO RAM

Comprehensive details for display-system designers are included in the Multi-port video ram application design guide. The 110-page guide gives a general background to video rams and details on Hitachi HM53461/2 v-rams including address mapping and timing information.

Most of the applications section describes a 512-by-512 pel bit-mapped display system for interfacing to a 16bit microprocessor. Sixteen 256Kbit v-rams arranged in four banks of four provide 16bit/pel and the pel rate is 25MHz. Smooth scrolling, clearing pels at high speed and multi-processor interfacing are also discussed in the guide.

Video rams in the 53461/2 series consist of a main 64K-by-4bit dynamic memory and a 256-by-4bit serial-access memory. The 53462 shown here includes a Boolean logic unit. During a data-transfer read cycle, addressed data is transferred from the main memory into the data register ready for serial access. Access time of the serial memory is 40-60ns whereas access time of the main memory is 100-150ns.

Function	Operation	Result
Ø	Ø	ZERO
1	AND1	D . M
2	AND2	$\bar{D}$. M
3	X4 -> X1	1024 x 1
4	AND3	D . $\bar{M}$
5	THRU'	D
6	EOR	D⊕M
7	OR1	D + M

Function	Operation	Result
8	NOR	$\overline{D + M}$
9	ENOR	$\overline{D \oplus M}$
10	INV1	$\bar{D}$
11	OR2	$\bar{D}$ + M
12	INV2	$\bar{M}$
13	OR3	D + $\bar{M}$
14	NAND	$\overline{D . M}$
15	1	ONE

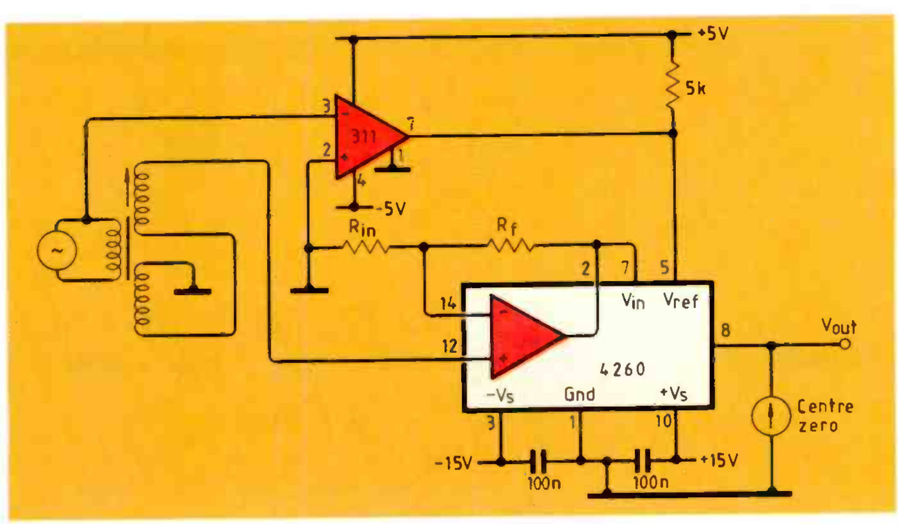
M = MEMORY CELL DATA
D = EXTERNAL DATA IN

LVDT WITH PHASE-SENSITIVE DETECTOR

Essentially, the 4260 synchronous detector is a unity-gain amplifier that can be switched between inverting and non-inverting modes using a t.t.l. level signal. It also includes an uncommitted general-purpose op-amp similar in specification to a 4558.

In RCA's preliminary data sheet for the RC4260, the linear variable differential transformer with phase-sensitive detector shown here is accompanied by circuits for suppressed-carrier modulation and precision rectification. Output polarity of the rectifier circuit is logic-selectable.

Distortion of the detector is typically 0.01%, it switches in 10μs and its gain differential is at most 1%.



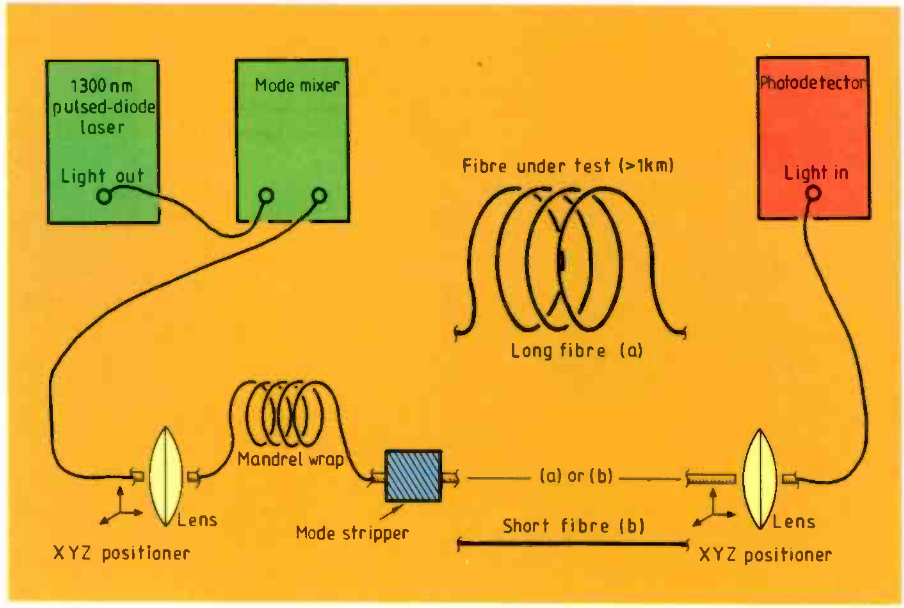
APPLICATIONS SUMMARY

OPTICAL FIBRE TESTING USING FFT

With pulsed diode lasers and fast detectors it is possible to measure optical fibre bandwidths up to 10GHz and pulse dispersions down to 20ps at wavelengths from 800 to 1550nm. An application note for the FPS10 Fourier processing system outlines the equipment and test set-ups needed to make these measurements.

The note, from Opto Electronics, describes how measuring bandwidth and dispersion involves comparing results from two different lengths of the same fibre, one typically greater than 1km long and the other a few metres long. Pulse-response measurements of long and short lengths of fibre are made and Fourier transforms of each measurement are carried out.

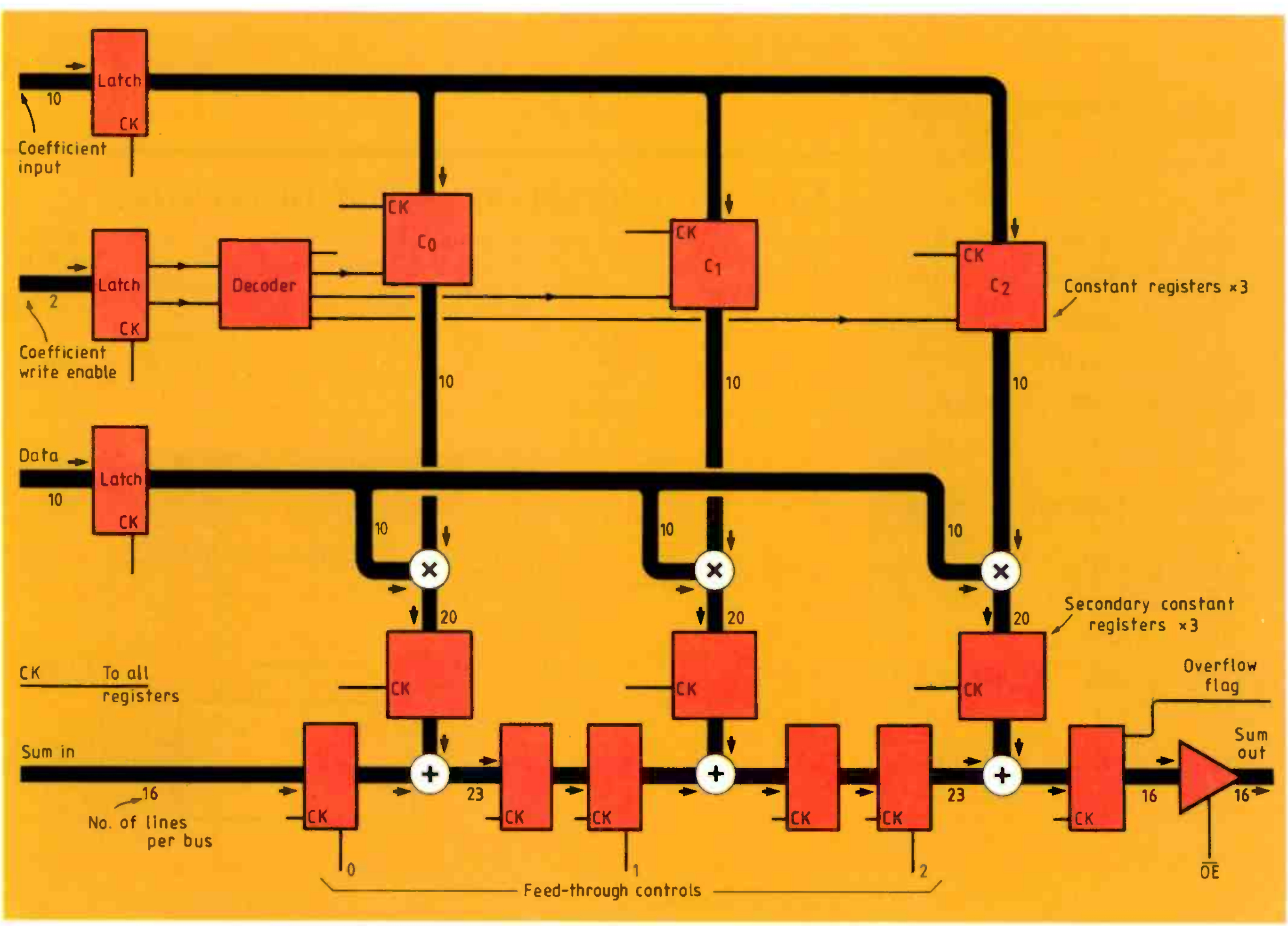
Frequency response of the long fibre is calculated by taking the ratio of long-to-short length Fourier transforms. Pulse response of the fibre is obtained by performing an inverse Fourier transform on the frequency-response curve.



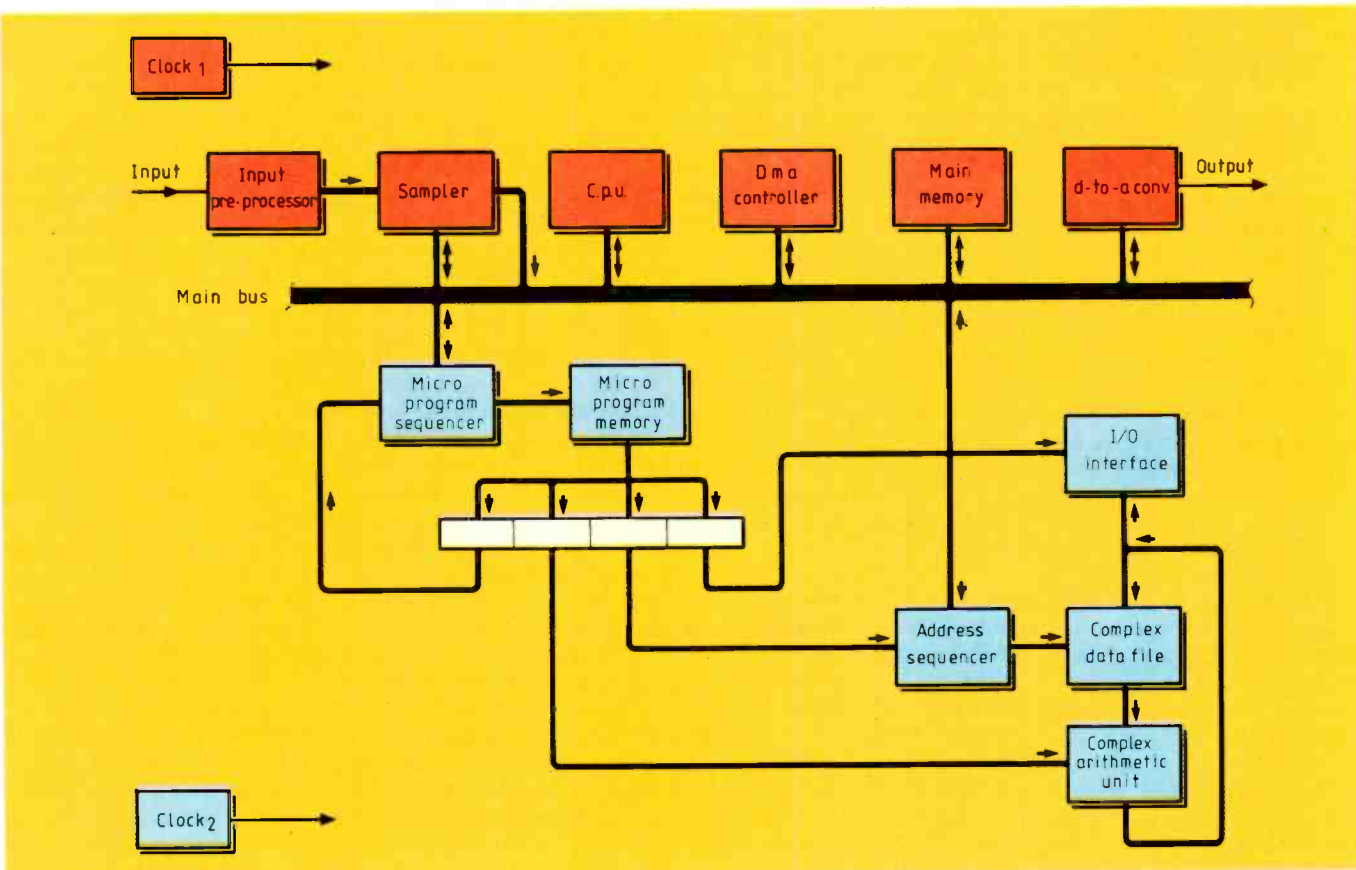
FIR FILTER

Three identical arithmetic cells each containing a 10-by-10 bit two's complement multiplier and 23-bit adder form the TMC2243 finite impulse response filter. Preliminary data on the TRW device includes specifications, general information and brief details on how to configure the device registers for adaptive filtering.

Applications of the 20MHz device include video and radar signal processing, one and two-dimensional convolution or video filtering and arithmetic elements in systolic array processors.



APPLICATIONS SUMMARY



SIGNAL-PROCESSING BUILDING BLOCKS PROVIDE FASTER FFT

An article in Logic Devices' product catalogue describes how high-speed c-mos building blocks form an FFT system that works up to 100 times faster than some single-chip solutions. The article discusses FFT in general, the two main types of single-chip digital signal processors, and a building-block approach that performs a 1024-point complex FFT in 500ns.

One group of single-chip digital signal processors, which includes the TMS32010/20 and μPD77230, has on-chip instruction and data memory. These processors work most efficiently when the program and data are in the chip's memory throughout the whole process. But computational throughput is still slow since only two data operands can be processed in any given cycle. If the number of sampled data points to be processed exceeds the on-chip memory capacity then data has to be stored in external memory which slows down processing and increases software overhead.

The second group of processors, which includes the LM32900 and ADSP2100, relies on external program/data memory. They have two independent buses to make accessing of external memory efficient but they can still only process one set of operands in any given cycle. Running two devices in parallel increases performance but control and synchronization circuits are needed.

Building blocks can minimize the number of machine cycles needed for each butterfly computation (flow of each basic FFT cell forms a 'butterfly' pattern). With the architecture shown each butterfly takes two machine cycles: pipelining is for 32bit complex-data FFT.

The article, entitled 'New high-speed c-mos building blocks provide a clean implementation of the FFT for applications where single-chip DSP microprocessors cannot provide the necessary throughput' is in the product catalogue supplement.

Performance figures for 1024-point complex FFT

Signal processor	Memory	Instruction cycle time	1024-point complex FFT	Sampling rate
TMS32010	144×16 data ram 1536×16 rom	200ns	75.9ms	13.1kHz
μPD77230	1K×32 ram 1K×32 data rom 2K×32 rom	150ns	10.75ms	100kHz
LM32900	External	100ns	13.42ms	78kHz
ADSP2100	External	125ns	7.2ms	142kHz
Building blocks	External	50ns	0.5ms	2MHz

ADDRESSES

Hitachi Electronic Components
21 Upton Road
Watford
Hertfordshire WD1 7TP
0923 46488
Telecom Gold 76:HEC011

RCA
Semiconductor Specialists
159 High Street
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West Drayton
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Opto Electronics
Oriel Scientific
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Leatherhead
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TRW
Accent Electronic Components
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Letchworth
Hertfordshire SG6 1TL
0462 686666

Logic Devices
Abacus Electronics
Abacus House
Bone Lane
Newbury
Berkshire RG14 5SF
0635 38670

DUAL-PORT STATIC RAMS
The telephone number with last month's description of a dual-port ram application was for VLSI Technology's facsimile machine; it should have read 0908 667595.

SATELLITE SYSTEMS

Electronic tracking for inter-orbit links

Fast acquisition, simple microwave components and no need for a separate tracking receiver are features of a British electronic beam-pointing system to be used for inter-orbit communication. The idea is to keep the antenna beam of one satellite accurately pointed at the antenna of another satellite, in a different orbit, to ensure good radiocommunication between the two spacecraft. This electronic tracking system, developed by ERA Technology Ltd, will be used by ESA for an inter-orbit, two-way, communication experiment at 20/30 GHz between the low-orbiting European Recoverable Carrier (Eureca) and the geostationary Olympus satellite (see item in July issue).

Direct radio links between satellites — without passing through ground stations — are not yet an established part of the technology, though the principle is quite old. They were used, for example, in 1969 between spacecraft in the Apollo (moon landing) project, several times during the 1970s, and in 1983 between a data relay satellite (TDRSS-1) and the Spacelab and Landsat spacecraft. For satcom systems, the possible advantages lie in the avoidance of double hops (requiring earth stations), a better utilization of the available frequency spectrum and a less complicated earth segment. Anyway, this is what ESA plans to investigate with the Eureca-Olympus experiment.

The WARC 79 inter-satellite frequency allocations to be used for this particular experiment are 22.5 - 23.55 GHz and 32-33 GHz, but there is another allocated pair of bands at 54.25-58.2 GHz and 59-64 GHz — well into the millimetre waves. In addition, both ESA and INTELSAT are considering the possible use of optical frequencies generated by diode lasers with wavelengths of 0.8 to 1.5 μm to achieve very narrow beams over long distances.

ERA's electronic tracking system is centred on a microwave antenna feed device, as shown in the photograph, to be installed in Eureca. The feed horn, for both transmit and receive, illuminates a shaped, dual-reflector antenna. In response to a beacon signal from Olympus the antenna beam is electronically squinted in different directions and the resulting different received signal strengths provide information for antenna steering.

Beam squinting is achieved by generating proportions of higher order waveguide modes within the feed horn to modify the aperture illumination. A higher order mode of suitable amplitude and phase, in combination with the fundamental mode, produces an overall phase tilt. This feed phase tilt results in a displacement in the antenna's radiation pattern — hence a beam squint.

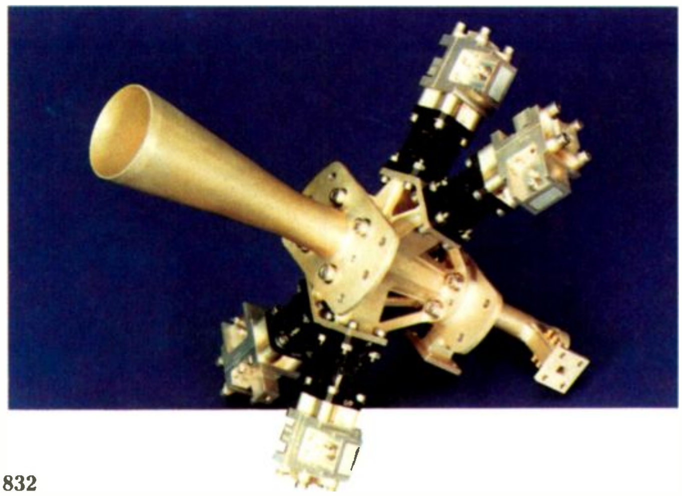
Referring to the photograph, the mode generator section comprises a central circular waveguide with four short-circuited lengths of rectangular waveguide coupled to its periphery in selected positions. Each auxiliary waveguide connected to the circular guide is terminated by a p-i-n diode. The mode generation is activated by reversing the bias of this p-i-n diode.

To locate the Olympus beacon transmitter the four higher order mode generators go through a search pattern under the control of the p-i-n diodes. In this the beam is sequentially switched from true boresight to each of four positions: elevation up and down; azimuth right and left. The strength of the beacon signal at each beam position is detected by the normal communication receiver in Eureca, converted into digital data by an a-d converter, and each measurement is passed to a microprocessor, where it is stored in conjunction with its co-ordinate directions.

Computation in the microprocessor then provide an error signal for a closed-loop control system operating the antenna steering. Thus the Eureca antenna is steered until its beam is accurately pointing at the Olympus antenna.

In the electronic scanning system the rapid switch-and-measure sequence allows the whole search pattern to be completed in a fraction of a second. Although the two spacecraft are always moving relative to each other, no substantial change in position occurs during this time frame. So the four measurements of the search pattern can be regarded as simultaneous. The ERA electronic tracking system has already been tested on earth stations working to satellites.

Antenna feed system for electronic-scan tracking developed by ERA Technology for the European Space Agency's 20/30-GHz inter-satellite communications experiment between the Eureca and Olympus spacecraft.



Third European comsat

A third European communications satellite for telecommunications and tv signal distribution is expected to be launched by Arianespace in August this year from Kourou, French Guiana (Africa). This is ECS-4, so called because it is part of the European Communications Satellite system. In the ECS system the comsats are specified, purchased and launched by the European Space Agency (ESA). They are then operated and managed by Eutelsat, another international organization but set up by the various European telecomms administrations (see December 1978 issue, p.63).

Under its Eutelsat colours ECS-4 will be known as Eutelsat I, Flight 4 (or I-F4). Here the Roman number 'I' indicates that the spacecraft belongs to a first generation of comsats, which so far amounts to two satellites in regular operation, Eutelsat I-F1 and Eutelsat I-F2 (or ECS-1) and ECS-2). Altogether, five comsats have been planned for Eutelsat I. They are manufactured by a European consortium led by British Aerospace as prime contractor. Later on a second generation of comsats, Eutelsat II, will be launched. Here the manufacturing consortium is led by Aerospatiale of France. ESA has so far ordered four spacecraft for Eutelsat II and there is an option for a further four.

Readers may well ask why a third European comsat is called ECS-4. Those with long memories will recall that an ECS-3 (to become Eutelsat I-F3) was actually built but was lost in a launcher failure in 1985. So the new ECS-4 really replaces ECS-3. Assuming this year's launch is successful and the new comsat goes into regular operation, ESA will then continue with the planned ECS-5. There is also a possibility of adding a sixth spacecraft to make up the total communications capacity originally intended for Eutelsat I.

Like ECS-1 and -2, the latest geostationary comsat is designed for relaying European public telecommunications traffic (telephony, data, facsimile etc.) and for distributing television signals, both for EBU broadcasters and for commercial satellite tv operators. It will be stationed at 10°E. Like ECS-2, it also carries an additional payload for private business data communications, called the Special Multiservice System (SMS). The last-mentioned provides digital channels for data rates of 64 kbit/s, intended for various kinds of information — speech, data, text, graphics, facsimile, slow-scan tv and video-conferencing.

The communications capacity for all these services is provided by twelve 72-MHz transponder channels for the public telecommunications and tv signal distribution traffic, plus two 72-MHz channels in a separate frequency band for the private SMS traffic. Uplinks are at 14 GHz and downlinks at 11 GHz, as is standard in the Ku-band Fixed Satellite Service. The 12 main channels are actually provided by six channel frequencies, which are doubled-up by the use of horizontal and vertical polarizations. Thus in the 11-GHz downlinks (within 10.95-11.7 GHz), channel 1 and channel 7 share the same channel frequency, but with different orthogonal polarizations, and so on, up to channels 6 and 12, which use a common channel frequency on the same principle. The SMS repeater has its separate downlink sub-band at 12.5 to 12.58 GHz.

Coverage of the European land mass is achieved by two broad antenna beams, called Eurobeams, and three spot beams named respectively Atlantic, West and East. As can be seen from Fig. 1, these are produced by six antennas on the spacecraft. All the primary telecomms and tv distribution uplink signals are received by a Eurobeam receiving antenna. The public telecomms downlink signals are sent back to earth by three spot-beam transmitting antennas, depending on destination, while the tv distribution downlink signals are radiated by a Eurobeam antenna. All the spot-beam transmitters give an e.i.r.p. of 40 dBW, while the Eurobeam transmitters provide 34 dBW. As can be seen from the diagram, the sixth antenna is used for both reception and transmission of the SMS payload data signals.

Uplink signals are all preamplified in four wideband receive chains, arranged to give a redundant configuration. They then undergo double frequency conversion, with common downconversion to the first i.f. The 72-MHz bandwidth is established in the i.f. section. In the primary 12 transmitting chains there is a switching system to the output duplexers which allows the comsat some flexibility to meet varying traffic requirements.

The digital modulation system adopted by Eutelsat for sending the p.c.m. public telecomms traffic through their comsats is four-phase p.s.k., operating at 120 Mbit/s. In this the transmitted carrier assumes any of four phases according to the instantaneous value of the modulating

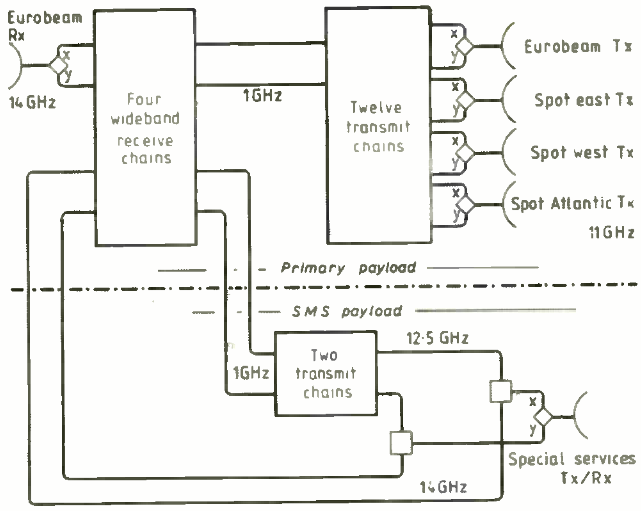


Fig. 1. Simplified block diagram of transponders in the ECS-4 comsat, showing the main telecomms/television payload at the top and the special business communications payload at the bottom.

signal. Each phase state conveys two bits of information. The television signals are, as usual, in the form of analogue f.m., requiring transponder bandwidths of 27 or 36 MHz. Audio is carried by sound-in-syncs for broadcast signal distribution and by subcarriers (typically 6.65 MHz) for the commercial satellite tv programmes. The separate SMS payload uses p.s.k. for its digital transmission, in a single-channel-per-carrier (s.c.p.c.) frequency-division system. It will handle, for example, BTI's Satstream Europe business service (and see photo of German earth terminal in June issue, p.603).

Perhaps the most characteristic feature of the ECS system is that from the very beginning it was designed to provide multiple access to transponders from different earth stations on a time-division, rather than frequency division, principle. ECS-4, therefore, uses time-division multiple access (t.d.m.a.) for its main telecomms traffic and does so in conjunction with digital speech interpolation (d.s.i.). This combination is more efficient than earlier frequency-division multiple access systems, allowing a greater number of telecomms circuits to be carried by a single comsat.

In t.d.m.a. a relatively low-speed continuous bit stream is processed in the earth terminal to be transmitted through the satellite in short bursts at a much higher speed. These bursts are interleaved with bursts from the other earth stations working through the same satellite transponder on the same frequency. A complete set of bursts from all the different earth stations using the satellite is called a frame. Because the comsat amplifier handles only one burst at a time before re-transmission it can be operated at high power without unacceptable distortion — hence the greater efficiency.

Digital speech interpolation exploits the fact that, on average, each participant in a telephone conversation is silent for about 60% of the time. A caller is only assigned a satellite channel when he/she is actually emitting sounds and so generating digits. In the intervening times the channel is available to carry the digital speech burst from other conversations.

Addendum on Astra

Since the item on Luxembourg's commercial television satellite was written for the June issue (p.603) more details have become available on this system.

The 16 channels at frequencies from 11214.25 MHz to 11435.5 MHz are, of course, slotted into what was once a 250-MHz gap in the Fixed Satellite Service (FSS) Ku band allocation, from 11.2 to 11.45 GHz.

This spectrum space was made available for FSS by an allocation decision at WARC 1979. Astra's transponder bandwidth is 26MHz. This may not seem to fit with our statement that the 16 channel frequencies are spaced at intervals of 14.75 MHz, but is explained by the fact that frequency re-use made possible by different polarizations allows channels to overlap. Thus the vertically polarized channel 2 partly overlaps both channel 1 and channel 3, which are both horizontally polarized.

Astra's European coverage, determined by beam shaping in the RCA 4000 satellite antenna system, will be a footprint something like a rectangle with rounded corners, wider (east-to-west) than it is high. An inner field-strength contour corresponding to a nominal transmitter e.i.r.p. of 50 dBW will extend about 22° in longitude, encompassing Dublin to Berlin, and about 13° in latitude, encompassing Edinburgh to Marseilles. Outside of this, a 46-dBW contour bulges at the south-west corner of the 'rectangle' to cover almost the whole of Spain. This outer contour will also enclose the northern half of Italy, southern Norway and Sweden, and the whole of Ireland and Scotland.

Société Européenne des Satellites is a company which owns and operates the Astra system. It does not produce television programmes. The commercial programme companies using the system will in general transmit their programe feeds directly to the satellite (in the 14.25-14.50 GHz uplink band) from fixed or transportable earth stations in their own countries or from wherever convenient. In the UK, for example, uplinks will operate through BT's London Teleport.

However, SES does provide an uplink earth terminal at its Betzdorf control station in Luxembourg for any programme companies who may wish to use it. Also at Betzdorf is an 11-metre dish antenna for satellite tracking, telemetry and control purposes. A transportable earth terminal is available there for back-up telemetry and command and for occasional uplinking requirements.

Satellite Systems was written by Tom Ivall.

A new look at gain-bandwidth product

Does the bandwidth of a feedback amplifier necessarily have to shrink as the gain is increased? Is it a fundamental limitation or is it simply a result of the way we design feedback amplifiers?

B. WILSON

It has become generally accepted over the years by most designers of electronic circuits containing feedback voltage amplifiers that the gain-bandwidth product available is constant. Observations of dramatically reduced bandwidths at higher gains have become so commonplace that it has been elevated subconsciously to the status of a physical law. But is this necessarily correct? Is it in fact an expression of a fundamental concept; or is it simply something that occurs solely as a result of the way in which we design feedback voltage amplifiers?

THEORETICAL

Figure 1 shows the traditional form of a non-inverting feedback voltage amplifier configured from a voltage operational amplifier (v.o.a). The aim is to produce a stable voltage gain by employing feedback around a v.o.a. which displays a very high gain, perhaps in excess of 100,000 or 100 dB, that is only imprecisely defined at the manufacturing stage. After the application of feedback the overall voltage gain is lower, but stabilized against changes in the v.o.a. gain.

If we restrict our attention to a v.o.a. exhibiting a single-pole response, the trade-offs can be seen graphically in Fig.2. It is self evident that, because of the falling v.o.a. gain above some low-frequency breakpoint, the bandwidth available for low gains is greater than that available for high gains. For the example illustrated, the gain-bandwidth product is always constant at 1MHz. In other words, this particular amplifier would be advertised as having a unity-gain bandwidth of 1 MHz.

Analytically, one may represent the overall voltage gain G_v after feedback by the usual expression

$$G_v = \frac{A_v}{(1+A_v\beta)}$$

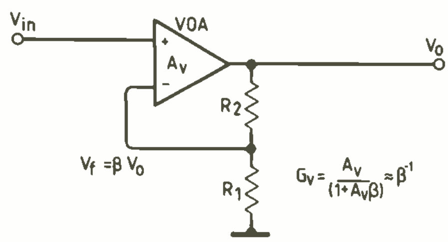


Fig.1. A feedback voltage amplifier is usually configured from a voltage operational amplifier (v.o.a).

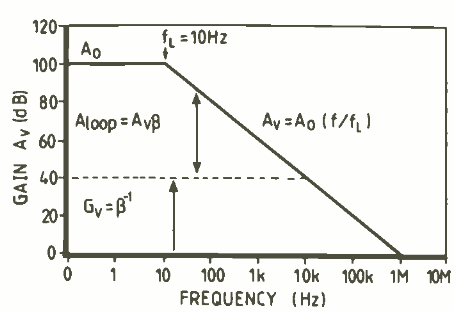


Fig.2. A v.o.a. using traditional feedback produced lower bandwidth at higher gains.

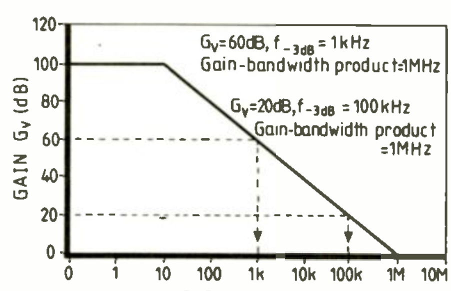


Fig.3. Reduction of loop gain at higher frequencies results in a constant gain-bandwidth product.

where A_v is the v.o.a. forward voltage gain as a function of frequency and β is the feedback voltage fraction. For conditions under which $A_v >> 1$ this is usually simplified to the familiar result

$$G_v \approx 1/\beta.$$

Bandwidth restrictions come about because A_v is a falling function of frequency, intersecting a line representing G_v and denying the system the loop gain that it needs in order to function correctly as a feedback system, as shown in Fig.3. The v.o.a. gain A_v may be related to its very low frequency gain A_o through the relationship

$$A_v = \frac{A_o}{[1+j(f/f_L)]}$$

where f_L is the low-frequency breakpoint, taken here to be a typical value of 10 Hz. At frequencies well removed from f_L the expression for the magnitude of A_v may be simplified to

$$A_v = A_o/(\frac{f}{f_L}).$$

To a high degree of precision it can be said that the system bandwidth is reached at the frequency where the loop gain A_{loop} has fallen to unity (or 0 dB). Figure 3 shows that this happens when

$$A_{loop} = A_v\beta = 1.$$

Substituting for A_v then gives

$$A_o\beta = (f/f_L).$$

Changing the general symbol f at the bandwidth limit to BW, and recalling that $G_v = \beta^{-1}$, then yields

$$\frac{G_v}{A_o} = \frac{BW}{f_L}.$$

Re-arranging,

$$G_v.BW = A_o.f_L.$$

In other words, the gain-bandwidth product most certainly is a constant and is equal to the product of the low-frequency gain A_o multiplied by the low-frequency breakpoint f_L.

For amplifiers with a two-pole response, the bandwidth restriction effects are even worse, of course. After the second pole has been passed, A_v falls even faster by an additional 20 dB per decade, reducing the bandwidth extension below that availiable from a single-pole response. This effect is not always immediately apparent, however, since the majority of v.o.as. are used with a dominant single response to avoid potential instability.

Can anything be done to improve the situation, especially since both the theoretical predictions and experimental results agree so closely? Is it indeed possible to design a feedback voltage amplifier where the bandwidth is independent of gain? The answer, as usual, depends upon describing the original problem in a different, and hopefully more illuminating, manner.

Looking again at Fig. 3 shows that the loop gain $A_v\beta$ may be re written as A_v/G_v, open-loop voltage gain divided by closed-loop voltage gain. For a given v.o.a., therefore, the loop gain available at any frequency is determined solely by the desired closed-loop voltage gain of the system . It is this fact which is responsible for producing a constant gain-bandwidth product. This restriction could be avoided quite simply by making the loop gain of a topology independent of its closed-loop gain, in which case the bandwidth would then be the same for all values of closed-loop gain G_v.

This may be arranged by designing a voltage amplifier using feedback around a current amplifier, as in Fig.4. In an analogous fashion to standard v.o.a. feedback analysis, one may assume that the voltage difference between the input terminals of the current operational amplifier (c.o.a.) is zero, equivalent to zero input resistance. Simple algebraic manipulation then produces an expression for the output voltage under no-load conditions as

$$V_o=\left(\frac{R_F}{R_1}V_1-\frac{R_F}{R_2}V_2\right).\left(\frac{A_i}{1+A_i}\right)$$

where A_i is the open-loop current gain of the c.o.a., assumed to display a similar frequency trend to the open-loop voltage gain A_v for a v.o.a., Restricting the analysis to the single-ended case with I_1 equal to zero for ease of comparison gives

$$G_v=\frac{V_o}{V_2}=-\frac{R_F}{R_2}\left(\frac{A_i}{1+A_i}\right).$$

Breaking the feedback loop conceptually at L demonstrates that the loop gain is given by A_i alone, with no contribution whatsoever from the closed-loop voltage gain. Hence the -3 dB bandwidth will now be governed by the frequency behaviour of A_i. Consequently, the bandwidth will be the same for all values of closed-loop voltage gain, set by R_F and R_1.

A parallel analysis may be developed when a v.o.a. is used to produce a defined closed-loop current gain, resulting also in a bandwidth that is independent of gain. It is therefore apparent that the restrictive case of constant gain-bandwidth product is a direct result of the feedback topology employed in previous traditional designs.

For a current amplifier that displays a high value of gain A_i, the closed-loop voltage gain of Fig. 4 will remain independent of A_i until the magnitude of A_i approaches unity. The frequency at which the magnitude of A_i becomes unity then corresponds to the -3 dB frequency of the closed-loop voltage gain. However, it is not necessary for the low frequency value of A_i to be very high, or even greater than unity, for the gain independence of the bandwidth to remain valid. As long as A_i remains well defined and stable the only consequence of a reduction in A_i is to reduce the factor by which R_F/R_2 is multiplied. The two situations of most practical interest will be to employ a very high, perhaps imprecisely defined, value of current gain such that the multiplication factor is unity; or to use a precise current gain of 1, in which case the factor will be exactly 0.5.

A class II current conveyor is an ideal candidate for this task, especially since it has a precisely defined unity current gain and a high-impedance input terminal in addition to the current input. Earlier articles in *Wireless World* have previously looked at mirrors, amplifiers and conveyors, but it will be useful to consider certain aspects of them here. Figure 5 shows the symbol for a current conveyor, where a voltage applied at the high impedance terminal Y is transferred directly to the low impedance terminal X. A current may be injected directly at X, or may occur as a consequence of an impendance being connected there. A direct copy of this current is then provided at the isolated current output, terminal Z. A current conveyor may be thought simply as a hybrid of v.o.a./c.o.a.

The most versatile design of current conveyor produced so far utilizes a v.o.a. and two current mirrors, connected to produce an output current by sensing the v.o.a. supply current, as in Fig. 6. This arrangement is necessary since manufacturers do not provide direct access to the collectors of a v.o.a's output transistors. To complete the picture, Fig. 7 illustrates how the current mirror may be constructed from four identical transistors to produce current replication with an accurately defined gain of unity. It is unusual to employ only transistors formed on the same substrate and packaged together to obtain the best matching and thermal tracking.

How may the current conveyors be used in practice to achieve voltage gain? Figures 8 and 9 illustrate the feedback connections required to produce both inverting and non-inverting voltage gains respectively. The topologies are extremely similar to the v.o.a. case, but it must be remembered that the inverting terminal is now a very low impedance current input. A little algebraic manipulation will show that the closed-loop voltage gain in each case is

$$G_v=-\frac{R_2}{2R_1}\text{(inverting)},$$

$$G_v=1+\frac{R_2}{2R_1}\text{(non-inverting)}$$

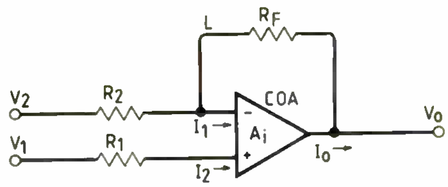


Fig.4. Voltage amplifiers may also be formulated by using feedback around a current operational amplifier (c.o.a).

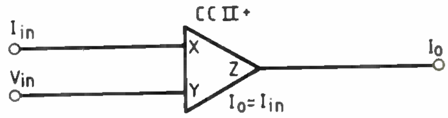


Fig.5. A class II current conveyor has a voltage input terminal (Y), a current input terminal (X) and a current output (Z).

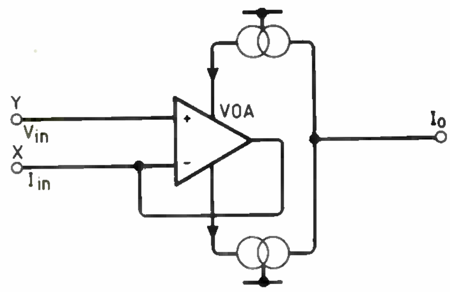


Fig.6. A current conveyor may be implemented from a v.o.a. and two current mirrors connected to give a current output.

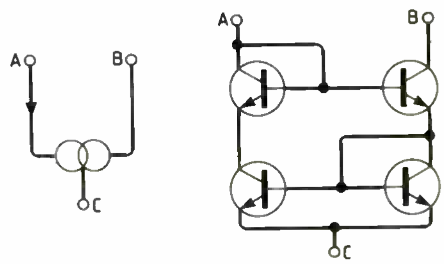


Fig.7. Stable and accurate current mirrors can be designed from four transistors.

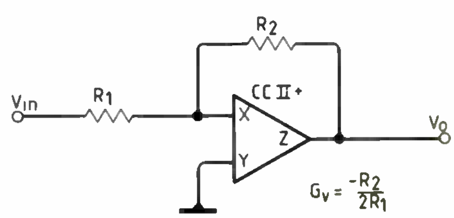


Fig.8. An inverting voltage amplifier with a constant bandwidth can be designed using a current conveyor.

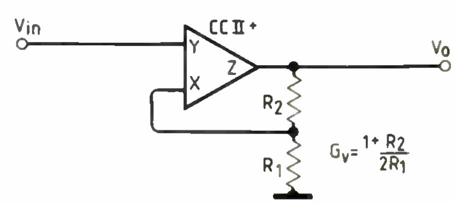


Fig.9. A non-inverting version is also easily available.

EXPERIMENTAL

The performance of voltage amplifiers constructed from current conveyors is extremely impressive. An inverting voltage amplifier may be designed by using CA3096AE array transistors for the mirrors and a 'bifet' LF351 as the v.o.a., formulated as in Fig. 10. Setting R_2 at 3.3 kΩ and varying R_1 produces gains ranging from unity to more than 100, with perfectly behaved square waves of up to greater than 10 V pk-pk output. In confirmation of the new analysis the output voltage risetime was found to be constant, in this case at about 100ns with a small overshoot, irrespective of the value of gain. Sinewave tests indicate a constant −3 dB bandwidth throughout the gain range of 3.5 MHz, exactly in accordance with the risetime measurements. Figure 11 presents the experimental gain-frequency plot, illustrating dramatically the freedom from gain limited bandwidth available from the new approach. The LF351 is advertised as having a unity-gain bandwidth of only 10 MHz: with the new topology it displays a behaviour equivalent to a gain-bandwidth of up to 350 MHz at 10Vpk-pk!

A constant bandwidth throughout the gain range is not the only advantage to be gained from this topology. Output voltage slew rate is also remarkably improved, since the v.o.a. output is now connected as a virtual earth and so does not move through any significant voltage whatsoever, leaving that task to the current mirrors. A risetime of 100ns for a 10Vpk-pk square wave when using an LF351 represents a slew rate of 100V/μs, whereas the data sheet indicates it has a maximum of 20V/μs. Substitution of other v.o.as, LM301A and 741 for example, with a much reduced slewing ability of less than 0.5V/μs, still results in almost identical results of nearly 100V/μs; a slew rate magnification of almost 200 in many cases.

In the non-inverting configuration the behaviour is extremely similar. Again setting R_2 at 3.3 kΩ, very sharp triangular and square waves can be reproduced with risetimes as low as 100ns. Figure 12 shows a photograph of 400 kHz output waveforms, both taken at a voltage gain of 15. However, in the non-inverting configuration, the v.o.a. output terminal is no longer a virtual-earth connection and slew rate effects begin to be apparent again at 10V pk-pk, especially as the gain is reduced. The effect is most noticeable at unity gain, where the v.o.a. experiences the full voltage excursion.

DISCUSSION

The new amplifier formulation uses current feedback to achieve bandwidth independence and cannot therefore supply a substantial output current without degrading the overall gain accuracy. A high-impedance voltage follower or high-speed, unity-gain current buffer should be added at the output for circuits where a significant output current is required. Alternatively the conveyor itself may use the current mirrors in a feedback connection to release a low-impedance output terminal. It is also possible, if required, for gain to be introduced into the conveyor circuit by including a current attenuator in the conveyor local feedback loop [1].

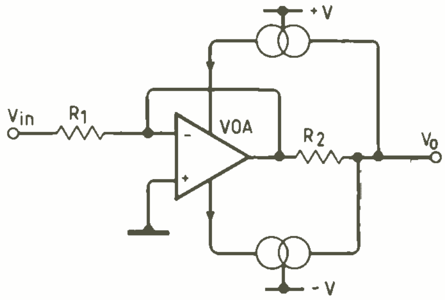


Fig.10. Actual circuit implementation of the new constant bandwidth amplifier with inverting gain.

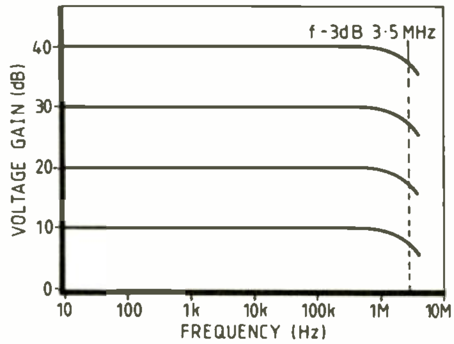


Fig.11. The frequency response from the circuit of Fig.10, showing a constant bandwidth for all gains.

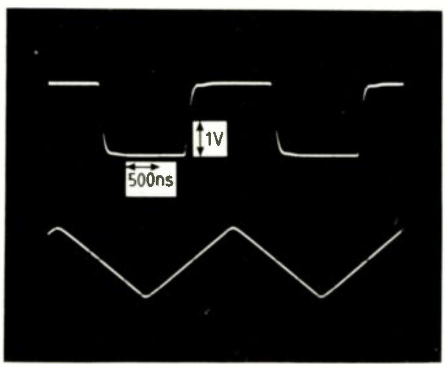


Fig.12. The non-inverting version also produces good fast triangular and square waves with risetimes as short as 100ns. (Scales: 1V/cm and 500ns/cm).

The effect of capacitance at the output of the current mirrors combines with resistance between output and ground to introduce a high-frequency pole into the circuit. For no-load conditions this resistance is determined primarily by R_2 alone. In most cases it is this pole which limits the high-frequency performance of the system, resulting in a risetime proportional to the value of R_2. Below a certain value of risetime, however, the current mirrors also become bandwidth limited, producing a characteristic double-pole overshoot in the square wave response below 100ns. For the best possible results, therefore, R_2 should be chosen to achieve the fastest risetime before the finite bandwidth of the mirrors becomes a limiting factor. R_1 may then be chosen to give the desired voltage gain.

To summarize, high gain and wide bandwidth can be obtained simultaneously if the traditional topology of a feedback voltage amplifier is modified to use current conveyors or current operational amplifiers. As an additional benefit, the restricted slewing ability of the v.o.a. can be overcome, even for a 741, opening up the area of high performance at relatively modest cost and complexity.

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2. Lidgey, F. J. and Toumazou, C., 'Accurate current follower' *Electronics and Wireless World*, April 1985, vol. 61, pp 17-19.

Brett Wilson lectures at UMIST in Manchester, where his two main interests are fibre optic communications and high-speed analogue electronics. He and his research students are currently investigating new designs of optical-fibre receivers and the transmission of high-quality multiplexed video signals by fibres.

BOOKS

Proficient C by Augie Hansen. Microsoft Press, Penguin Books, 494 pages, paper covers, £19.95. Extensive handbook for the intermediate or advanced programmer working in a DOS environment. Sections deal with DOS and program development, using standard libraries and interfaces, file utilities, the ANSI device driver and screenj routines. Attractively presented. The many example programs are also available on two discs, as source code or as executable programs.

Private Mobile Radio – a system planner by John Davies; 48 A4 pages ring-bound, soft covers. Available direct from the author, price £8.50 inclusive (Europe £9.50, overseas £11), at 26 Walnut Close, Penwortham, Preston, Lancashire. Do-it-yourself kit for prospective users, to be used in conjunction with the author's Private Mobiel Radio: a practical guide (Heinemann). Contents include a questionnaire designed to establish basic system requirements, a preliminary specification for discussions with equipment suppliers, draft form of tender, guidance notes and so on.

Programmable Logic Handbook by Geoff Bostock. Collins Professional Books, 243 pages, hard covers, £25. Authoritative survey of this fast-growing device family. The final part of the book deals at length with a wide diversity of logic elements showing how they may be fitted into programmable logic devices. Appendices list p.l.d. manufacturers and companies offering c.a.e. support.

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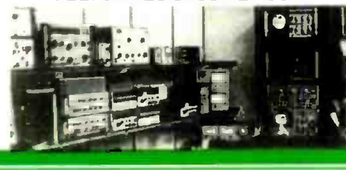

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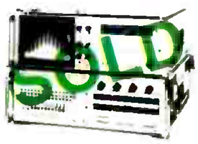

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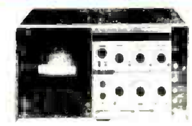

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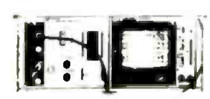

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The program is fully compatible with the Marconi Tracker ball described below.

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A suite of six utility programs which add additional features to the 'Diagram' drawing program. The utilities include the saving and loading of areas of diagram to and from disc. The ability to display the whole of your large diagram on the screen at one time (in either 4★4 or 8★8 screen format). The addition of borders and screen indents to diagrams, and the ability to shift a whole diagram in any direction.

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This high quality device comes with it's own Icon Artmaster drawing program and utilities to enable it to be used in place of keyboard keys, joysticks, or with your own programs.

For Model B & B+ (with Icon Artmaster) £60.00 + VAT
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Pointer ROM available separately £12.50 + VAT
P&P on Trackerballs £1.75

ADFS Utilities ROM

ADU is a new product which will prove invaluable to all users of the ADFS. (Including Winchester owners)

The ADU Rom allows direct access to utilities which previously required the use of the ADFS utilities disc.

Many novel features are included in the commands allowing such facilities as the copying of all the files on a DFS disc onto ADFS in a single pass and Backing up between discs of different size (including Winchesters).

There is also a very powerful sector editor with automatic correction of CRC bytes and a menu routine with over 30 possible operations on ADFS discs.

Please write or phone for more details.

PRICE £29.00 + VAT

PCB

This new release from Pineapple is a printed circuit board draughting aid which is aimed at producing complex double sided PCB's very rapidly using a standard BBC micro and any FX compatible dot-matrix printer.

The program is supplied on EPROM and will run with any 32k BBC micro (including Master series). Also supplied is a disc containing a sample PCB layout to demonstrate the programs features.

By using an EPROM for the program code the maximum amount of RAM is available for storing component location and ASCII identification files etc. (Up to 500 components and 500 ASCII component descriptions may be stored for a given layout). There is no limit to the number of tracks for a given PCB, although the maximum size of board is restricted to 8" * 5.6".

Using a mode 1 screen, tracks on the top side of the board are shown in red, while those on the underside are blue. Each side of the board may be shown individually or superimposed. A component placement screen allows component outlines to be drawn for silk screen purposes and component numbers entered on this screen may be displayed during track routing to aid identification of roundels.

The print routines allow separate printouts of each side of the PCB in a very accurate expanded definition 1:1 or 2:1 scale, enabling direct contact printing to be used on resist covered copper clad board.

This program has too many superb features to describe adequately here, so please write or 'phone for more information and sample prinouts.

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Converter leads to enable the Trackerball to run mouse software and the mouse to run trackerball software (inc. DIAGRAM). Please state which way round when ordering.

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ENTER 20 ON REPLY CARD

Acorn's fast risc microcomputer

Major manufacturers are developing reduced instruction set processors for minicomputers, but Acorn's has gone into a micro.

Acorn has launched a range of high-performance microcomputers, which it says is the fastest in the world. The range is named Archimedes, after the greatest scientist of classical antiquity, and it is based on the company's 32-bit reduced instruction set processor.

Two families make up the initial range: the 300 series, which becomes the new BBC Micro and will carry the support of the BBC's computer literacy project; and the enhanced 400 series, aimed at scientific, engineering and business users. Further series are promised, and both processor and system will be available to o.e.ms and value-added resellers.

A feature of the new machines is their ability to emulate or co-work with other processors: in this way they will be able to run "legal" software written for earlier BBC Micros, and with 80x86 emulation they will have the power to run MS-DOS applications such as those for the IBM PC.

The standard operating system is called Arthur, which Acorn says will offer a high degree of familiarity to users with BBC Micro experience. But the family also supports Unix: Acorn will supply the Berkeley 5.0 version. A windows-icons-mouse-pointer user interface comes with all Archimedes machines, together with BBC Basic V. Other languages supported include Ansi C, Iso-Pascal, Fortran 77, Prolog, Lisp and Comal.

A wide range of applications software is on the way from various suppliers, including three word-processors, an integrated database/spreadsheet/graphics package and a terminal emulation program. The BBC will launch a full commmunications package in October. Early products from independent houses will be c.a.d. and electronic publishing packages, a relational database, educational programs and several commercial applications.

Archimedes machines can be expanded by plugging modules into a backplane. The first modules are for i/o (with user port, a-to-d and 1MHz bus), rom expansion, midi (musical instrument digital interface) and MS-DOS. Early next year will come an Ethernet card, a hardware floating point unit and a SCSI card. Third party supplier are preparing an IEEE-488 (GPIB) module, a high-performance a-to-d interface, a video frame-grabber and a modem.

All members of the series have a three-box configuration which includes an IBM-style keyboard. They offer 18 standard screen modes, with an additional three if a multi-sync monitor is used; two support 132-column text. Up to 256 colours can be used at once, from a choice of 4096. The sound system allows users to call on eight voices simultaneously across a seven-point stereo stage. Synthesized speech is possible by redefining the library of built-in sounds.

Acorn's risc microprocessor is a v.l.s.i. design in which many of the more elaborate internal operations provided in other processors have been pared away to streamline operation of the chip. It gives the new machines a typical processing speed of around four million instructions per second.

According to Basic benchmark test results quoted by Acorn, Archimedes comfortably beats rival micros with a speed advantage which is rarely less than three or four times and in most cases is very much larger. Only on graphics processing is Archimedes outstripped, and then by 80386 machines.

BBC Basic V is downwards-compatible with the versions provided on earlier BBC Micros, but includes new structures such as the 'Case...When and While...Endwhile' borrowed from Comal. The built-in assembler now generates Acorn risc machine code rather than the 6502 variety; Acorn says that any programmer familiar with the 6502 will take to Arm code like a duck to water.

SPECIFICATIONS

ARCHIMEDES 300

Memory: 0.5Mbyte (1Mbyte on 310), 0.5M rom.

Storage: built-in 3.5in floppy disc. An additional floppy or hard disc drive can be fitted internally.

I/o: Parallel printer and RS423 serial ports; co-processor bus: Acorn Econet socket.

Expansion: backplane for two modules.

Price, ex-v.a.t.: £799 for model 305: £1075 for 440 with colour monitor, excluding educational discounts

Availability: now. Large volume from September.

ARCHIMEDES 400

Memory: 1M byte (4M byte on 440), 0.5M rom.

Storage: built-in 3.5in floppy disc (plus 20Mbyte 3.5in. hard disc on 440). A second drive can be added to the 410.

I/o: Parallel printer and RS423 serial ports; co-processor bus: Acorn Econet socket: support for 1162 × 864 high-resolution monitor.

Expansion: four-module packplane.

Price, ex-v.a.t.: £1399 for model 410: £2499 for 440 with colour monitor, excluding discounts.

Availability: November (440): early 1988 (410).

FEEDBACK

Dirty design

You will still have some readers who listen to a.m. radio but I fear that if my experience is anything to go by we are members of a dying race.

Designers of much equipment seem to concern themselves only with the functioning of that equipment in isolation and appear completely indifferent to interference occasioned to other equipement.

Both switched-mode power supplies and digital circuitry in many devices appear to be all the rage. My Dynatron (Philips) television set, whether in use or whether on stand-by, renders it impossible to listen to either medium-wave or long-wave broadcasts. A neighbouring hotel has installed a Viceroy 6 + 16 call connect system which radiates particularly nasty interference on long wave, medium wave and the low-frequency end of the short-wave band. Only after threatening British Telecom with court proceedings was some work done to reduce the interference from the hotel telephone installation, but even now it still remains troublesome.

My overall impression of the British Telecom engineers was that they did not have a complete understanding of the equipment in question and were therefore in difficulty in attempting to deal with the problem.

It seems to me entirely reasonable that we should require design engineers to consider other equipment users when evolving their designs and for manufacturers to go to considerable lengths to prevent spurious unwanted radiation from their equipment. The matter is serious and displays a slovenly contempt for others. When I was young, a friend refused to show me how to build a super regenerative receiver because he thought that would be unfair to my neighbours. He was certainly right and I think it a pity that others are not so public spirited.

I recently spent a short holiday in Scotland. Alas that hotel had a Viceroy as well! Is there no escape?

F. B. Kyle
Workington, Cumbria

Mathematics

Notwithstanding the comments of Messrs MacHarg and Clements in the May issue, my criticism of Mr MacHarg's letter (January) still holds.

I'm not sure what point Mr MacHarg is trying to make in his May reply. In his first two paragraphs he has confirmed my points that his 'proof' "does not hold" mathematically, but in is fifth paragraph he uses the same 'proof' to show that fallacies can lie behind mathematics. If he wishes to show the possible fallacies of mathematics, a 'proof' which breaks several rules of mathematics really can't be used to argue his case, without first showing these rules to be incorrect.

As for his ramblings against mathematics being an active dynamic logic, which came first, the chicken or the egg? Mr Clements' axiomatic demonstration of the lack of value of mathematics fails with his first axiom. Mathematics is not just a form of communication, to quote the Oxford Dictionary, mathematics is "The science of numbers and space". By its nature, any science is more than a form of communication. I assume he is confusing the science of mathematics with mathematical symbols — used to communicate ideas. In my March letter I said "mathematics is an active dynamic logic and may be expressed in plain English if so required" meaning that mathematical symbols may be expressed in English, not that the logic is just that of words.

Mr Clements also seems to have the wrong idea on mathematical division and integers. Yes, cells in a nutrient medium do divide, or do they multiply? Little matter, they reproduce in an exponential manner. Exponentiation, as it happens, can be simplified into multiplication and further into addition, something I would gladly show, if you so wish.

Division of x by y is the same as asking how many times can y be subtracted from x before being left with zero, or an integer less than y if only considering integers. As an example, consider a bag of ten apples. I can give 10 people one apple each only once

NEXT MONTH

Computer interference. Using an Amstrad computer as an example, Richard Marshall analyses the problem of electromagnetic interference from computers and describes the working of a commercial device designed to reduce the emissions.

Engine management. Pat Jordan looks at the use of microprocessors in electronic engine management systems. The sensing of parameters, processing of data and emission and performance control are discussed and possible future developments in adaptive systems and electronic driving controls are considered.

Rocks and radio. Medium-frequencies (300kHz to 3MHz) can propagate in rock, albeit with difficulty. Dr Austin examines the principles upon which the process depends and describes the work done over many years to solve the problem of reliable subterranean communication.

Tripos – life after the Amiga. The workings and future of this real-time multitasking operating system for 68000 family processors.

Logic and sexual equality. Logic 1 and logic 0 are either equally significant opposites, or 1 is assertive and 0 is simply the absence of 1. John Kennaugh explores the difference between the two points of view, with reference to intentional logic symbols.

Memory systems for small computers. The advent of 32-bit processors into the personal computer allows the more efficient use of memory by the concept of virtual memory, brought about by using paged or segmented memory techniques. Rodney Stubbs explains.

Marconi – the Father of Radio. Guglielmo Marconi may, or may not, have been the first, but at least he could make transmissions over a reasonable distance when others were still trying to send fifty metres. He was an improver of others' work, but he also had the ambition to communicate reliably by radio.

Handshaking state diagrams and field – programmable logic sequencers allow you to produce your own m.s.i. chips with a PC and low-cost logic programmer.

FEEDBACK

(i.e. 10 ÷ 10 = 1) or I can give five people one apple each, twice (10 ÷ 5 = 2), else I can give four people two apples each with two left over or else give them 2½ apples each (10 ÷ 4 = 2½ or 2 remainder 2). I hope my rambling has demonstrated exactly what mathematical division is.

Interestingly, if reproducing cells are considered to divide (in the mathematical sense) then that would suggest that division of the integer one by two repeatedly (cells 'splitting' into two repeatedly) is equal to infinity, when in fact slicing an apple in half repeatedly will show that one divided by two repeatedly tends towards zero. Therefore 'division' of cells cannot be considered as being the same as mathematical division. Peno's postulate that 'one is a positive integer' has not been violated, but shown to be true.

Assuming that our culture started with one cell (it cannot start with less) as the cells reproduce we have more cells, so we have not violated the postulate that 'no positive integer has one as its successor! I conclude then that replication is no more than multiplication (and hence addition) and so multiplication, division, addition and subtraction can all be found in nature.

John R. Ridley
Masirah
Sultanate of Oman

Quality assurance

I find myself in broad agreement with Mr Whitehead (June Letters). I have recently helped to steer my company through a successful application for AQAP-1 and it is true that the focus of the system is on enhancing company quality performance, not on continuous knuckle-rapping. The only issue I would take with your correspondent is on Secton 4, where he implies that QA requirements can be relaxed when ordering from a supplier who can supply the sub-assemblies to BS 5750, components to BS9000, etc. This is simply not true: none of these releases provide any express or implied enhancement of quality. They are objective indicators that systems are in place to monitor and, if necessary, to correct problems if they should occur (or before they occur, if *successful* statistical methods are involved).

K. V. Castor-Perry
Beckenham
Kent

Toroidals and surface mount

I was interested to read the article in the March issue on the background to toroidal transformers. Alas (not surprisingly) it was a bit one-sided in the listing of pros and cons. The following comments based on my experience as a designer might perhaps help others.

Points in favour of toroids

- low radiated magnetic field
- low profile
- good rated-power to size ratio (but see below!)
- acoustically quiet

Against

- higher interwinding capacitance
- vulnerable to "shorted turn" failure if the mounting bolt is electrically connected both ends, even by accident!
- output power rating is also absolute maximum rating, i.e. a brick-wall current limit
- not continously rated at full power, so all right for class B audio, but for power supplies must be downrated to 60%
- typically twice the price per rated watt on small units
- Varistor strongly recommended to protect the primary against the "switch-off pulse" even on the smallest cores

I use toroids a lot, but for real power with "that little extra in hand just in case", a standard E/I core with its softer saturation characteristic is still by far the best.

On the subject of surface-mount techniques, the recent articles are highly relevant to the mass manufacturing side of the industry, but there is very little attention being paid to the maintenance of the product and the needs of the small quantity user.

My work includes repair and modification of modern small Japanese equipment full of s.m.ds. Only RS Components, so far, out of half a dozen industry suppliers I've checked, stock a range of R's and C's and getting hold of i.cs and other semiconductors is like drawing hens teeth from a storeman of the old school. S.m.t tools are also hard to find (I can recommend the DeSoutter pick-up pen) and very expensive for what is on offer.

If we are to be able to make use of the system then it should be more widely available and less like joining the Masons.

R. F. Stevens
Ickenham
Middlesex

Relativity

Dr Scott-Murray's June letter further confuses the issues raised by the Hafele-Keating experiments, in which two sets of atomic clocks were sent on a series of airline flights which took them round the world in opposite directions, and were compared before and after their journeys. In these experiments two distinct effects occurred, namely: –differential ageing, arising because the clocks carried round the world were exposed to accelerations which caused each set to traverse a closed path within the inertial frame in which, for the few days the experiment lasted, the centre of the earth was approximately at rest

– gravitational red shifts. As the altitude of each aircraft changed the corresponding change in the earth's gravitational potential affected the rates of the clocks it carried.

The results Dr Murray refers to as the ' "acceleration potential" term', and as the 'Lorentz velocity term' " arise from alternative ways of calculating the *first* effect. The first way gives an approximate answer, since it is based on the 'Principle of Equivalence', which is itself approximate. The second way, which involves the implicit assumption that accelerations do not affect the rate of an ideal clock, gives the exact answer. The *second* effect can be calculated approximately from Special Relativity using the classical expression for gravitational potential, which is usually more than adequate.

To my knowledge no experiment involving the motion of finite objects, whether using rotors, or aircraft, or satellites, is claimed to verify terms in the Special Relativity formulae involving powers of v^2/c^2 greater than the first. However the experiments with his energy mesons which Dr Murray so carefully ignores verify the formulae with great precision.

As for his comments on the design of the Stanford electron linear accelerator, what Special Relativity actually says is that the measured velocity of an *isolated* electromagnetic pulse travelling in a vacuum is the same in all frames. The electromagnetic pulse travelling down a wave-guide is a composite of many pulses absorbed by and re-radiated from the atoms in the wall of the guide, and so has a group velocity smaller than 'c'. Thus particles such as electrons may either fall behind the pulse travel in step with it, or run ahead of it.

In any case, as I pointed out in the March letters, to be accelerated the electrons must travel in step with the wavelets within the pulse, i.e. not at the group but at the phase velocity. The design problems arose from the requirement to excite the waveguide so as to keep the phase velocity smaller than the velocity of light, while avoiding the excitation of mixed modes.

C. F. Coleman
Grove
Oxfordshire

Re the misinterpretation of experiments. If we are given that unlike charges attract and that charges of one kind do not exist separately, it follows that two like charges will be attracted apart by their companion charges. There is no logical necessity for a repulsive force and no experiment can prove that such a force exists. The idea of a repulsive force has survived for 700 years but the record for the subversion of science by experiment probably belongs to the Sun God.

A similar situation exists with the electromagnetic experiments used to justify relativity. That theory treats the constancy of light velocity as a kinematic phenomenon. Classical physics treats it electromagnetically by requiring that Maxwell's equations apply to all observers and then deriving the field relations. Both methods involve the Lorentz correspondence but, in the classical case, not as a kinematic relation between observers. The end result is the same for both methods so the experiments are no more a proof of relativity than of classical physics.

There appears to be a difficulty in distinguishing Newton's scheme for the description of phenomena from that phenomena. Thus we have such assertions as 'mass is constant in classical physics' followed by the derogation of classical physics. This is akin to saying the validity of a computer program depends on the data fed to it. In fact, Newton's requirement that space-time be neutral merely allows each branch of physics to have its own independent laws and imposes no restriction on any phenomena, so one would expect his scheme to be applicable whatever the experimental data may be. This argument needs to be faulted before the scheme is rejected and it is not clear how experiment can do it. Nor, of course, can relativity's soothsayer logic do it.

R. Berriman
Palmerston North
New Zealand

Tercentenary of Newton's Principia

The tercentenary of Newton's *Principia*, perhaps the greatest book ever written,is sadly being sullied by the limitations and alteratioins allegedly imposed on its contents by Einstein's relatively (Tom Ivall, Satellite Systems, *E&WW*, vol. 93, Feb. 1987 p.159. In fact all the republications of the *Principia* in the twentieth century are tarnished by this disgraceful smear within their own pages.

Naturally, there are inaccuracies and errors in the *Principia*, but Einstein did not correct them; nor did Einstein generalise Newton's laws. On the contrary, Einstein repudiated explicitly and unreservedly the most basic tenets of the *Principia*, though because of Orwellian doublethink the contemporary conventional physicists and historians seem incapable of recognising this little anomaly.

The most flagrant example is Einstein's rejection of Copernican heliocentricity (i.e. the physical superiority of the Sun's reference system over the frames of, say, Mercury or Earth, or Titan or Apollo 9, or the Orient Express) in favour of general relativistic polycentricity (i.e. the complete equivalence of all frames, both inertial and non-inertial). This point is significant because without heliocentrism there would have been no Kepler's laws, no Newton's laws, no rockets, and no artificial satellites.

Another elementary relativistic error is the extraordinary statement "force is a mathematical fiction, not a physical reality" which reduces Newton's second law (f=m a) to a mere definition of force. the absurdity of this queer relativistic precept becomes manifest when stated thus: "a mathematical fiction (force) produces a real effect (acceleration)". As for the third law, that is rendered pure fiction in its entirety. Of course a law of nature is a causal relationship between at least two (defined by other means) physical realities.

Evidently the only effective way to bring the relativists to their senses is to blast a punch in their faces, preferably by a champion boxer. (But perhaps the relativists can Lorentz-transform to a frame in which the force of interaction between fist and head is exactly zero?) Newton of course treated 'force' as the physical reality that it is.

A correct appraisal of the contents of the *Principia*, and of the achievement of Newton (Britain's, and possibly the world's, greatest ever scientist), will be possible only when the relativistic strictures are recognised as the blatant errors that they really are.

But these issues are not merely matters of academic concern. For the relativistic errors impede and prevent not only theoretical but also technological advances. We had the opportunity to point out in the *American Journal of Physics* (vol. 54, Nov. 1986, p.969) how the confusion stemming partly from the relativistic errors had hindered and delayed the invention of the laser and of the intensity interferometer; and in *Nature* (vol. 321, 1986, p.734) and *Electronics & Power* (vol. 32, 1986, p.789) how the confusion springing entirely from the same errors has so far prevented the development of the optical translation sensor.

T Theocharis
M Psimopoulos
Blockett Laboratory
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London SW7

Planck's constant

In reply to Mr Akil's comments in April's Feedback and to Mr Brindleu's of May on my note about Planck's constant and the atomic fine structure constant, February 1987, I give the following answer. The relation $h=2\pi m_e c r_e\ (a-1)$ is got by the following premise:

Start with Bohr's basic atomic model of orbiting electrons around a proton nucleus. The forces acting in such a system are electrostatic forces and mass inertial forces. Assume the mass density is the same in both the proton and the electrons, and that the proton behaves like a current wire loop in a magnetic field, hence effected by a torsional force when turning out from a neutral position in the electrostatic field between the proton and electron. This oscillation creates small disturbances in the orbiting movement of the electron, giving rise to a resonance condition between this oscillation and the orbit time. That is the quantum condition. Then assume the frequency of radiating energy is in proportion to the medium value of the difference between two successive proton oscillating frequencies, then you have the solution in a nut-shell.

The fine structure constant approximately constitutes the quotient between the proton mass and the electron mass raised to the exponent of 2/3, given by the constant mass density of both proton and electron. The model generates Schrödinger's wave equations as well as other well-known relations from quantum mechanics. The model gives the proton an extension (radius) of about 35 fermi as well as new knowledge of the properties, structures and behaviour of elementary particles. Thus, I say that the relation above conceals deep secrets of the nature of matter.

Ove Tedenstig
Märsta
Sweden

Inductive coupling

Two minor points regarding Tom Ivall's article on my range-insensitive links (June issue): The first is that the approximate expression for the 'pulled' frequency is

$$\omega = \omega_0/\sqrt{1 \pm k}$$

and not as stated. The second concerns Fig. 2. The 74HC04N is a hex inverter; one inverter is used for the first stage of the transmitter, and five stages in parallel for the second, output stage.

P.E.K. Donaldson
MRC Neurophysiological
Prosthesis Unit
London

Hugh Pocock

The obituary of Hugh S. Pocock in your May 1987 issue brings back to me many memories over a very long period, for I knew him well and can emphatically endorse your brief summary of his personal character and expecially its gentlemanly nature.

My first contribution to what was then *"The Wireless World & Radio Review"* was in the issue of 15th August 1923, and received the distinction of 'top billing' on the front cover. Even at that early date it was issue number 209, and cost 4d net (1⅔p), and was registered as a Weekly Newspaper. Unlike most of my subsequent contributions, this first one was entirely practical, being a detailed description of my invented machine made from second-hand parts to provide about 800 volts for my valve transmitter from the then-usual d.c. mains supply.

M. G. Scroggie (Cathode Ray)
Bexhill
Sussex

Feedback also appears on page 786.

Q and oscillator stability

Recent interest in the origins and use of Q is widened by involving pendulums and timekeeping

D.A. BATEMAN

I would like to join the recent debate on the origins of Q, both by adding to the article by Dr Smith[1] with some more equations involving Q and in the historical search for the first use of Q. In the former case it is how Q is related to the frequency stability of an oscillator.

I used the factor Q (and then derived the equations given later) by researching in an entirely different field – that of horology. A number of years ago I made a precision pendulum clock (Fig.1) which is moderately conventional in having a "one second" pendulum (period ½Hz) with a lead bob and invar rod. The pendulum, however, is maintained by a photoelectric sensor and electromagnetic drive. In addition, the sensor and logic circuit detect when the amplitude exceeds a defined value: when this occurs the next drive impulse is omitted. The energy is therefore supplied on demand more or less as drive-one-period, miss two, drive one, miss one, drive two, etc. Another refinement on the pendulum, which is hidden behind the dial plate, is an aneroid barometric compensator to correct for small changes in rate following from changes in buoyancy when the air pressure changes. Before fitting the compensator the error was of the order of – 0.0092 seconds per day per millibar increase in pressure.

As may be deduced from the above, the timekeeping is fairly good, having a standard deviation of better than 70ms/d over a 30 day sample. In crude terms, the clock keeps time to within about a second a month.

To check the accuracy of the amplitude control (which is ±½ second of arc) I measured the decrement, and incidentally, the Q. Swinging freely, the pendulum has a Q of 15,400, whereas the presence of the case and sensor restricts the air circulation to give a loaded Q of 12,700.

The traditional view in horology was that control of the amplitude of a pendulum would eliminate errors due to drift in amplitude and thus give immediate and significant improvements in timekeeping. It will be recalled that the restoring force is not exactly proportional to amplitude and therefore a pendulum does not execute perfect simple harmonic motion. I did not entirely subscribe to the view about major improvements in timekeeping by amplitude control (nor isochronism by other means), but suspected that the accuracies of clocks as a whole are dominated by the Q of the oscillating component, be it balance wheel, tuning fork, pendulum, quartz crystal or atomic resonance. There is nothing new under the sun, for I subsequently found that a number of other technical horologists has also observed the link between accuracy and Q, although I believe that I did take the subject a little further, both theoretically and experimentally.

Again in horology, George Airy (later Sir George Airy, the 7th Astronomer Royal), in 1826 proved that the act of impulsing a pendulum would change its period[2]. He derived a relation for the fractional change in period in terms of the mass and length of the pendulum, driving force and the escapement geometry. Pursuing the link with Q, I was able to prove that Airy's equation could be expressed more simply in terms of Q as

$$\Delta\Omega = -\frac{1}{2Q\tan\beta}$$

where $\Delta\Omega$ is the shift in frequency due to the impulse phase error β.

In practical clocks, the majority impulse near the optimum of $\beta = 90°$. Even if this is not achieved, it is of no great consequence as the shift in frequency $\Delta\Omega$, compared with the "ideal" unimpulsed "free" pendulum, can be treated as a constant and corrected for by an almost trivial adjustment of the length of the pendulum.

Accuracy, on the other hand, is the variable behaviour of the oscillator, and the rate of change of frequency due to small changes in phase angle is

$$\Delta\omega = \frac{1}{2Q\sin^2\beta}\,.\Delta\beta.$$

For example, with a Q of 1000, $\beta = 90°(\pi/2)$ and a phase instability of $\Delta\beta = 1°(\pi/180)$, then $\Delta\omega \approx 10^{-5}$.

This is a clear statement that accuracy, at least in the short term, is directly related to Q. (Note the factor of 2 in the equations – quoting Lady Jeffreys "Other definitions appear in the literature; one has to cultivate a robust attitude to the intrusion of 2 or π.")[3]

ERROR VERSUS QUALITY FACTOR

POINT ON GRAPH	CLOCK OR OSCILLATOR	Q (Loaded)	ERROR
	Balance wheels		
a	Cheap alarm clock, pin pallets	40	15s/d
b	Compensated, good quality jewelled lever	100	4s/d
c	Torsional ring "pendulum" (Atmos clock)	330	2s/d
d	Hamilton chronometer	330	1.7s/d (marine specification)
e	Mercer chronometer	580	0.5–1.7s/d
f	Randall constant force escapement prototypes 1978, 1979	700	0.29–0.45s/d
	Tuning forks		
g	Junghans Resonic (300Hz)	1000	2s/d*
h	Omega Megasonic (720Hz)	2500	1s/d*
i	Bulova 2181 (360Hz)	2000	0.5s/d
j	NPL standard, 1934 (1000Hz)	5000	5×10^{-8}(hourly) 3×10^{-7}(weekly)
k	Laboratory standard, USA 1932 (480Hz.)	52000	10^{-7}
	Pendulums		
l	Synchronome	3400	2s/week
m	Big Ben	6600	0.5s/d
n	Bateman regulator, photo-electric amplitude control	12700	0.07s/d
p	Gravity survey, transportable double pendulums, low pressure (Gulf Oil)	35000	10^{-7}
q	Gravity survey ("Cambridge pendulums")	90000	10^{-7}
r	Shortt, low pressure, 30mm.Hg	106000	0.008s/d
s	Fedchenko, low pressure, 4mm Hg	200000–500000	0.0003s/d
	Quartz crystals		
t	Wristwatch, flexure mode, NT cut	50000–150000	5s/month*
u	Square plate, GT cut (laboratory)	200000	10^{-10}(1 minute) 10^{-9}(7 hours)
v	Essen ring	10550000	4×10^{-10}(1 hour) 10^{-8}(1 week)
w	Marconi F3160 laboratory standard, lenticular AT cut	6000000	1.5×10^{-11}(1 sec.)
x	Hewlett Packard 10543A laboratory standard	2000000	10^{-11}(1 sec.)
	Atomic		
Cs–1	Caesium beam, NPL2 1972	1.8×10^{8}	2×10^{-12}
Cs–2	Caesium beam, NPL3 1977	5.7×10^{7}	2×10^{-13}
H_2	Hydrogen maser	2×10^{9}	5×10^{-13}
Rb	Rubidium cell, commercial (Efratom)	5×10^{7}	2×10^{-11}
Fe^{57}	Radio-active iron, Mossbauer resonance effect	3×10^{12}	10^{-15}
	Electronic		
y	High stability tuned inductor and capacitor	200	10^{-6}(1 hour) 10^{-5}(1 day)
z	Superconducting cavity resonator	3×10^{9}	1.2×10^{-13}(10 sec.)

* Commercial specifications

Short-term accuracy is sufficient for many cases, but the major interest is almost certainly in the longer term, particularly in clocks. Again there is the link with Q, assuming, of course, that drift errors due to temperature, etc. are negligible over the relevant time interval. After a good deal of research I was able to collect together data for Q and accuracy for a very wide range of oscillators. Although the bias is towards horology, the table gives the results of the survey; they are also plotted in Fig.2. Some well known clocks are included: one such example is the clock at the Palace of Westminster, popularly known as Big Ben. My own clock – in a domestic environment – fits neatly on the nominal $\Delta\beta = 1°$ line. For the individual source references see reference 4.

The overall correlation of accuracy with Q is strong, the main deviations being the commercially quoted quartz watches and the atomic clocks. For the watches the principal limitations are the production trimming tolerances, whereas atomic clocks are refined to suffer the minimum instabilities.

Given the mechanical definition of Q

$$Q = \omega_r \frac{M}{R}$$

(where R has dimensions of MT^{-1}) the equation supports the more or less commonsense view that a clock pendulum should be massive, with low resistance, and a little unexpectedly for tradition, a high frequency. It is worth noting that before the advent of the microelectronically driven growth of quartz clocks and watches, there were the beginnings of trends in these directions. Mechanical wrist watches, too, were starting to incorporate "hi-beat" balance wheels (5Hz) in increasing numbers.

It has been pointed out that the accuracy-versus-Q equation is based on the instability of the input energy[5]. This is true, but paradoxically, I have long held the opinion that it is the output of the energy that is uncontrolled. Strong support is given by the performance of the non-impulsed Cambridge and Gulf Oil gravity survey pendulums. These pendulums were swung in-line in anti-phase at low pressure and decaying freely; measurements of the period with radio time signals gave the local value of g. Whatever the source of instability, an analysis of the errors of clocks using Allen variance shows that for well made clocks (i.e. with temperature control and of sound construction) the principal source of error is due to flicker noise[6].

The use of Q is certainly beneficial in understanding certain aspects of precision timekeeping. Conversely, it is a puzzle why textbooks on vibration theory and oscillators make so little of the benefits of high Q for frequency stability. Perhaps this article is a small step in that direction.

To return to the early origins of the term, several years ago I also scoured the literature, with the Handbook of Wireless and Telegraphy, 1938, coming close for a UK publication. A colleague[7] carried out a similar search, finding that Terman in his book Radio Engineering used Q extensively in his first edition in 1932. A second find, with the

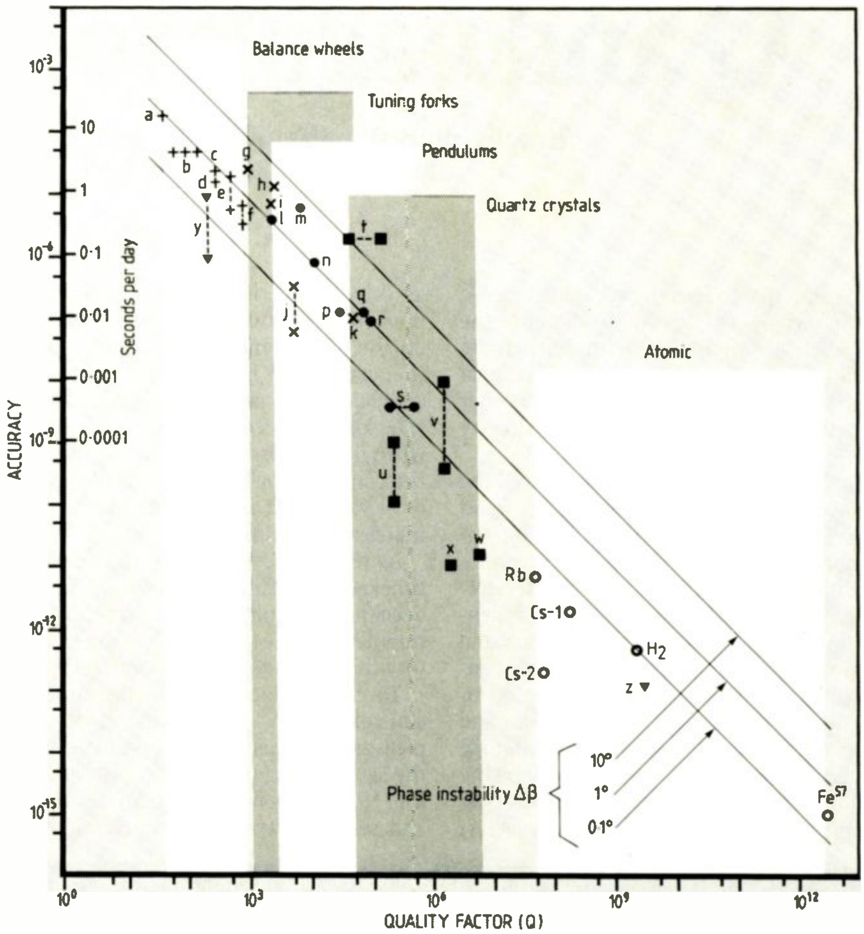
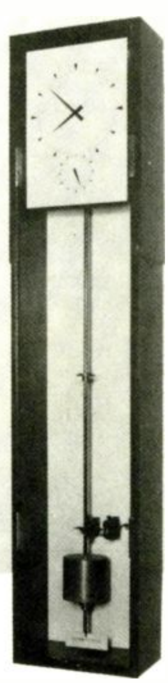


Fig.2. Correlation between accuracy and Q for practical clocks and oscillators: extremes in scatter are associated with commercial tolerances and laboratory standards.

quite explicit definition of Q as ωL/R, was Bayly[8], 1931. A footnote to the title of this paper states that the paper was first presented at a meeting in Toronto on 8 May, 1929. As a dedicated user of Q, I am delighted that the hunt started by Lady Jeffreys has traced the earliest published use of the term[9], that is, to K.S. Johnson[10] in 1924. My colleague's references, together with those unearthed in the search, confirm that Q was becoming established in the early 1930s.

Fig.1. The author's precision pendulum clock with photoelectric control. Q of pendulum 12,700; accuracy (SD) 70ms/d.



Finally, to add yet more to the collection of formulae involving Q, there is the very useful factor of 4.53, where Q equals 4.53 multiplied by the number of periods for the amplitude of a decaying oscillation to decay by half.

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3. Jeffreys, B., A Q-rious Tale; the Origin of the Parameter Q in Electromagnetism. *Q. Jnl. R. Astr. Soc.*, 26, pp 51-52, 1985.

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9. Jeffreys, B., (lett.) *Elect. & Wireless World*, 93, 37, April 1986.

10. Johnson, K.S., Transmission Circuits for Telephonic Communication, Van Nostrand, 1925, Western Electric 1924.

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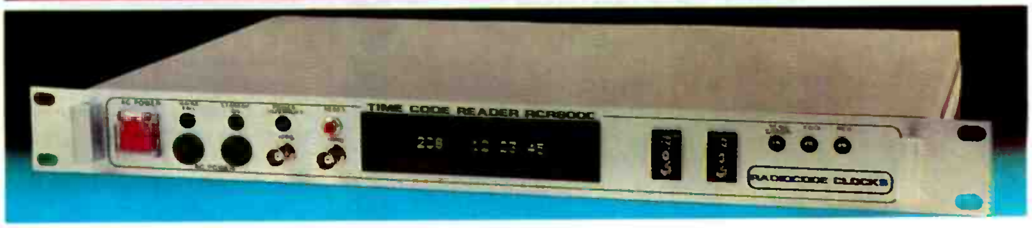


Accurate timekeeping

A range of new products, all concerned with timekeeping, has been produced by Radiocode Clocks Ltd. Several of them are related to time and frequency standards broadcasts. RCC 8000 is a new micro-controlled instrument to receive, decode and analyse time-coded transmissions to provide a secure and automatic time/calendar system. The decoded signal is used to provide a reference for the instrument's own crystal-controlled clock. RMC 1000 is a master clock synchronizer which can provide precise control of a time source, such as an atomic clock. It is programmed through a front-panel keypad. It offers a resolution of 100ns and can be pre-programmed to allow for summer time, leap years, leap seconds and any other correction needed. There is a range of master/slave synchronized clock systems, controlled by one or two master radiocode clocks with a number of monitoring, distribution and display options.

The internal serial time codes used in broadcast transmissions, such as IRIG, XR3, SMPTE and the like, are catered for both in generating, receiving and synchronizing equipment.

Similar options are provided for frequency standards, with rubidium atomic oscillators, or off-air receivers with a wide choice of monitoring and distribution equipment.

Throughout the product range, emphasis has been placed on versatility, compatibility and reliability. Modular systems allow easy modification or upgrading. Standard inputs and outputs, such as RS232 and GPIB, are used.

Applications are as diverse as monitoring seismic activity, phase-locking transmitters and receivers, synchronizing computer systems, time stamping, master-slave control systems, and controlling power station line frequency.

Radiocode Clocks Ltd, Jennings Road, Kernick Road, Penryn, Cornwall TR10 9LY. Tel: 0326 76007.

New Avo meters

A pseudo-analogue 'dynamic pointer' is included in the AVO M2000 range of digital multimeters. This is the liquid-crystal equivalent of a needle and, says Thorn-EMI, has a response similar to that of a moving-coil movement so that varying reading can be closely monitored. The M2000 is not one meter but a whole range with a number of different models and varying uses and prices from a meter for a trainee electrician through to one for laboratory standards work. They come in both hand-held and bench models. The hand-held ones are designed to be droppable and have features to make them easy to use, such as a probe holder to allow single handed operation, with 'range hold', 'data hold' and 'peak hold' facilities. The l.c.d. readout has 10.5mm high numerals and the meters' accuracies range from ±0.7% on the M2004 to ±0.1% on the M2008. The AVO M2008 also has true r.m.s. measurement. Thorn EMI Instruments Ltd, Archcliffe Road, Dover, Kent CT17 9EN.. Tel: 0304 202620.

Electron-beam integrated-circuit investigator

A new system for diagnosing and debugging v.l.s.i. circuits comes from Sentry Schlumberger. It combines a scanning electron microscope with cad/cae tools into a compact workstation. When looking at faults in i.c. structures, designers need to investigate the circuit under operation. This usually involves microprobing but there are inherent problems with this method: the probes offer loading on the circuit, they can damage it, the circuit needs to be prepared for probing and there are buried circuits that cannot be probed at all. With light geometry, probing is more difficult.

The new technique works by focusing a beam of low energy electrons onto the device under test. Secondary electrons are emitted from the surface of the device, and their energy depends on the voltage present. An energy filter and electron detector recover these secondaries, and generate an analogue signal that varies with the chip voltage. If the beam is scanned, the analogue output is a video image where the bright areas represent zero voltage regions and the dark areas positive regions.

"By effectively linking a voltage contrast image of a live circuit with cad/cae information" says project director Neil Richardson, "Sentry's IDS5000 achieves unprecedented efficiency and accuracy in v.l.s.i. debugging, allowing chip manufacturers to compress prototype development by months".

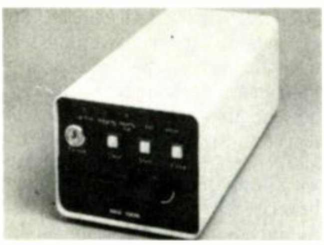
Using the voltage contrast phenomenon offered by E-beam technology, IDS5000 can effectively probe submicron features, make voltage measurements, display waveforms and make comparisons between actual and simulated waveforms. Powerful software locks the microscope display with the layout display, allowing each display to track the other, eliminating the great 'navigational' problems involved in searching for particular nodes on a chip with hundreds of thousands of elements.

Extensive system integration has produced a high-performance easy-to-use diagnostic system that makes E-beam probing accessible to all engineers. Secondly, advanced software provides links between the symbolic netlist, geometrical layout, and the physical device, removing the probe positioning problem for the user. The system will be on display at exhibitions this year and will be available for investigating sub-micron i.cs in 1988. Sentry Schlumberger, Ferndown Industrial Estate, Wimbourne, Dorset BH21 7PP. Tel: 0202 871718.

NEW PRODUCTS
TEST & MEASUREMENTS

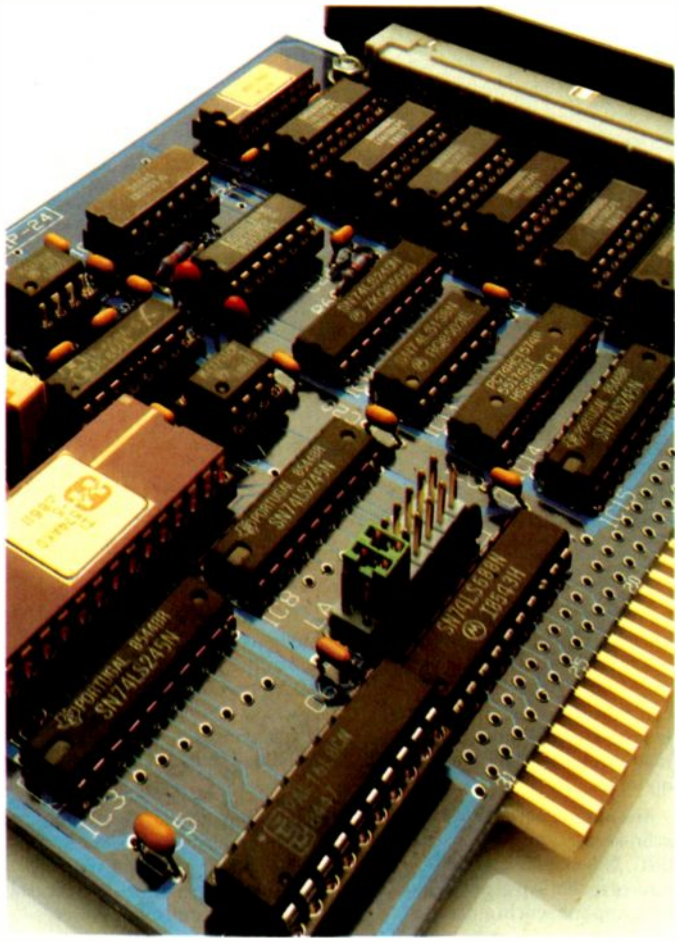
Untended data recorder

Service and process engineers can use this data recorder to capture a data stream and record it on an IBM-PC compatible disc for later analysis. The recorder has a standard RS-232 serial port which can accept ASCII or 8-bit binary data which it records onto a 5.25in floppy disc. The unit can be left unattended, apart from the neccessity of changing discs. Files may be opened or closed by push-button operation and the battery back-up continues storing the data in a buffer memory while a disc is being changed, thus giving an uninterrupted record. A warning light indicates that the disc is nearly full. Monode Ltd, 12 Market Square, Leighton Buzzard, Beds LU7 7EY. Tel: 0525 383883.



Transducer monitor

A 5-input module will display the level of transducer signals of any one of the inputs, selected from the front panel. PS-D5 is the latest addition to the Entran range of tranducer measurement systems. When used with the PS-30A transducer supply and amplifier module when it can be calibrated in engineering units, and can display up to ± 19.99 of the selected units. The module runs from its internal 9V battery, and there is a 'low-battery' signal. The unit fits into a standard rail to allow multi-channel systems to be constructed. Entran Ltd, 5 Albert Road, Crowthorne, Berks RG11 7LT. Tel: 0344 778848.



Analogue data acquisition on a PC

Two analogue input cards have been added to the Blue Chip range of industrial i/o cards for the IBM PC. the AIP card plugs into any PC expansion slot and allows voltages up to 10V to be read by the processor the AIP-24 has 24 differential channels while the AIP-48 has 48 open-ended channels. They are designed for sampling fast analogue signals in industrial, laboratory of scientific applications. APC with six free slots could read up to 288 inputs.

A high-speed multiplexer is used to scan the input channels. Low-level signals are boosted by the programmable amplifier. The signal is sampled and converted to digital. A 12-bit a-to-d converter with sign detection logic is used to give a resolution of 1:8000 or 0.0125%.

The board is port-mapped to allow it to be addressed by most programming languages. Example programs in GW-Basic and Turbo Pascal are supplied. The boards are compatible with the XT and AT computers and most clones. Blue Chip Technology Ltd, Main Avenue, Hawarden Industrial Estate, Deeside, Clwyd CH4 3PP. Tel: 0244 520222.

Automated audio measurement

Developed specifically for making automated measurements for all areas of audio technology, the compact, multi-funcition NFA-1, from Wandel & Goltermann, is claimed to eliminate many of the laborious procedures that are normally needed for manual tests. Its menu-controlled operation allows it to be used as a test set for specialist applications. Set-up times are drastically reduced.

Depending on the options fitted, the NFA-1 has up to 30 measurement modes. The automatic test programme permits measurements to be taken simultaneously at as many points along the line as required. If necessary, it can be left to make these measurements unattended. The instrument combines both receiver and transmitter and allows three operating modes – transmit, receive, or both together for loop measurements, with a time delay between the two programs. Transmit and receive programs are synchronised by means of a start/source/program identification signal sent over the link to be measured. This identification lasts for one second and can be evaluated by all receivers connected. Results can be displayed or documented in three ways: v.d.u., printout or memory storage, for further processing.

Fitted with an automated line tester the NFA-1 can quickly test check mono and stereo circuits. Wandel & Goltermann Ltd, Progress House, 412 Greenford, Middlesex. Tel: 01 575 3020.

Monitor tester

The MT700 tv monitor tester from Grundig has a range of signal outputs including composite colour, RGB, and RGB-TTL, making it suitable for testing a wide variety of monochrome and colour tv monitors. The tester provides the common standards of 625/875/1249 lines at 50Hz, 525/625/735/1023 lines at 60Hz, and three additional line patterns between 512 and 1535 lines with a maximum line frequency of 38kHz at 50Hz.

Each tester is programmed to suit individual customer requirements and the V and H pulses may be varied

through the t.t.l. output to allow testing of monitors with pulse configurations deviating from the standards.

The instrument offers a range of test patterns including a circle and standard colour bars. Other features include 16 different character signals to evaluate sharpness and reproduction of vertical characters; a multiburst signal for frequency response measurements with expansion up to 18MHz maximum; and an integrated 'monitor test' signal of +2 and 0% to −2 and 100% for adjusting the brightness and contrast settings respectively.

Positive/negative video inversion is possible with all 16 displayed characters and the MT700 also offers a character test pattern which estimates the quality of the display of critical characters on the screen. The interlace function can be turned off for jitter-free monitor test images. Available through Electronic Brokers Ltd, 140 Camden Street, London NW1 9PB., Tel: 01-267 7070.

NEW PRODUCTS

Analogue training module

A bench-top module from Flight Electronics provides a self-contained base for prototyping and experimentation of analogue circuit designs. The FLT-101 includes a built-in power supply, two meters, function generating oscillator variable up to 100Hz, potentiometer, switches and a loudspeaker. The working area is a matrix of 1680 tie-points which will accept most components and all standard-pitch integrated circuits.

Circuits can be built, powered and tested and modified quickly and accurately, it is claimed. Flight Electronics Ltd, Ascupart Street, Southampton SO1 1QL. Tel: 0703 229041.

Free design service for thick-film hybrids

A company that specializes in thick-film resistors is offering a free design service to companies wanting to use such components for p.c.b. and surface mounted hybrid circuits. Holsworthy Electronics, with its sister company CGS Resistance, claims to be able to help customers in many ways. They are particularly aware of the unwritten codes of practice evolved during the development of such circuits. They are willing to work from a complete circuit diagram or "a doodle on the back of an envelope."

"In collaboration with the customer," says Alan Greenwell, technical director, "we can help define component operating parameters, active or passive, and ensure that the circuit design is right and that it can be manufactured easily and competitively." Holsworthy can be commissioned to produce protypes and undertake all testing in manufacture and quality assurance.

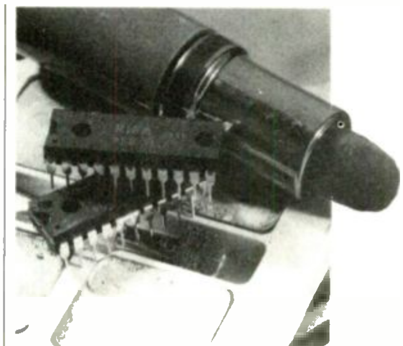
The company can also advise on whether a conventional p.c.b. circuit could be better produced as a surface-mount board. Holsworthy Electronics (Sales) Ltd, Hacche Mill, South Molton, Devon EX36 3LL. Tel: 07695 3151.

New generation teletext decoder

The advent of the subscribe group broadcast teletext service has prompted the development of new decoders. The information is encrypted so the decoders need to receive, decode and decrypt the teletext pages. The Data Text from IGC Industries will receive the 'pseudo page' format broadcast by the commerical tv networks and 'Packet 31' pages transmitted through Ceefax and Oracle. Individual decoders are addressable and will only process information designated for their use. The decoded data can be displayed by a computer or dumb terminal, printed or shown on a dot-matrix message display.

Data Text decoders have automatic digital tuning, analogue filtering, full 'hamming' processing and a large input buffer memory. IGC Industries are also information providers and can transmit information to the Air Call computer to be linked to Oracle or the ITN network.

IGC Industries Ltd, 202 London Road, Waterlooville, Hants PO7 7QU. Tel: 0705 264477.



Clog-free desolder pumps

These Swedish Introvac desolder pumps feature a totally sealed spring mechanism with self-cleaning action to avoid clogging by solder deposits. There are three models: standard, anti-static and heavy duty and they are available from HRS Electronics Ltd, Electron House, Great Barr Street, Birmingham B9 4BB. Tel: 771 2525

Lan linker through Kilostream

Linking Ethernet local area networks on separate sites is possible with the Netlink 5 bridge from MBS Communications. It uses a dedicated digital bi-directional line such as BT's 64Kbit/s KiloStream service or 2Mbit/s MegaStream service as the link between the separate local area networks. It will also operate with a shared dedicated line that is accessed by multiplexer. The system is protocol independent and can link similar networks. It satisfies the requirements of ISO level 2 recommendations for data communications.

The system operates in two halves, one at each end of the line. It can transmit up to 100 Ethernet packets in a second at 64Kbit/s and up to 2000 packets at 2Mbit/s. It has a buffer memory for up to 128 minimally-spaced packets. Internal processing enables the system to learn which packets are local and which are to transmitted down the line. Bridges on each side of the link can be paired so that only the stations intended to receive the data can do so, thus offering data security.

The system is part of a range of equipment for linking networks. Netlink 6 consists of a pair of subsystems housed together and uses a dedicated two-way link at 4Mbit/s to join two different networks on the same site. Coming are a fibre optic link and a laser or infra-red link.

MBS Communications Ltd, 119 High Street, Windsor, Berks SL4 6A.

Microstepping motor controller

A dual d-to-a converter in a 22-pin in d.i.l. package can simplify the design of control circuits for microstepping motors. The PBM3960, from Rifa, is a microprocessor compatible dual 7-bit converter with sign. Analogue voltage outputs can be set to a required level and the circuit generates two current decay signals, one for each channel. When current decay, sign and analogue outputs are connected to Rifa's PBL3771 a microstepping motor control system can be produced with minimum component count and reduced assembly costs. The PBM3960 is easily interfaced to Motorola 6800, 6808, 6809 and Intel 8085 8-bit microprocessors. All signals are t.t.l. compatible. Two address pins control which of four D-type flip-flop registers are addressed and these are automatically reset on power up. The device runs from a nominal +5V supply. Details from Rifa AB, Market Chambers, Shelton Square, Coventry CV1 1DJ. Tel: 0203 553647.

Training systems for tele-communications

A range of modules has been produced by LJ Electronics has been designed to offer hands-on training for electronics engineers and technicians. Planned to be part of a much wider range, the first set of modules, Modicom 1 to 3, covers a curriculum that looks at the techniques of: sampling and filtering; pulse amplitude modulation and demodulation; time division multiplexing; transmitter/receiver synchronization, including p.l.l. pulse code modulation and demodulation; and error-correction systems including the use of Hamming code. A set of course notes (CT02) offer a complete curriculum for a programme of work based on these initial modules.

LJ Electronics Ltd, Francis Way, Bowthorpe Industrial Estate, Norwich NR5 9JA. Tel: 0603 748001.

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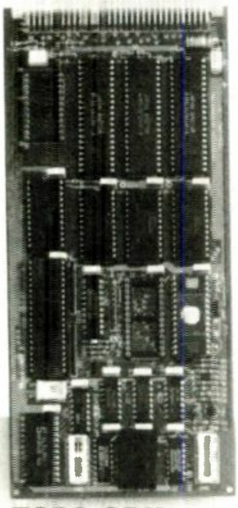

The Cavendish Automation 7030/1 CPU versions support the Intel BASIC-52 package. This unique implementation allows direct manipulation of SFRs, internal data RAM, including bit addressing, together with full floating point. Many tasks which would normally require an assembler can now be written interactively using this fast tokenized interpreter.

Of course, some time-critical routines may require an assembler. Needed routines can be called from BASIC with interrupts being handled at either level, and what's more, an entire function library of over sixty routines may be called from BASIC by the assembler, enabling simple negotiation of floating point, trig functions, multiple precision logical operations and string/character handling.

* Copyright Bryte Computers Inc

The Cavendish Automation CA 7032 CPU versions are available for programming using FORTH*, and provide interactive programme development and the advantages of speed using a compiled language. As with the BASIC package, numerous unique primitives allow full access to the 51 Family architecture.

Assembly language programming is supported together with interrupt handling in FORTH or assembler and timekeeping is included from years down to machine cycles with practically zilch overhead.

Our relay ladder implementation just has to be the simplest and easiest way to manipulate I/O lines from the CPU. The CA 7033 version CPU cards support Relay Ladder implementations which can stand alone or operate under BASIC. A unique feature is the ability to escape at any time from any ladder string into a User Function Module (UFM) which is fully defined by the User. Virtually no restriction exists in calling a UFM, which may be written using assembler or in high-level language, for controlling displays or scanning keyboards, etc.

Short programmes run at loop speeds measured in microseconds, not milliseconds, and standard features such as RUN on hardware reset/power-on reset are also simple to invoke. The user has complete control over how I/O channels function. All outputs may be loaded as inputs by reading the output state.

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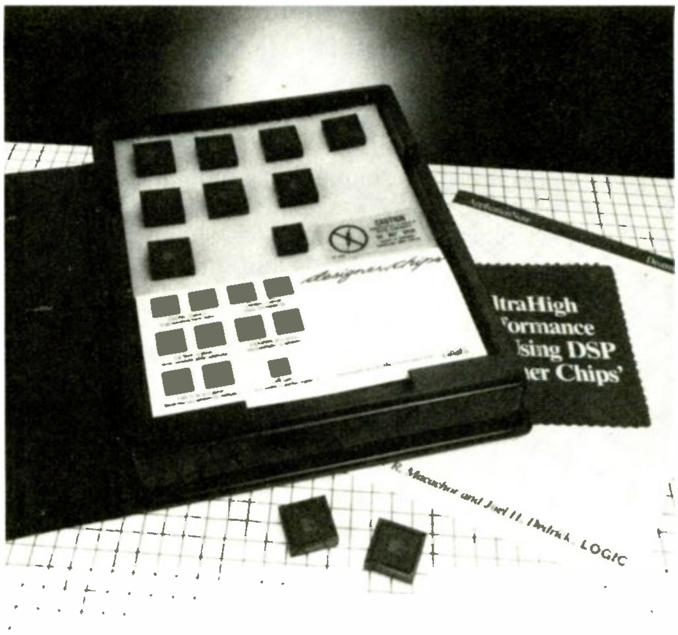
NEW PRODUCTS
COMPUTING

Five functions on one processor peripheral chip

To use the Fujitsu 8086 processor it was necessary to use five peripheral devices. These have now been tacked together into a single integrated 100-pin flat package, the MB89391.

The chip can be connected directly to the processor and includes a clock generator which also synchronizes the external ready and reset signals with the system clock. The bus controller decodes the status signals from the processor and generates command and control signals to the peripheral devices. The interrupt controller handles priority levels for up to eight interrupt signals and can be expanded by an additional controller up to 64 levels. The direct memory access controller provides four d.m.a. channels and can access up to 1Mbyte addresses. The fifth section is a timer and also included on the chip is a bus arbiter for dealing with conflicts with other chips requiring access to the data or address buses.

The combination of these functions into a single package allows very compact p.c.b. assembly for a computer. Fujitsu Microelectronics Ltd, Hargrave House, Belmont Road, Maidenhead, Berks SL6 6NE. Tel: 0628 76100.



Digital signal processing design kit

The "Designer Chips" tool kit is a new idea for developing digital signal processing (d.s.p.) prototype designs and is claimed to offer improved performance and greater architectural flexibility than other solutions.

The kit combines selected logic c.mos d.s.p. parts into a single package, maximized for ultra-high performance. Featuring 11 high-performance devices, plus sockets, the kit is optimized for maths-intensive, real-time processing with pipelined architecture.

Logic Devices' kit provides architectural flexibility while minimizing device count by allowing the designer to tailor the precise mix of logic circuits for each application. In addition, each building block, or device, in the kit is optimized for speed. The kit allows prototyping of such common d.s.p. functions as Fast Fourier Transform (FFT), and achieves speeds of up to 100 times faster than single-chip alternatives.

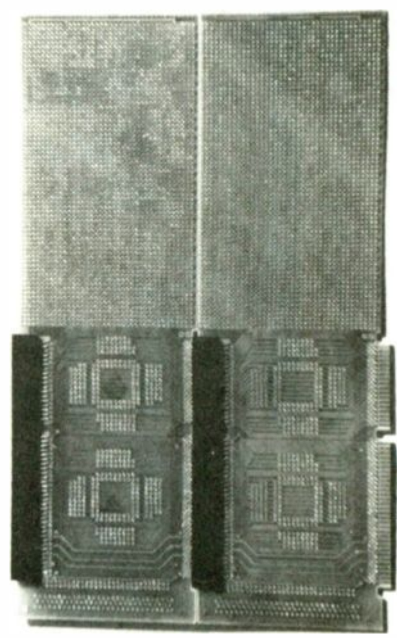
Applications include video processing, high speed data analysis, data compression, and image recognition.

Designer Chips included in the kit are two LSH32JC 32-bit cascadable barrel shifters, two LRF08JC five-Port 8 by 8 register files, two L4C381JC 16-bit cascadable adder/subtractors, two LMA1010JC 16 by 16 multiplier accumulators, two LMU217JC 16 by 16 micro-programmable multipliers, and one LPR520JC 4 by 16 multi-level pipeline register.

All devices are packaged in surface mount plastic leaded chip carriers. In addition, 11 p.l.c.c. sockets are provided for easy prototyping, along with an up-to-date application note and a complete product catalogue that contains technical articles. Abacus Electronics is the sole distributor for Logic Devices' products in the UK. Abacus Electronics Ltd, Bone Lane, Newbury, Berks RG14 55F. Tel: 0635 36222.

PC prototyping board

A prototype card is suitable for IBM PCs and compatibles. Known as Option One, the card combines a prototyping area with a built-in extender. It includes power buses, identification references etched in the copper for all pad positions, a noice reduction grid and two surface-mounted component positions for 68-way chip carriers. The edge connectors have nickel/gold contacts and all pad positions are solder marked to remove the risk of solder shorts. The card is fitted with an AT-type extender connector so that a circuit can be continued on an additional card, without having to address an additional slot position from the computer. The extension can be easily snapped off if not used on an AT-compatible computer. Market Options Ltd, 75 Middle Gordon Road, Camberley, Surrey GU15 2JA. Tel: 0276 29005.



A sideways view of multi-tasking

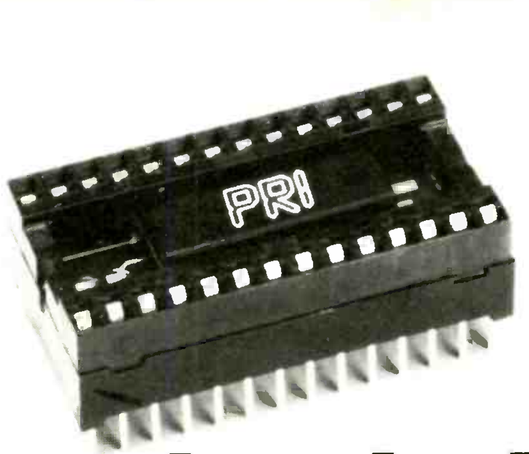
Multi-tasking usually consists of the ability of a computer to run different programs at the same time by multiplexing them together so they appear to be running concurrently. A new low-cost system for the BBC computer takes a different angle: it freezes the current task, dumps the whole computer status and memory to disc and then frees the computer for another task. A keypress restores the computer to where it was, and the original task may be continued. The Sideset rom allows several tasks to be nested and also provides additional utilities such as a calculator, a calendar, address book, notepad and the like. The nested windows display allows the output of several programs to be displayed at the same time. £39.95 mail order from Maze Technology, 11 Braemar Avenus, London NW10 0DY. Tel: 01 452 8372.

16-bit processor from Zilog

A Z80-compatible, 16-bit processor, is the Zilog Z280. Fully compatible with existing Z80 applications software, the device interfaces readily with all Z80 family peripherals in its 8-bit data bus mode, and to Zilog's family of Z-Bus peripherals in the 16 bit data bus mode.

Enhancements on the device are similar to those found on Zilog's 32 bit processor, the Z80000, and include a three-stage pipelined c.p.u. architecture, 256 bytes of fully associative cache memory, capable of using the burst mode access feature of nibble mode d.rams, and a memory management unit capable of addressing up to 16Mbyte of memory. Complementing these features are on-chip peripherals such as three 16 bit counter/timers, four high speed d.m.a. channels and a full duplex uart.

New instructions include signed and unsigned multiply and divide as well as 16 bit variants of the Z80 instruction set. The Z280 also has several new addressing modes which extend the existing Z80 addressing modes. Other on-chip peripherals include a bus interface unit which performs automatic wait state generation, bus scaling and global memory handshaking, a 120 bit refresher/controller and d.rams and a crystal oscillator. Other on-chip logic can be initialized at reset to link one of the Z280's d.m.a. channels to the uart which then bootstrap loads a 256 byte program into program memory, allowing the possibility of a totally romless system. The full Zilog part number is Z8028010VSC, which is a 10MHz Z280 in a 68 pin plastic leaded chip carrier. Available through Gothic Crellon Ltd, 3 The Business Centre, Molly Millars Lane, Wokingham, Berks RG11 2EY. Tel: 0734 788878.



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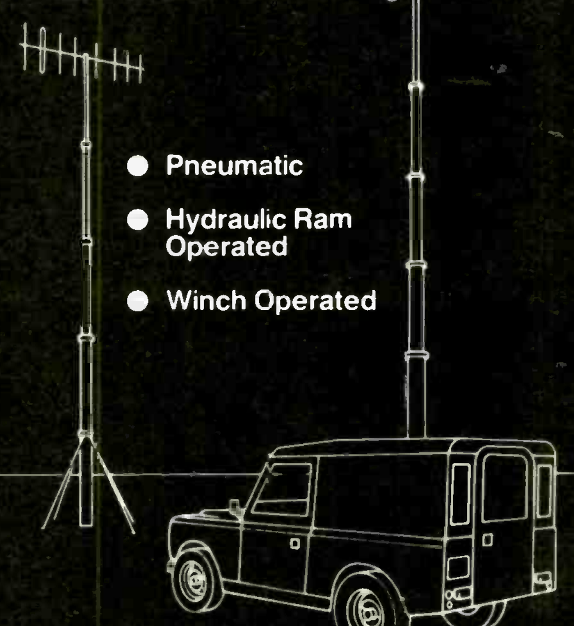

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A 'low cost' 8-bit parallel flash a-to-d converter uses 256 comparators across a precision input reference network. The comparators' inputs are fed to latches and then to an encoder network to produce an 8-bit data byte. The data is then converted to tri-state l.s.-t.t.l. outputs.

The Motorola MC10319L runs from a +5V supply and a wide tolerance negative supply of −3 to −6V; the power consumption is about 620mW. The full scale deflection should be between 1V and 2V, and the analogue input between −2V and +2V.

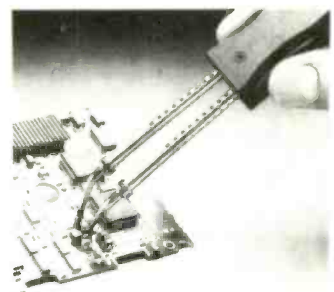
The maximum sampling rate is 25MHz. An over-range bit is provided to allow either over-range sensing or facilitate the connection of two MC10319s in parallel to form a 9-bit converter. Applications include video display and radar processing, high speed instrumentation and tv broadcast encoding. The device is available in a 24 pin d.i.l. ceramic package. Motorola Ltd, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP.

Membrane switch panels

A combination of touch-switch membranes and p.c.bs can make an attractive and functional front panel for instruments. The p.c.bs from NFI are double-sided with plated-through holes. Switch circuits are printed on one side, the switch being made by touching the membrane overlay. On the other side of the board can be surface-mounted all associated components, such as indicators and displays, i.cs, buzzers and relays. This removes the need for a secondary p.c.b. to carry such components. There is also no need for additional support substrates. All button functions can be printed on the membrane. NFI Electronics Ltd, Dodnor Lane Industrial Estate, Newport, Isle of Wight. Tel: 0983 526535.

Hot tweezers for surface mounting

A system designed for the manual assembly of circuits with surface-mounted devices, such as capacitors and resistors have the additional advantage of being safe for use with static-sensitive components. The SMD solder tweezers from OK Industries have soldering tips which allow the simultaneous soldering of both sides of a component, avoiding the problems of cold spots. The tweezers are earthed through their control unit which can be adjusted to control the temperature between 100 and 325°C. OK Industries UK Ltd, Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants SO5 5RR. Tel: 0703 619841.



In-car entertainment

Few would disagree with the view that there have been few really significant changes or improvement in the design or performance of domestic radio receivers in recent years, except perhaps for a few of the better "all-band" models designed for h.f. performance. Indeed, for optimum interference-free reception of medium- and long-wave stations there are few current sets that can match some of the vintage valve sets of the 1930s and 1940s. Similarly, the acoustic performance of, for example, some of the original Murphy designs in the late 1930s, with their baffle-mounted loudspeakers, has too often given way to the ubiquitous "trannies" sold at prices low enought to attract the impulse buyer.

But in one area at least, radio and associated audio systems have been steadily developing, with seemingly little concern with price, to become the present sophisticated "in-car entertainment" (i.c.e.) systems. These embrace equipments selling at prices ranging up to over the thousand-pound mark, including radio receivers with synthesized tuning systems, press-button or automatic tuning to strong signals, high-fidelity stereo and multiple loudspeakers, CB and cellular two-way radio; electronic navigation and the various automatic tuning and station identification facilities soon to be extended to include those offered by the EBU "Radio Data System" (RDS).

Specialist retailers/installers rather than the manufacturers appear to be reaping the main benefit. Manufacturers are grumbling that this section of the market has become heavily over-subscribed. Mitsubishi recently pulled out of i.c.e. and other major firms are reported as likely to follow.

Buzz words in this area include security coding; microcomputer control to select strongest signal, diversity-reception complete with two aerials and two front-ends, self-programming, etc. Recently, in-car Compact Disc (CD) units are being promoted in the UK, despite fears by some that they may later be squeezed out by in-car d.a.t. digital audio tape players.

Security systems have become a major selling feature. It is claimed that in the UK alone one i.c.e. unit is stolen on average every minute of the day, often accompanied by damage to the vehicle: no longer is it primarily just a question of external car aerials being vandalized. Security coding systems are now often designed so that any withdrawal of power when removing the unit from the vehicle causes the set to refuse to function until an individual "secret code" is fed in via push buttons, some with the added refinement that punching in an incorrect combination puts the coding system out of action for several hours in order to frustrate any attempt to find the correct combination by repeatedly trying. Window stickers are often supplied intended to discourage thieves from attempting to rip out security-coded units. Clarion, for instance, intends also to market the key units in a form such that they can be removed and taken away by the driver when he leaves his vehicle unattended.

Some i.c.e. units provide very high-power audio (up to more than 100 watts per channel) claimed as needed for use with relatively small loudspeaker enclosures, even though the safety aspects of having excessive volume of audio in vehicles and so isolating drivers from external noises, including horns or mechanical malfunctions, have been questioned by such bodies as RoSPA.

A survey of "What's new in car sound systems?" in *Electronics Australia* shows many of the same trends as are evident in the UK and the USA, although medium-wave a.m.-stereo has yet to reach Europe and possibly never will do. Considerable emphasis is placed on the use of CD players in cars, praised by the Australian journal as providing, when used with good amplifiers and speakers, "spectacularly better than f.m. reception or cassette reproduction in most cars". Another reason is given as "the ease of handling and the reduced concern about dust and grime. Nor do you have to worry about rewinding tapes and you can repeat any musical selection as often as you want, at will."

It is claimed that "car CD players have proven to be reliable and not at all prone to mistrack because of the high vibration and shocks in a moving car. There is still an element of caution about leaving compact discs in direct sunlight because of the danger of warping, but this applies more to the CD cases than the discs themselves."

The journal believes that the biggest drawback of having CD in a car is the risk of theft, often accompanied by damage to bodywork and interior when equipment is ripped out by thieves. Sony has a remotely controlled CD unit which is sited in the boot of the vehicle out of sight of thieves. Other firms incorporate various forms of security coding.

Clarion has recently announced that it is to launch a d.a.t. car player in Japan this autumn but that release of the model in Europe will hinge upon when d.a.t. software becomes available, following the long dispute over copyright, with the recording industry still seeking to compel manufacturers to incorporate anti-copying devices to prevent direct copying of digital CD records.

In-shot stereo only?

Stereo radio has taken a long time to establish itself in the UK and remains a minority listening mode. There are many engineers who remain unhappy with the pilot-tone system, not only because of its cross-talk limitations, its proneness to interference and multipath distortion but also because of the severe reduction of coverage compared with the monophonic transmissions. None of these restrictions applies to the digital stereo systems proposed for both terrestrial and d.b.s. television systems.

Yet there must remain doubt, not on the stereo technology, but on the combination of a large sound stage with a relatively small tv picture. Nobody wants viewers to switch off the picture in order to enjoy the stereo sound.

During May, both the BBC and IBA mounted public or private demonstrations of compilation tapes featuring a varied selection of clips from different tv programmes that have been recorded with stereo sound, including orchestral, drama, sports, light entertainment, etc. My impression of both demonstrations was the degree to which they emphasized the need for restraint on the part of producers and the need to avoid returning to that now distant era when every stereo demonstration featured table-tennis and passing trains. Undoubtedly the production of good tv-stereo is not easy, what with the problem of changing camera angles, zoom lenses and the like. These can give rise to some most odd effects that have nothing to do with the basic excellence of the stereo sound. Voices or instruments seen in-shot with the sound apparently coming from well left or right of the picture are decidedly off-putting.

Student radio

The long drawn-out struggle to establish a true, socially-committed "community radio" in the UK has rather lost its way in view of the stop-go policy of the Home Office and the confusion between "community radio" and low-cost, deregulated commercial radio. It is, however, often forgotten that two types of community station have been running for many years: hospital radio on closed-circuit and student radio using low-power medium-wave transmitters, often with inductive loops or other techniques to restrict coverage mainly to the university campus.

It is interesting to find that a long-time advocate of community radio, Norman McCloud of the "Wireless Workshop", a Brighton firm that caters specifically for low-cost and special-event radio for which licences have also been available for several years, has launched, on behalf of the National Association of Student Broadcasters, a new quarterly technical newsletter, oddly named *Eric*. The first issue includes a discussion on the use of v.h.f./f.m. stereo for student radio, based on a leaky co-axial cable system, and a note on telephone balancing techniques for separating incoming and outgoing speech for phone-ins etc.

Radio Broadcast is written by Pat Hawker.

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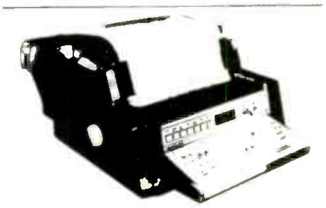

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TELEVISION BROADCAST

Aircraft flutter

One of the long-standing, but little discussed, problems of television reception on both v.h.f. and u.h.f. is the occasional disturbance of pictures resulting from the scattering of signals by passing aircraft. In effect, the receiver becomes part of an elementary form of bistatic radar though fortunately for broadcasters and most viewers the disturbances are not frequent enough or severe enought to provoke complaints. Many viewers remain in ignorance of the cause of these occasional picture disturbances unless they live in the immediate vicinity of a busy airport.

About 1970, the Rev. Paul Sollom, G3BGL, of Douai School, in collaboration with J.A. Lane of the Radio and Space Research Station (now part of the Rutherford Appleton Laboratory), as part of an investigation into tropospheric propagation, showed clearly how aircraft scatter is responsible for the "steam-train effect" (waa-waa-chuff-chuff-chuff) on v.h.f./f.m. radio, but relatively little research ever seems to have been carried out in the UK into the extent of the problem on v.h.f. or u.h.f. television signals.

Certainly in South London, near an occasionally used flight path into Heathrow, picture disturbances can be seen at times when aircraft noise is audible and sometimes before the aircraft is heard. On the strong local tv signals from Crystal Palace, the disturbance are not unduly annoying but nevertheless are clearly visible. Many viewers near Heathrow must be affected to a much greater extent.

Aircraft flutter and the equivalent "steam-train effect" are manifestations of multipath reception, accompanied by Doppler effect and changing path lengths. A fresh study of this phenomenon is described in a report "Prediction of fluttering disturbance in tv signals caused by aircraft scattering" by Shiro Ito published recently (NHK Laboratories Note No 344, March 1987) and occasioned by the increasing amount of air traffic, the larger size of aircraft and the greater number of airports.

Initially, to determine the scattering characteristic of a modern large aircraft, a 1/100th scale model of a Boeing 747, coated with conductive paint, was rotated in a radio anechoic chamber and illuminated with 12 GHz signals. It was found that the scattering characteristics of the model could be modelled for computer calculations by a combination of 46 rectangular reflectors. This finding was subsequently verified on real aircraft in the Tokyo area in a location where Band 1 signals fluctuated for about 15 seconds each time a 747 flew into Tokyo airport. The maximum fluctuating amplitude of the signals was about 13dB. The report shows that computer studies can now be used to calculate and predict the amplitude and period of the fluctuation of field intensity, the delay and the ratio of desired to undesired (D/U) signal.

The method gives the v.h.f. fluttering zone for a single flight, leaving the problem of multiple flights for the future, and also the extent to which this model could be applied to u.h.f. transmissions. But whether there is any practicable way of reducing the effect on tv screens, other than by careful locations of nulls in the vertical radiation pattern of the receiving antenna, remains open to doubt, and is not considered in the NHK report.

Satellite broadcasting poses problems

The time may or may not be coming when we shall see widespread viewing in the home of programmes coming direct from geostationary satellites. Few now dispute the value and economic advantages of satellite distribution links that provide programme feeds at relatively low cost to multiple terrestrial transmitters or cable networks. But high-power satellite transponders at the hundred-watt level are still only a promising if risky technology, held back by the difficulty and launch cost of providing sufficient electrical power on a satellite of reasonable weight to provide more than about three of four transponders on the satellite and the lack of flight-proven high-power travelling-wave-tube amplifiers.

The pulling out of Amstrad Consumer Electronics, one of the five original founders of the BSB consortium, must make one wonder whether the suggested £200 for the cost of satellite receiving equipment for use with an existing tv set will be met, particularly since it now appears that BSB's channels will be encrypted and (subject to Government approval) use the D-MAC transmission standard. The number of viewers who have proved willing to pay £1000 or so for equipment capable of receiving cable programmes from the low-power distribution satellites can, in the UK, be numbered in hundreds rather than millions; in the USA the sale of C-band tvros fell away sharply when the premium film channels began encrypting last year after the total of direct viewers had reached about 1.6 million. A number of the UK firms that entered this market have already fallen by the wayside.

DBS and, even more so, low-power distribution satellites still transgress the broadcasting adage that capital costs should fall primarily on the broadcaster rather than on millions of viewers. There is also the problem that DBS cannot cater for "regional programmes", so that the existing terrestrial network will need to continue for many years yet, if we are to avoid tv broadcasting becoming limited to national programming.

But one wonders to what extent the public is already being misled by the enthusiasm of popular science writers and the media in general. Many writers still seem to think that viewers will remain fascinated at the mere idea of watching programmes from outer space, whether in the English language or foreign languages. Surely, after a few days it is the standard of the programmes that will matter. DBS, like cable, is just a means of extending programme choice, though eventually it may offer higher definition and wider screens.

I have been reading the recent Penguin paperback "The beginner's guide to satellite tv" by Richard Maybury (121 pages, £3.95) which insists dogmatically that satellite tv is "the tv of the future" and enthuses over the 20 or so channels already being beamed "directly at every home in western Europe from orbiting satellites 36,000 kilometres above the equator", continuing "In less than five years there could be as many as one hundred television channels to choose from, and the equipment will cost less than £200 at today's prices. Stick around – we are at the very beginning of a revolution in communications and broadcasting that is potentially every bit as important as Marconi's first tentative clicks and buzzes!"

While such books do contain a lot of useful background material on space technology they also, unfortunately, often include material that is false or misleading. What on earth for instance is one to make of the confident assertion (page 118 in the glossary of terms) that B-MAC is a system developed by the BBC (*sic*) and D-MAC is a high-definition system! Similarly the earlier section on MAC seems to suppose that the prime purpose of this family of systems is to provide encryption. It gives Oak/Orion as one of the most commonly used scrambling systems, with no mentioin of VideoCipher II, which has become virtually the de facto satellite-link encryption standard in the USA. Nor any warning that many of the tvros currently being sold will not be suitable for reception of D-MAC links or DBS systems.

One has no wish to nit-pick errors in a book that does have some merits, but it seems a pity that a firm with the reputation of Penguin, in addressing a readership that needs sound guidance in an area of considerable complexity and rapid changing of plans and technology, did not take the precaution of having the text read by those directly concerned with the technology and economics of tv broadcasting.

As John Gau put it recently in *The Daily Telegraph*: "Forget satellites, forget cable, forget the latest fashionable piece of technology that its supporters claim will revolutionize television as we know it. The Tories' manifesto commitment to compel the BBC and ITV to take 25 per cent of their programmes from independent producers will have a far bigger impact on British broadcasting."

Television Broadcast is written by Pat Hawker

Handheld hazards

One of the objectives listed for a service such as Donald Cox advocates is user safety from strong electromagnetic fields. This would clearly be achieved with the envisaged power levels of the portable equipment. Several years ago, Motorola engineers investigated the potential hazard of using hand-held radio equipment with short, normal-mode, helical ("rubber duck") antennas only a few inches away from the users' eyes. The conclusion then reached was that a safe limit for such a handheld transceiver, based on measured rates of tissue absorption and heating, was about 7 watts of r.f. output. Since then there has been, at lest in some countries, a tendency to impose lower safety limits in the v.h.f. spectrum than were standard at the time of the Motorola study.

In these circumstances it is surprising that there is still a trend towards providing higher transmitter powers in handheld equipments, limited primarily not by safety considerations but by battery life. For example, the recently introduced Yaesu FT73 handheld transceiver for amateur radio with a very short (2in) "rubber duck" normal-mode helical antenna can provide up to 5 watts of r.f., with the antenna likely to be very close to the heat-sensitive eyes of the user. While its power is below the safe maximum suggested by the Motorola study it may well seem a little too close for comfort of mind. It is perhaps time for manufacturers and users to think in terms of lower power levels or alternatively the use and positioning of antennas that would be less inclined to concentrate the r.f. field at eye level.

Handheld units of more than milliwatt power have also been readily available in the UK for several years for use as cordless telephones, sometimes offering ranges up to 20 or 30km. The tighter DTI regulations relating to the importation, sale and use of unauthorized cordless telephones finally came into force on May, although not without a measure of confusion brought about by the DTI press statement seeming to imply that no units operating on frequencies below 853MHz are legal. In fact, all of the authorized units use frequencies below 853MHz and remain legal, operating on the DTI assigned channels at low-power intended to restrict the range to under 200 metres, although receivable on sensitive communications receivers at greater distances. BT have been developing cordless phones using digital modulation techniques at around 900MHz for several years, and would be well-placed for providing such services as apparently now envisaged by Bell.

Universal portable radio

The influential *Proc. IEEE* journal, in its April issue, accorded to portable radio communications the accolade of an invited, book-length (42 pages) paper "Universal digital portable radio communications" by Donald C. Cox of Bell Communications Research. In doing so, it notes that "providing voice and data communication to people away from their wireline telephones has become a major comunications frontier. This frontier is being penetrated by evolving new approaches to portable communications, e.g. cordless telephones, mobile radiotelephone and radio paging. However, these approaches have many limitations: none can provide universal portable communications services."

The paper examines the strengths and limitations not only of these already booming services but also radio data systems, automatic call forwarding in electronic switching and even Citizens' Band radio with its advantages of providing simple two-way radio but restricted by its "chaotic, undisciplined, unreliable, simplex mode and no privacy" nature.

Donald Cox seeks to define the objectives and possibilities for a universal portable radio communications service which, he concludes, could be provided by using demand-assigned digital-radio links for the final thousand feet or so or telephone loops, using radio frequencies of the order of 900MHz. He suggests that portable units with a transmit power of less than 10 milliwatts would suffice both for outdoor and indoor operation. He believes that universal telephone-linked digital services could provide special services with enormous social benefits.

He shows that there are several radio-link techniques that could be used to ensure reliable radio performance in difficult environments and appeals for a suitable block of the radio spectrum around 900MHz or 1GHz to be assigned for such a service.

More amateur spectrum

The release of a substantial amount of additional v.h.f. spectrum to both Class A and Class B radio amateurs from June 1 and the reclassification of the 70 MHz (extended to 70.0–70.5 MHz "secondary status" represents a major gain for British amateurs, despite the continued power and other limitations on the use of the 50 MHz band.

50.0 to 51.0MHz becomes a "primary allocation subject to not causing interference to other administrations" (i.e. the Band 1 television services in European countries). Antenna height is still limited to 20 metres above ground level with horizontal polarization only and maximum power of 14dBW e.r.p. (carrier), 20dBW e.r.p. peak envelope power on s.s.b. No mobile operation is permitted. 51.0 to 52.0 MHz now becomes available on similar terms, but is accorded a UK "secondary" status.

The "four-metre" band, which has never been an international allocation, is accorded "secondary" status, with maximum power of 16dBW (carrier) and 22 dBW p.e.p. but this is the power output fed to the antenna elements and is not reduced by the use of high-gain transmitting antennas as is the case on 50 MHz. The UK, Gibraltar and Eire, however, are about the only other countries permitting operation in this part of the spectrum so that most international operation has to be "cross-band".

The new regulations will be especially welcome to Class B licensees who until June 1 were entirely restricted to the use of frequency bands above 144.0 MHz. It remains to be seen whether Sunspot Cycle 22 will reach the level of activity at which 50 MHz is liable to open regularly for long-distance F-layer ionospheric propagation but it wil be surprising if there are not at least some openings. Users of both bands are also well placed to take advantage of medium-distance propagation by Sporadic E, meteor-scatter and auroral modes.

H. f. resurgent

Ever since the 1960s, in the years that have seen the apparent unstoppable growth of satellite communications and broadband cable, more recently in the form of optical fibres that some believe will eventually supplant satellites for point-to-point services, I have consistently argued that there is still a continuing role for h.f. communications, in spite of the limited capacity and all the problems inherent in ionospheric propagation. In support one could quote the recent revival of interest on the part of the US Navy with its current major requirement for jam-resistant h.f. systems for its ships.

Dr Nicholas Machin in his new book H. F. Communications – a systems approach (Pitman) adds weight to this argument. He stresses the re-awakening of interest in h.f. attributing this largely to the growing realization of the vulnerability of satellite communications as a result of the development of anti-satellite techniques.

He suggest this new lease of life for h.f. has been further enhanced by its marriage to computer technology which he considers offers tremendous potential to improve its performance and reliability and has the major aim of minimizing reliance on the once essential highly skilled communications specialists and operators who, he admits, had considerable understanding of the transmission medium.

While Dr Machin clearly welcomes this de-skilling of the craft of radio operating and the substitution of machine-intelligence, I feel we should spare a thought for the phasing out of the once all-important radio operator.

Radio Communications is written by Pat Hawker.

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OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.75
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.55
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.85
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL800	0.80
PCL805	0.90
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PE06-40N	42.00
PFL200	0.95
PL21	2.50
PL36	1.75
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	2.95
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	72.00
QB3-1750	139.50
QB5-3500	595.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
QQE03-12	7.95
QQE03-20	35.00
QQE06-40	45.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV06-40A	27.50
QQV06-40A Mullard	39.50
QQV07-50	55.00
QQZ03-20	42.50
QS75/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90

QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	5.75
QV05-25	2.50
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-208	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RSS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
A30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.59
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/200	9.00
SP41	5.00
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3-2000	395.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT21	45.00
TT22	45.00
TT100	69.00
TTR-31MR	65.00
TY2-125A	85.00
TY4 400	85.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.25
UBC81	1.50
UBF89	1.00
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	1.00
UCL82	1.75
UCL83	2.50
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.00
UL41	5.50
UL44	3.50
UL84	1.50
UL85	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V246A/2K	315.00
V2406/1K	225.00
V241C/1K	195.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75-30	3.00
VR101	2.00
V105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50

W77	5.00
W729	1.00
W739	1.50
X24	4.50
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG1-2500	75.00
XG5-500	22.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	149.50
Y502	25.00
Y65	6.95
YD1100	75.00
YJ1060	265.00
YL1020	42.50
YL1060	195.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZM1005	8.00
ZM1020	6.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
1B22	10.00
1B27	55.00
1B35A	45.00
1B63A	75.00
1C1	2.50
1C5GT	2.50
1FD1	2.50
1G3GT	2.50
1J3GT	2.50
1K3	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1P39	19.50
1R5	0.90
1T4	1.00
1U4	1.75
1U5	1.00
1X2B	1.40
1Z2	8.95
2AS15A	11.50
2B7	1.50
2B22	69.50
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C43	60.00
2C51	0.75
2C53	45.00
2CY5	1.50
2D21	1.95
2D21W	3.15
2E22	49.00
2E26	7.95
2J42	93.00
2J55	295.00
2K25	35.00
2K25 Raytheon	75.00
2K26	95.00
2K29	250.00
2K48	140.00
2K56	250.00
2X2A	5.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A3A	3.95
3A4	1.10
3A5	4.50
31L5	0.95
3AT2	3.35
3B2	3.00
3B4	4.95
3B7	4.50
3B24	10.00
3B26	24.00
3B28	15.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3BA	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3Q4	2.50
3V4	1.75
3W4GT	2.50
4B5518	115.00
4-65A	65.00
4-250A	79.50
4-400A	87.50
4-1000A	425.00

4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4C35	145.00
4CX1000A	425.00
4CX4000A	1100.00
4CX250B	49.00
4CX250B EIMAC	59.50
4D32	125.00
4CX250BN	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4XC1500B	398.50
4E27	195.00
4GS7	2.25
4J52	75.00
4JC6A	2.95
4KT6	1.50
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AM8	2.15
5AN8	1.20
5AR4	2.00
5AU4	1.50
5B 110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	15.00
5B-257M	15.00
5B-258M	14.50
5C22	125.00
5CL8A	2.50
5J180E	2950.00
5R4GB	5.50
5R4GY	4.95
5T4	5.95
5U4G	2.95
5U4GB	4.50
5V4G	1.50
5Y3GT	1.95
5Z4GT	1.50
6/30L2	0.70
6A 203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AG5	1.50
6AG7	1.50
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.95
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.95
6AN5	4.50
6AN8A	3.50
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU5GT	4.50
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AX4GT	1.95
6AY3B	1.95
6AZ8	4.50
6B7	2.80
6B8G	1.50
6B10	1.95
6BA6	0.95
6BA7	4.50
6BA8A	3.50
6BE6	0.95
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.50
6BK4	4.00
6BK7A	1.95
6BL6	85.00
6BL8	1.15
6BM6	115.00
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN8	3.95
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.25
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95

6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CN5	1.60
6CM7	2.95
6CS6	0.75
6CS7	0.95
6CW4	6.50
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	1.50
6DQ5	6.95
6DQ6B	2.50
6DT6A	1.50
6DW4	2.15
6E5	3.95
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	2.95
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GE5	3.95
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GM6	2.65
6GS7	2.15
6GV7	2.50
6GW6	2.50
6GW8	2.50
6GY5	3.95
6H1	9.50
6H3N	2.50
6H6	1.95
6H6GT	1.95
6HF5	5.50
6HF8	2.50
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	2.00
6J7	4.15
6JB6A	4.50
6JE6C	6.50
6JU8	2.50
6JS6C	6.50
6J7G	4.15
6K7G	2.00
6K8G	3.00
6KD6	6.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	5.75
6L6GC Philips	6.50
6L6GT	1.95
6LD20	1.15
6LF6	7.50
6L6GAY SYLVANIA	5.50
6LJ8	2.50
6LQ6	6.50
6Q7GT	1.20
6R7G	3.15
6S4A	1.95
6SA7GT	1.35
6SC7	1.50
6SG7	2.50
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
6SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U6WA	3.50
6U8	1.15
6U8A	1.50
6V6G	1.25
6V6GT	1.50

6VGG	1.00
6Y6G	3.95
6X2N	1.00
6X4	1.50
6X5GT	1.00
6X5GTY	1.00
6X8B	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7AU7	1.50
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10EW7	2.95
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD12	0.65
11E2R	45.00
11E3	55.00
11R3	5.50
12A6	3.95
12AD6	1.50
12AH7GT	4.95
12AL5	1.00
12AT6	1.25
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12AU7	0.65
12AV6	1.95
12AV7	2.50
12AX7	0.85
12AX7S	7.95
12AX7WA	2.30
12AY7	3.95
12AZ7A	1.95
12B4A	4.50
12BA6	1.50
12BE6	1.95
12BH7A	2.95
12BL6	1.75
12BY7A	2.75
12C8	2.50
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12E1	19.50
12E14	38.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J5GT	3.95
12J7GT	3.50
12JZ8	2.95
12K5	1.95
12K7GT	1.50
12K8	1.95
12SA7GT	1.95
12SG7	4.75
12SH7	1.95
12SK7	1.95
12SJ7	1.50
12SQ7GT	1.95
12SN7GT	1.85
12X4	1.95
12SY7	4.50
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
16GY5	2.95
17BE3	2.50
17DW4A	2.95
17EW8	0.95
17JZ8	4.50
18D3	6.00
18GB5	3.50
19AQ5	3.50
19AU4GT	2.50
19G6	9.00
19G3	17.00
19H4	35.00
19H4R	25.00
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	7.95
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21JZ6	4.95
21LU8	3.75
24B1	39.50
25DQ6B	2.95
25L6GT	1.75
25BQ6	1.75

29C1	19.50
29KQ6	6.50
30C17	0.40
30C18	1.48
3F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
80	4.50
83	8.50
83A1	7.50
84	3.00
85A1	6.50
85A2	2.50
90AV	15.00
90C1	3.50
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	15.00
95A1	6.50
100E1	10.00
108C1	1.50
150B2	6.50
150C2	2.50
150C4	2.15
155UG	25.00
185BT	1.50
211	33.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	4.50
572B	55.00
705A	8.00
708A	8.00
724A	275.00
726A	75.00
7591A	6.50
7025S	6.95
803	14.95
805	59.00
807	2.50
810	85.00
811A	15.00
812A	35.00
813	27.50
813 Philips	35.00
829B	14.50
833A	95.00
866A	6.50
872A	20.00
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00
958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	6.95
2050	5.50
2051	5.50
3534	4.00
404A	10.95
927	15.00

1927	25.00
4687A	9.50
4212E	250.00
4313C	4.00
4328D	9.00
5636	5.50
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5675	28.00
5678	7.50
5687	4.50
5692	3.50
5696	4.50
5704	3.50
5718	6.15
5725	2.50
5726	2.50
5727	2.50
5749	2.50
5750	1.85
5751	2.95
5763	5.75
5814A	3.25
5823	9.50
5829WA	6.50
5840	3.50
5842	11.00
5847	10.95
5879	5.00
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5065	2.25
6005	1.85
6012	16.00
6021	3.65
6057	3.75
6058	3.95
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Siemens UK developments

Woodley, near Reading is the site for the new Systems Development Group of Siemens. Its aim is to provided system planning of medical facilities, factory automation management, and the integration of components into telecommunication and information systems. One of the group's initial projects if the interfacing of Sinix, Siemens' version of Unix, with their hardware running under MS-DOS, providing a 'transparent' link between the two operation systems. The linking of Sinix to a high-speed graphics terminal is also high on their list of priorities. Another project is to develop an emulator that allows a Siemens PCD-2, or any IBM-PC clone, to function as a high-speed terminal connected to a central processor via Ethernet, an RS232 interface, V11 interface or a simple modem. The Group is also currently developing a symbolic debugger for the 'C' language, with a windows-oriented user-interface to improve usability.

In addition to developing Sinix-based systems, the group also carries out systems programming for the Siemens 7,500 series mainframe computers, which use the BS2000 operating system. Here, particular areas of application are job control language and compiler development.

The group, indeed Siemens as a whole, is firmly committed to conforming to, and helping to develop, standards in operating systems, communications and in processor architecture.

Ban on many cordless phones

Since the 21st May, all cordless telephones that do not conform to the DTI conformance specification MPT1322 and operate on frequencies below 853MHz must not be sold. It is illegal to use, import, or manufacture such phones. By outlawing certain cordless telephones the DTI aims to remove a considerable source of interference to a wide range of legitimate radio users, including emergency services. Because of poor technical standards and the use of incorrect frequencies, their higher output power can disrupt other radio users.

Other measures to amend the technical definition of cordless telephone apparatus have also come into force. Copies of the Statutory Instruments relating to this new legislation (SI Numbers 774/87 and 775/87) are available from HMSO. Copies of the DTI performance specification MPT 1322 are available from: The Library, Radiocommunications Division, DTI, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Touch-sensitive robot

A joint project team from British Aerospace and Hatfield Polytechnic are developing a robot with a sensory feedback, i.e. a touch system. One system built at Hatfield uses a Fanuc A1 robot with an Astek six-axis force sensor fitted to its wrist joint on which is mounted a gripping device. This system is controlled by a BBC-B computer. A closed loop control system responds to the data fed back from the sensor. The robot is programmed to insert a peg into a hole. As the peg is not in perfect alignment with the hole, the magnitude of the force exerted on one side of the peg is resolved into x, y and z components by the Astek sensor and is transmitted to the computer. A control algorithm is used by the computer to process the data and provide responsive movement commands so that the contact forces are reduced. It is an incremental process, the peg being moved in small steps until it is freely inserted.

Such a system has the potential of providing precision assembly with improved quality control; a detailed record of assembly operations would be generated for subsequent analysis in the event of problems. The project is part of a cooperative agreement between Hatfield Polytechnic and BAe for a programme of joint endeavour covering research, education, training and the exchange of staff. Another initiative was the establishment of a British Aerospace Research Fellowship in v.l.s.i. circuit design.

Human factors in electronics design

The operator actually has to use equipment and, if it is not easy, a system is likely to be rejected or not used to its full potential. This is the message of a pilot scheme aimed at improving 'human factors' design in electronics-based equipment and software which has been launched by the Design Council and the Alvey directorate.

This new initiative recognises that the success of the rapidly growing variety of products that rely on electronics depends increasingly on the way that they meet the real needs of the user rather than simply relying on superior technical performance. Human factors design is becoming increasingly important now that most such equipment is being used by people who are not computer specialists and that an ever wider range of products, from teaching aids and video recorders to machine and process control systems, are electronics-based.

'Support for Design – Human Factors' is available to companies with up to 500 employees in one operating unit (which allows subsidiaries of larger companies to participate) and will provide up to fifteen days of design consultancy with two-thirds of the cost being paid for by the Department of Trade and Industry. Companies that have already benefited from a 'Support for Design' project can apply for a human factors design project.

The pilot scheme is intended to use skills that are normally beyond the scope of conventional ergonomics and industrial design and the scheme will draw particularly on the expertise of the three human factors centres funded by the Alvey Directorate and a small number of independent consultants.

Within the scheme, consultants will be able to advise on the design process in general or concentrate on specific aspects. Projects are likely to range from analysis of requirements, specifying and designing the user interface, building and testing mock-ups and prototypes, designing training and operating

EXHIBITIONS & CONFERENCES

28 August – 6 September
Funkausstellung: International audio and video fair Berlin (incorporating MediaForum). International Congress Centre, Berlin. Details from AMK Berlin, Postfach 19 17 40, Messedamm 22, D-1000, Berlin 19, FRG.

2 – 4 September
MediaForum Berlin '87 Congress and exhibition on telecommunications, including broadcasting. Details as above.

8 – 10 September
Digital signal processing; a short course at the Institute for Information Technology, University of Sheffield. Details from Mrs C. Scown. Tel: Sheffield 768555 Ext. 5100.

9 – 11 September
Electrostatics summer school. University College of N. Wales, Bangor. Tel: 0248 351151 Ext. 2749.

15 – 18 September
Design Engineering Show and conference, NEC, Birmingham. Cahners Exhibitions. Tel: 01 891 5051.
EED 87, electronics in engineering design. NEC, Birmingham. Cahners as above.
Test and transducer; international conference and exhibition. Wembley Conference Centre, London. Trident International. Tel: 0822 4671.

22 – 23 September
Computer Networks; short course at the IIT, Sheffield. See 8 September for details.

23 – 27 September
PCW 87: 10th Personal Computer World Show, Olympia, London.

29 September – 1 October
NAV 87. Navigation data, dissemination and display conference and exhibition. Heathrow Penta Hotel. Organized by the Royal Institute of Navigation. Tel: 01-589 5021.
Semiconductor International; design, assembly, test, materials and chemicals. NEC Birmingham. Cahners Exhibitions. Tel: 01-891 5051.

5 – 8 October
HDTV 87: International colloquium, Ottawa, Ontario, Canada. Details from HDTV Coloquium, Journal Tower North, 300 Slater Street, Ottawa, Ontario K1A OCB, Canada.

procedures, and evaluating the effectiveness of equipment or software. For further information about 'Support for Design – Human Factors' contact: Andrew Hartley, Support for Design, The Design Council, 28 Haymarket, London SW1Y 45U Tel: 01-839 8000.

* * *

Human factors at a more psychological level are the subject of other Alvey research projects. A 'programmable user models' project will evaluate several psychological approaches to human/computer interactions by assessing how well each approach addresses a sample of problems experienced by computer users. From this study, it is hoped to improve understanding of the desired characteristics of a computer language that is easy to understand.

A further phase will involve programming and evaluating prototypes of the language. These will have built-in constraints corresponding to the human limitations of understanding. It is intended that eventual users of the facilities will incorporate similar constraints at an early stage in the design of new software.

This research is being coordinated by Logica Ltd in collaboration with the Applied Psychology Unit of the Medical Research Council and STL Technology Ltd. Another new project which Logica is coordinating, with the collaboration of commercial and academic research facilities, is to develop an Intelligent Computer Aided Instruction (ICAI) system and knowledge base for teaching the operation, maintenance and programming of a computer-controlled machine tool. The project, known as the Knowledge Based Engineering Trainer (KBET), is based on TUTOR, Logica's intelligent tutoring system, produced in collaboration with the Royal Signals and Radar Establishment. Using principles of knowledge-based technology, the system provides a next-generation improvement in computer assisted training. TUTOR has been demonstrated successfully as a Highway Code training aid, but has been designed to help teach a wide range of subjects.

One of the most important features of the KBET project will be the integration of video-disc equipment into the ICAI system. By this means the inclusion of video in the training material will provide improved learning opportunities.

Emergency network

An alarm communication system is under test in Sweden. After only a short period of use it has demonstrated that the time between alarm and action can be considerably reduced. The system, called Coordocom, integrates and coordinates information for alarm centre operators. It does this by providing one single channel for all emergency communications and concentrating them into a single audio and visual channel. The operator has control at all times over the communications using radio, telephone, teletex and facsimile equipment to control field personnel while keeping in contact with those who need help. A display screen also shows which calls are waiting and which services are available. The system can extract addresses from the Swedish telecoms subscriber list.

The system is built from three main parts: a communications exchange, computers and the operators work stations. The Norwegian Nerion exchange was originally designed for air traffic control. Three networked Vax computers control the links between the exchange and work-stations and provide information storage, as well as back-up for each other. The work can be distributed to as many work-stations as are needed to cope with the emergency. Prepared procedures can be displayed on the screen for the operator to follow. One example is an airport emergency where 40 pre-planned procedures are already programmed. There are also a large number of general-purpose emergency plans, e.g. for house fires. The system includes a number of databases including, for example, information on poisons. A resources module contains information on all the emergency facilities, including vehicles and equipment. The operator's screen is divided into two sections with one part showing communications equipment logging, such as which calls are waiting and for how long. An operator can deal with up to five different events at the same time. The rest of the screen is the operator's notepad and form-filling area. Messages to/from other operators can be written to and read from this area. Such a system is applicable to a wide range of traffic control operations, such as taxi and haulage companies or other authorities.

User's guide to IT

A useful guide to implementing IT projects in a business environment is provided by a report: "Information Technology – The future user environment" produced by the Alvey IT users' panel. It expresses a user's view of where IT is going over the next five years.

The panel had been formed to give user guidance to the Alvey research programme. Before considering user needs in software engineering, it became apparent that a preliminary study was needed to formulate a strategy for harnessing IT to business needs. This report is the result. It is divided into three sections; an analysis of trends, a description of the kinds of products and services which are expected to be the building blocks for future systems and a discussion of the ways of defining and implementing systems which will meet users' needs. The report concludes with appendices which discuss the technical strategy for software in more detail.

Copies of the report are available from the Institution of Electrical Engineers.

All bids made at a Christie's London auction are recorded on tape by this 22-channel voice logging system from Philips which records the incoming bids from 17 telephone channels as well as the auction room bids and the auctioneer's voice.

Faraday for all

The IEE Faraday lectures have traditionally toured the country and been given at theatres or lecture halls to sixth-form pupils. The most recent lecture, presented by ICL on the technology and future of computer science, has been produced in a video form and a copy of video tape has been sent to every secondary school. This has increased the availability of the lectures as limited space or excessive travel prevented many schools from attending the lectures. This video production was funded by the DTI and the Manpower Services Commission. A competiton related to the theme of the lecture has been designed to heighten awareness of IT and its appication in modern industry. Called "The Faraday 2001 Time Capsule Competition" it invites teams of 16-18 year old competitors from different disciplines to look into the future and envisage the roll of IT in the year 2001. The winning entry will be sealed into a capsule and placed in the London IEE headquarters. For the purpose of judging, entries must be submited before the end of the calendar year. They will be divided between ten geographical regions which will be judged in 1988 with cash prizes to the top five teams in each region. These regional winners will qualify for a national final to be held in April 1988. Further information can be obtained from the competition coordinators, Hobson Publishing plc. Bateman Street, Cambridge CB2 1LZ.

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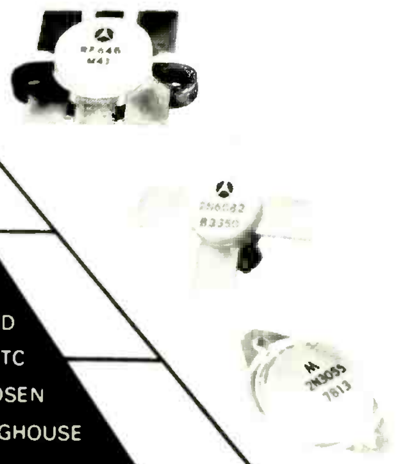

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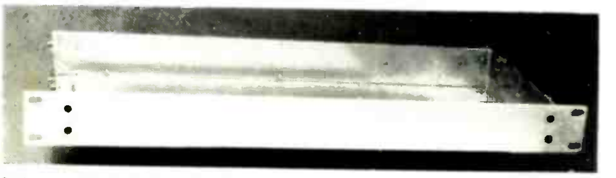

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Department of Electrical and Communication Engineering

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LECTURER I/II
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SENIOR TECHNICAL INSTRUCTOR/PRINCIPAL TECHNICAL INSTRUCTOR
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Applicants resident in the United Kingdom should also send one copy to the Association of Commonwealth University (Appts), 36 Gordon Square, London WC1H 0PF, from who further information may be obtained. 467

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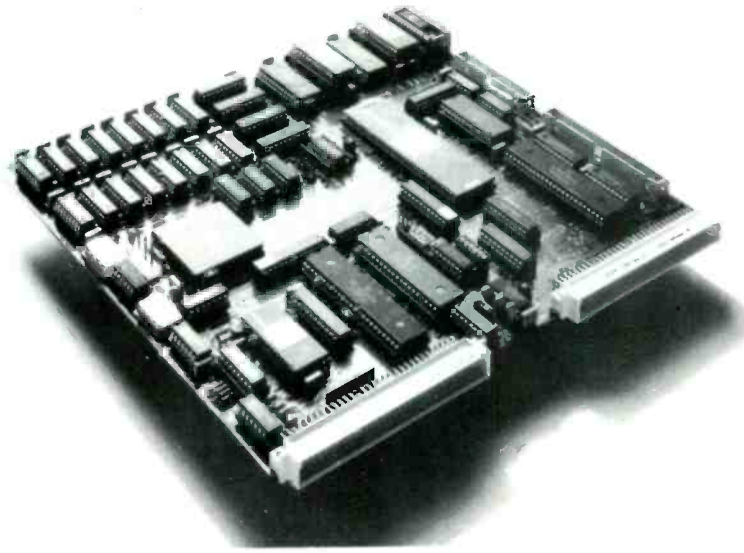

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