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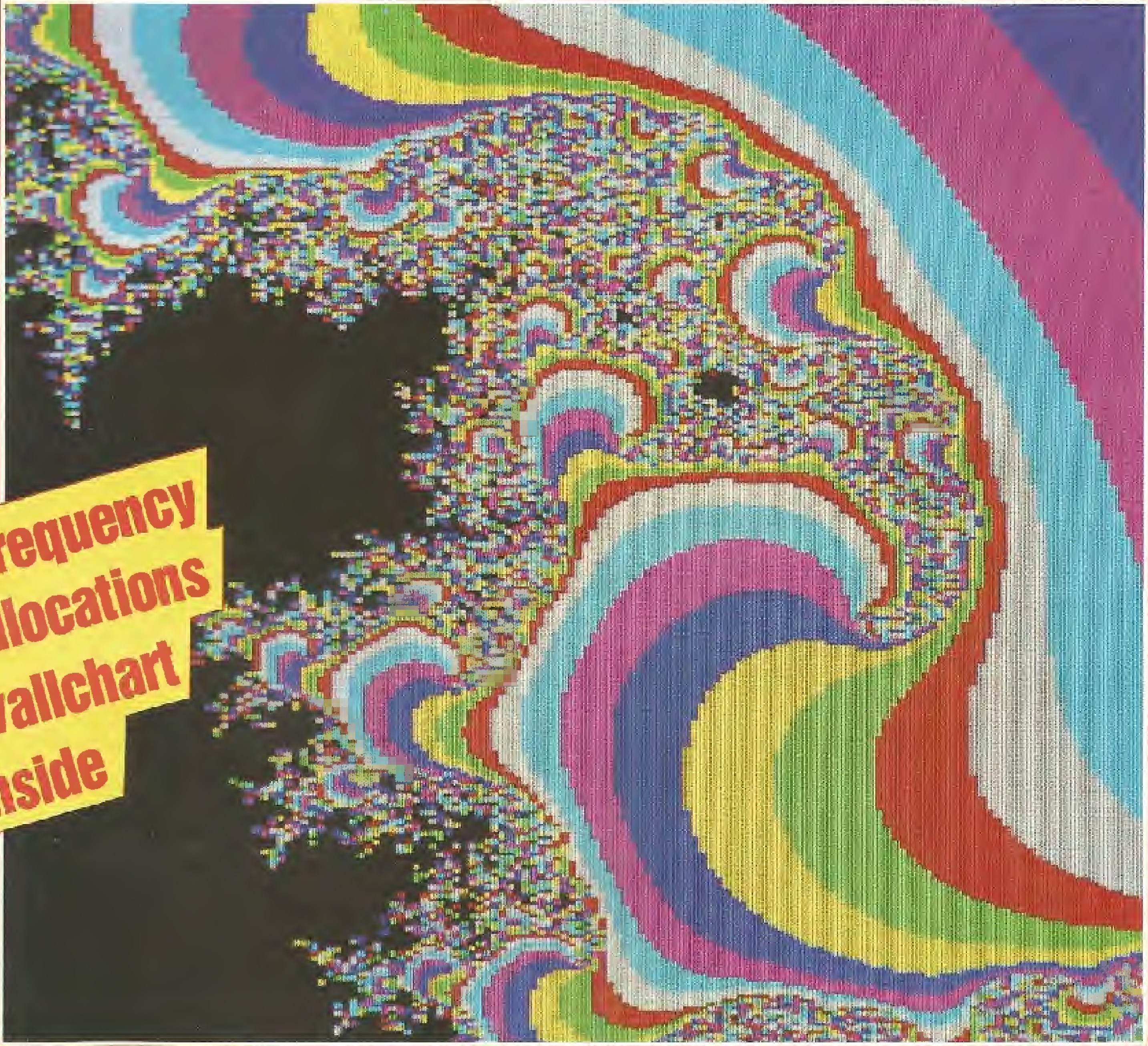

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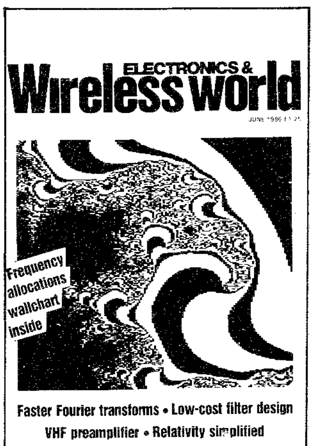
FEATURES

REGULARS



This example of a Mandelbrot Set is described in News commentary, page 5

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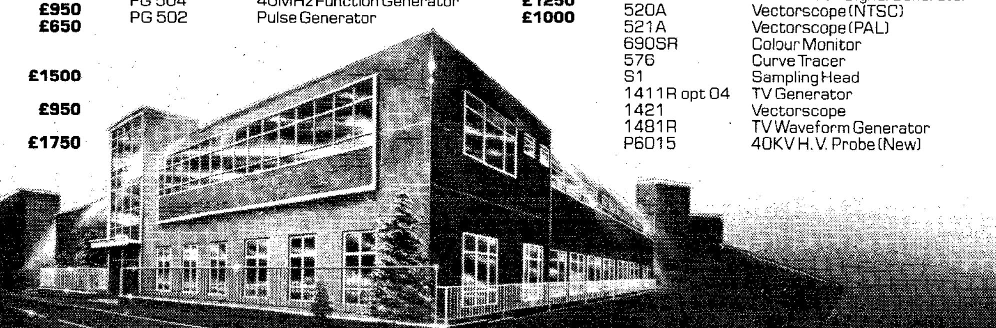

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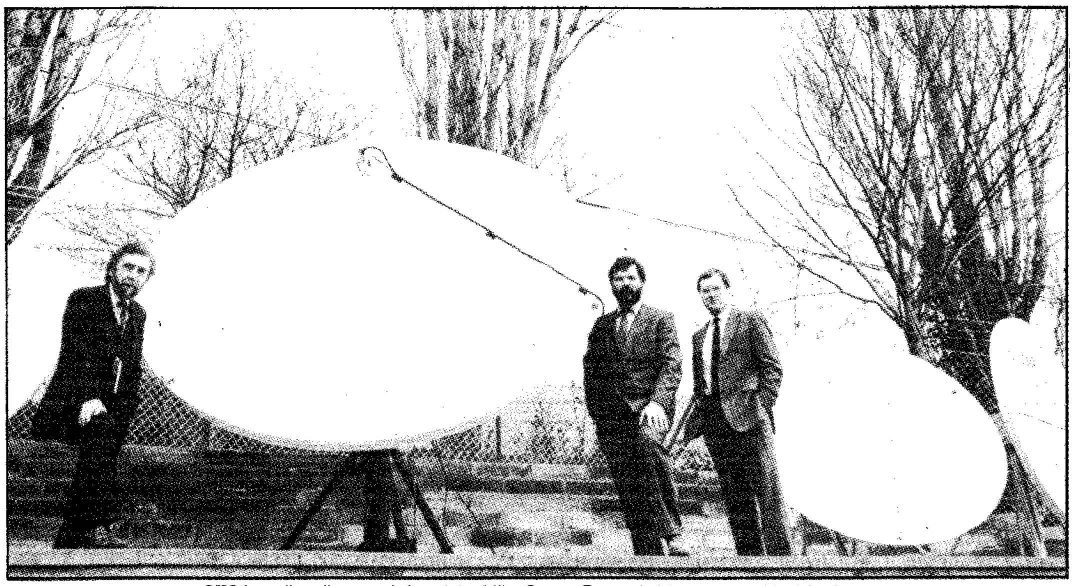


STS founding directors left to right: Mike Stone, Roger Ashby and Nick Heckford.

Satellite tv company aims for 25% share

Satellite Technology Systems are set to capture 25% of the UK market for satellite tv and data reception equipment. The company, formed in 1983 and who made their first sale a year ago, hope to sell at least 1,500 systems by the end of the year. They estimate the UK market size this year to be 8,000 units, give or take 2,000, with a value of £9 million and expect that to double in 1987. Speaking at the company's recent product launch, m.d. Roger Ashby expected STS turnover would be £1 million within a year, rising to £10 million after five years. At this sort of level prices could be expected to fall to £600 for a domestic equipment set-up.

The STS 300 'entry level' domestic system costs around £1000 and comprises a 1.2m dish (for SE England) with 42dB gain, down-converter with a noise figure of typically 1.9 to 2.3dB (2.5dB max) and 50dB gain, and a receiver with 40 preset channel positions, subcarrier tuning from 5 to 8MHz, remote polarization control, and both v.h.f. and baseband video outputs. "Our domestic product offers very high quality reception" says technical director Mike Stone, "far better than anything else at a comparable price."

The '600 series' for commercial and educational use has a larger dish diameter and a different receiver, operating with voltage synthesized tuning in 20MHz steps and wide/narrow bandwidth selection. For hotel and club installations receivers would be individually tuned to permit simultaneous reception, and could feed up to 600 tv sets.

The company disclosed that Television South plc had acquired a 47% shareholding in STS with an investment of £440,000.

Radio waves that don't radiate: a new resource?

Research being conducted at Bradford University could lead to a hitherto unused part of the radio spectrum being opened up for public use. The idea is to exploit wavelengths in 4.5–5.5mm region (about 55-65 GHz) which normally suffer strong atmospheric absorption by molecular oxygen. At 60GHz, signals suffer an additional propagation loss factor of 20 for each kilometre traversed.

Professor Peter Watson and Dr Andrew Richardson plan to exploit this limited range in such a way that the same frequency can be re-used more or less *ad infinitum* for short range wideband links. Such links, for local area networks, ENG applications, etc. would for all practical purposes be non-interfering, analogous perhaps with a number of human conversations going on simultaneously in the same room.

Watson believes that these properties make 60GHz uniquely suitable for an entirely new form of regulation based on land ownership. As with a garden hosepipe, it would be possible to spray one's own property, taking only slight care to avoid it going over the fence.

Their work is directed toward eliminating the bulky precision components at present in use. Gunn oscillators and antennas fabricated with microstrip technology are just two examples of the approach currently being explored.

Good idea – shame about the business sense

"British inventors still don't understand the needs of a start-up business" says Keith Gummery, from Spicer & Pegler, one of the judges in the Internepcon IDEA '86 award scheme for new electronic designs or applications. The 100 entrants showed the breadth of creativity available but: "The judges were greatly disappointed by the quality of the plans seen. In spite of the guidelines provided by the organisers, few seemed to take seriously the need to set out the supporting facts for their plan to convince other of their business priorities," he said.

Mr Gummery's company of chartered accountants will be advising the four winners: Brian Payne of Electronics Aids for the Blind for a telecommunications system for the blind/deaf; Mark Hawood of Enigma Electronics for a secure seal for vehicles; John McKechnie, MTS Cambridge for a secure voice transmission system; and Steven Parkes for a Transputer-based music synthesizer.

Fibre Network

London University is to get an interactive video network based on fibre optic links. It will link seven of the University sites, allowing meetings, tutorials, seminars, lectures and conferences to take place between remote sites. The system will use switched-star techniques and the latest generation of optical fibre equipment, developed for transmission in BT networks; each fibre can carry four colour tv channels with the associated sound and an addition 2Mbit/s data channel. The network will be developed by the university in collaboration with the BT Research Labs, Martlesham.

Who needs it?

In a recent speech to RETRA, the chief executive of Grundig International, Wolfgang Barth, addressed the problem of technological overkill in consumer products.

He pointed out that the effect of rapidly changing technology "has often been to build new technology into products simply in order to convince the customer that they should buy something new. The real needs of the customer appear to take second place".

Going on to discuss market research into customers' requirements, Mr Barth claimed that "marketers cannot create human want. They can only succeed with products which satisfy a current human need". He sought to argue that "people are not only important... they make rational choices".

While agreeing wholeheartedly with the first remark, one must point out that the enormous success of the policy to which Mr Barth is opposed means that the second remark cannot always be true.

Cupboards all over the developed world must surely bulge with unregarded calculators and home computers, produced as a result of market creation: no human need for them was expressed before the advertising started. It became possible to make them small and cheap, so the customer was made to feel under-privileged unless he bought them.

Mr Barth comments that one now needs the skills of an airline pilot to operate the controls of a hi-fi unit. There are buttons to press, dials and leds to take note of, switches and knobs to adjust – and all this to play a tape or disc. The kind of equipment which offers all this gadgetry enjoys a head start on the dealers' shelf, the no-nonsense variety being too devoid of Jones'-impressing light-flashing to appeal to any but the person who just wants to hear music. How many purchasers of 'midi' systems, all of which appear to possess rudimentary graphic equalizers, have the use of a sound level meter and noise source with which to set them up?

There is a large section of the consumer market which relies for its very existence on persuading customers that they need a slightly reduced version of the Houston mission control centre to perform the simplest of operations, a large proportion of the front panel probably never being used, or used in ignorance.

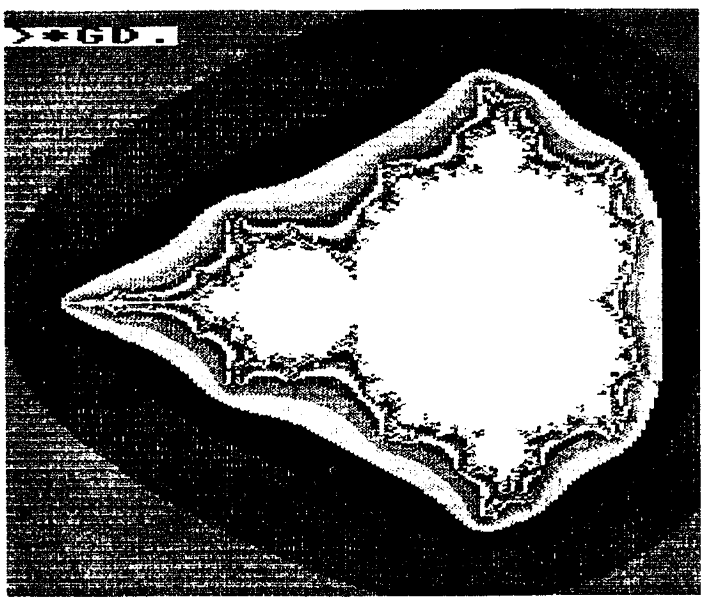
Mr Barth's heart is clearly in the right place, but his remark that people "can only be persuaded to buy what they actually need" must, in the light of experience, be suspect.

Recursive geography

The pattern on the front cover is a computer image of part of the Mandelbrot Set. Benoit B. Mandelbrot studied fractals; those mathematical equations which invoke themselves and can therefore be reiterated *ad infinitum*. In particular he used a computer to study the graphical representation of complex numbers using the formula, amongst others, $z = z^2 + c$ where c is also complex. Starting with $z = 0 + j0$, he used the formula to get a new value of z and then reiterated to get another new value, and so on. The size of z is recorded over a range of values for c.

For most values z rises rapidly toward infinity, however for a few values the size of z does not rise in this way and it is these values that comprise the Mandelbrot Set. Computer graphic images are produced by plotting the real and imaginary values of c on the x and y axes. For each position of c the number of iterations of the formula needed for the value of z to reach a limit is counted.

For a colour computer the number of counts can be represented by colour bands. In monochrome it is necessary to alternate between black and white for the bands or provide a grey scale. The computer program to plot the images is deceptively short. The image of the complete Set on this page takes about two hours to run on a BBC Micro: close-up images like the one on the front cover can take days. (Recent Transputer demonstrations have included generation of Mandelbrot images in seconds to illustrate the speed of the system.)



Radar to watch raindrops

There are two respects in which the standard weather radar sets are not very good establishing the severity of a storm and deciding whether it's rain, hail, snow or whatever. The reason is that echoes on conventional radars look much the same whatever the nature of the precipitation.

Since 1982, Professor Peter Watson of Bradford University has been collaborating with the Rutherford Appleton laboratory to develop the use of switched polarization radar to overcome this difficulty. The importance of polarization in the context of meteorology is that horizontally and vertically polarized waves are reflected to differing extents by different forms of precipitation. Snowflakes, because they tumble in random fashion, reflect horizontal and vertical waves more or less equally. The same, though, is not true of rain.

Contrary to popular belief, a raindrop in flight is not pear-drop shaped; it's more like an oblate spheroid, flattened above and below. What's more, the ratio of the vertical to horizontal axis varies in a known way with the size of the drop. Because of its consistent symmetry, a raindrop of whatever size will therefore reflect horizontal and vertically polarized waves to differing extents.

Professor Watson has quantified all these effects using a switched polarization radar developed a number of years ago at the Rutherford Appleton Laboratory. This radar was originally designed to research the effects of rain on satellite transmissions. Watson has now been able to use it to asses its value in terms of terrestrial weather forecasting. So confident is he of the value of switched polarization radar that he believes it will measure accurately the amount of precipitation falling on the ground anywhere within the radar's range.

New law proposed for ideas

The whole patent and copyright regulations are to be overhauled according to plans published in a government White Paper 'Intellectual Property and Innovation'. Its main proposals are to:

- make the Patent Office a statutory body.
- introduce a new unregistered design right which will cover protection of original designs which are not artistic works, such as spare parts.
- make patent litigation easier.
- introduce a 10% levy on blank audio tapes. The levy will entitle users to make private copies of broadcasts or pre-recorded material but not to copy programs. (There will be confirmation thae computer programs are protected by copyright. Private recording of tv programs will also be made legal).
- permit educational recording of radio and tv programs and to reduce copyright obstacles on photocopying for education.

The copyright laws will include transmissions from satellites. The statutory recording licence is to be abolished. Anyone wishing to record a perfomance of a work will have to negotiate individually with the owner of the copyright, and the Performing Right Tribunal will be extended to cover all copyrights.

The tape levy has aroused much heated discussion on both sides, and there are likely to be some lively debates when the proposals are introduced as a Bill.

Research initiatives

Collaboration between companies at the pre-competitive stage is to be encouraged by National Electronics Research Initiative, sponsored by the DTI. Two such initiatives has been announced by Geoffrey Pattie, the minister for information technology: pattern recognition and silicon microsystems.

Pattern recognition is part of a machine intelligence programme and consists of two parts; one for image-understanding systems and the other on self-learning machines and speech recognition. The overall objective of the scheme is to cover high-level inference, integrated pattern processing machines, automatic machine learning from training examples, and the implementation of all this in v.l.s.i. circuits.

Silicon microsystems is a method of interconnecting integrated circuits on a silicon motherboard. Chip manufacturing technology will be used to provide very fine lines for connection and allow a greater density of mounted i.cs. The programme will cover thermal, electrical, mechanical and optical properties, Design methodologies, attachment and sealing methods and the effectiveness of the techniques.

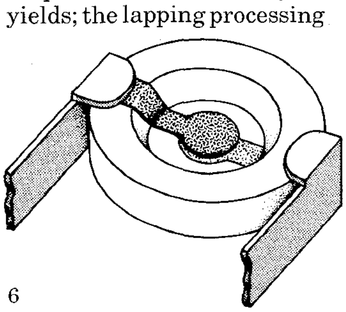
There are a number of companies participating in the two initiatives which will both be based at the RSRE, Malvern.

Crystals for up to 75MHz fundamental

Crystals oscillating at up to 75MHz in fundamental mode and third-overtone crystals up to 200MHz can be produced "on a commercial scale" according to manufacturer STC. Devices for up to 60MHz are already available.

Current wet-etch techniques have only been able to produce quartz crystals thin enough to operate at up to about 25MHz in fundamental mode. Trying to produce crystals for operating at higher frequencies results in very low yields; the lapping processing starts to break the edges of the quartz blank.

By selectively etching quartz blanks in buffered hydrofluoric acid, say STC, it is possible to produce dish-shaped crystals with an extremely thin middle disc – 22μm – and a more substantial outer rim.



Is your data base illegal?

Now that the Data Protection Act has become law, there are still only a third or a quarter of the estimated 300 000 data users who have registered, according to the National Computing Centre. While many of the large users left it to the last minute, many more may have received erroneous advice that they are exempt and do not need to register.

"More worrying than the failure of so many organisations to register" says Tony Elbra, author of the NCC's Data Protection Training Package, "is the probability that they have also neglected the other requirements of the legislation. These include the obligation to take security measures to protect personal data; to grant access to the records by the subjects of the data; to keep data accurate and up-to-date and to avoid unauthorized disclosure or loss of personal data. This can only be met where all staff have a good understanding of the legislation and their responsibility under it."

Mobile batteries

An unusual contribution to the MRUA annual conference, reported on page 15 of this issue, gave some idea of developments in novel forms of battery for mobile radio use. One of the most promising is the nickel-cobalt rechargeable cell, a modification of the familiar nickel-cadmium cell. It provides twice the power density and gives a virtually identical cell voltage, yet costs only 30% more in raw materials. Prof. Tseung has solved certain unspecified technical problems in fabricating the cell and believes that all it needs now is financial commitment from a manufacturer.

The size and weight of batteries have already become limiting factors in miniaturising portable radio equipment. And indeed the battery industry has a long way to go before it can equal the 10MW power transfer rate that motorists enjoy at petrol stations. However, Prof. Tseung (City University) has narrowed the gap by investigating two other chemistries for high-power portable applications.

One is the zinc-air battery, which offers an energy density of 150Wh/kg. This uses atmospheric oxygen as a depolarizer. In the conventional zinc-air button cells used for electronic watches, access to air is restricted to prevent drying and carbonation of the potassium hydroxide electrolyte; and this in turn limits the current output. However, the zinc-air battery might be radically redesigned for radiotelephone use to provide extra air holes which could be opened up to supply heavy currents under transmit conditions.

Another type, the aluminium-air cell, doubles the energy density yet again to ten times that of the conventional NiCd cell. The City University has solved problems of sludge formation and hydrogen evolution and suggests the battery may be an attractive proposition for high- power portable units.

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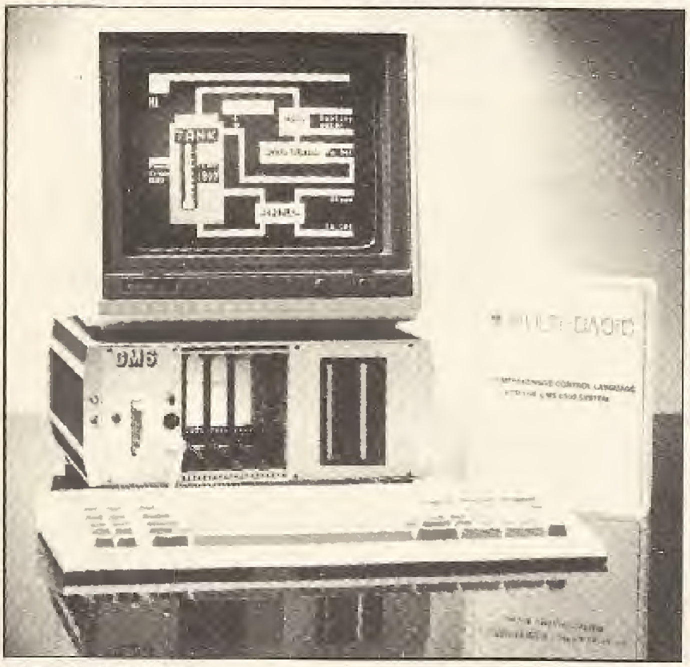

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CIRCLE 47 FOR FURTHER DETAILS

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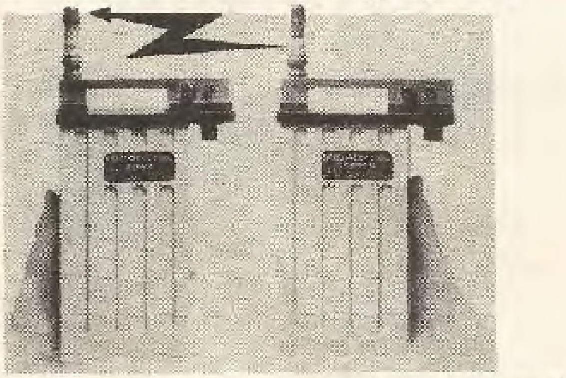

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CIRCLE 63 FOR FURTHER DETAILS

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10in	50	8	SEAS	Bass Woofer, Hi-Fi	£19.50	£2
10in	25	8	Elac	General Purpose	£9.50	£1
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10in	60	8	Soundlab	Twin Cone Full Range	£19.50	£2
10in	300	8	WEM	Woofer Hi-Fi, PA	£36	£2
12in	45	4 or 8 or 16	Baker	Disco – Guitar – PA	£18	£2
12in	60	8	Baker	Bass Woofer	£25	£2
12in	75	4 or 8 or 16	Baker	Disco – Guitar – PA	£22	£2
12in	100	8	Goodmans	Woofer	£30	£2
12in	120	8 or 16	Goodmans	Disco – Guitar – PA	£36	£2
12in	100	8	H – H	PA – Disco	£39	£2
12in	100	8 or 16	Baker	Disco – Guitar – PA	£28	£2
12in	150	8	Celestion	Disco – Bass Guitar	£65	£3
12in	200	8	H – H	PA Disco	£68	£3
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15in	100	4 or 8 or 16	H – H	Disco – Group	£49.50	£2
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CIRCLE 87 FOR FURTHER DETAILS

MANAGING ELECTRONICS

As Japan gradually overtakes the USA in the mass production of integrated circuits and is far ahead of both the USA and Europe in the adoption of surface-mounted-device technology, and with the possibility that manufacture of Sinclair home-computers will, under Amstrad aegis, move from the UK to the Far East, there continues to be speculation on the decline of British electronics manufacture. Poor management, poor reliability, lack of marketing skills, lack of imagination and business acumen, misguided interventions by Government and civil servants or the politicians they attempt to advise... all are being mooted as prime causes of the decline.

It has always seemed to me that at least some of our troubles stem from the precipitate withdrawal of major British firms from "consumer electronics" 20-30 years ago, mainly because profit margins seemed more assured in defence and professional electronics as a result of the calamitous "stop-go" policy on consumer credit by successive British governments. The sudden surges of demand whenever credit restrictions were relaxed and over-production when "disposals" suddenly dried up again reduced the industry to a game of chance and left the door open for the Japanese to come in, in a big way, during the colour-tv boom of the 1970s.

American industry has not been without its problems. Dr Ralph Evans, the editor of *IEEE Transactions on Reliability*, has attacked traditional "western movies" thinking about good guys versus bad guys. "If a bad situation is identified, any change will be (considered) a change for the better, and the sooner the better... the difficulties it engenders are directly proportional to the amount of ignorance about the situation... busines schools taught for many years that a manager did not need to know much, if anything, about a company's products and processes, that management techniques were independent of these irrelevant things." On the contrary, Dr Evans stresses "managers have to know enough about the processes and products for which they're responsible to be able to answer the four quality questions: (1) What can go wrong? (2) How and when we know it did go wrong? (3) What can we do if it does go wrong? (4) How can we prevent it going wrong (or mitigate its effects)? If managers come up short of any of the answers, then they must allocate resources to find the answers. Many of the processes for which managers are responsible are people processes rather than machine processes, but these processes do depend on the product (including services) being offered by the company. You can't control it if you don't understand it."

A report in *Nature* claims that the disaster to the Challenger space shuttle was in part due to the failure of bad news about the risk of rocket failure to travel upwards to the people responsible for deciding how quickly to push ahead with the programme... "the familiar phenomenon that the bearers of bad news usually win less than meagre credit".

TRANSMITTING LOOPS

For many years it was usually considered that an electrically small resonant-loop antenna, although effective as a directional receiving system, had far too low a radiation efficiency to be a serious contender as a transmitting system. This was because, as for all electrically small elements, radiation resistance can be extremely low. With a conventional wire loop, most of the energy fed to the system is dissipated by the r.f. impedance to the loop. In the mid-1960s, however, the US Army Limited War Laboratory, faced with the problems of mobile and transportable radio communication in the jungles of south-east Asia, developed an octagonal loop having 5 ft sides, capacitively matched to 50 ohm co-axial cable and mounted on a short pole for use between 2 to 5 MHz. This was claimed as being capable of "usually doing as good a job as a full-length dipole 40 feet above the ground". The loop, being tunable to the operating frequency, did not, unlike a vertical whip antenna, depend on an efficient earth system or ground plane.

The ability to achieve an efficiency approaching that of a dipole depended on using a matching unit with high-value capacitors rather than lossy (ohmic) inductors and the use of large surface copper tubing of at least 1.5 in diameter, having extremely low r.f. resistance at these frequencies.

Subsequently a number of radio amateurs showed that reasonable results could be achieved using the outer sheath of good-quality 0.5 in coaxial cable, although commercial units offered for such applications as unobtrusive diplomatic radio communications (an h.f. loop antenna could – and possibly still can – be glimpsed just above the roof parapet of the US Embassy in Grosvenor Square, London) tended to use 4 or even 6 in diameter tubing. Flat roof installations usually have also a heavy copper ground plane. They form weighty but compact and unobtrusive installations.

An alternative form of "miniloop" patented by J.H. Dunlay ("Wide-range tunable transmitting antenna", US Patent 4,433,336, June 28, 1971) comprises an electrically small, capacitively tuned outer loop inductively excited by an even smaller inner loop. This miniloop technique has been used in various forms. At the IERE's "Radio Receivers and Associated Systems" conference at Leeds, July 1981 (incidentally, another conference in this series is being held at the University College of North Wales, Bangor, July 1-4, 1986), a Swedish engineer Sven Ramstron described a three-turn, silver-plated tuned transmitting and receiving square loop (each side 500mm) inductively coupled to a single-turn loop, which in turn was fed through a broadband balun transformer from 50 ohm coaxial cable; this had originally been tested on the 3.5, 7 and 14 MHz amateur bands, but had been developed as a compact 1.9 to 16 MHz antenna for professional or defence communications. Among the features claimed for the Swedish design were small size, integrated tuning unit, no requirement for a ground plane, omnidirectional radiation in azimuth and elevation (two 30dB nulls in near field), no sliding contacts, harmonic reduction due to high Q, etc.

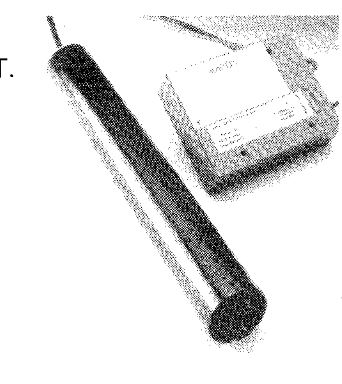
A recent note by Donald E. Barrick of Ocean Surface Research (*IEEE Trans. AP-34*, January 1986) discusses the operation and equivalent circuit of the basic miniloop antenna, verifying the advantage that the input resistance to the inner loop can be large (50 to 200 ohms) and broadband, although the input (radiation) resistance of the outer loop when fed alone is generally only a fraction of an ohm. This makes it much easier to feed a miniloop than a conventional loop design, permitting a reasonably good match over nearly a decade bandwidth, provided that the outer loop is tuned to the desired operating frequency and is electrically small at the upper end of the band. He shows however that the miniloop technique may be unacceptable in some radar applications, because its high-Q tends to stretch and delay the pulses by many times their width.

CORDLESS 'PHONES

Few subscribers appear to be aware that both ends of telephone conversations made over "cordless telephones" can be received over distances of at least some hundreds of metres and, with the higher-power "illegal" models, over some miles.

While the legal cordless 'phones are confined to specific channels between 1.6 and 1.8 MHz (base to handset) there are still many higher-power "illegals" around 1.95 MHz (within a shared amateur band) some of which appear to be used virtually as low-cost, mobile-radio communication systems by small firms.

The DTI recently warned



dealers still selling "cordless" units not complying with the frequencies and power limits specified by the Radio Regulatory Department that they could lay themselves open to a six months prison sentence and a £5000 fine. However, the DTI have still not formally issued an order under the Telecommunications Act that would make it illegal to sell, advertise or rent out such equipment.

Meanwhile cordless 'phones, both legal and illegal, are reportedly causing local harmonic interference in the 3.5 MHz shared-amateur band and fundamental interference at considerable distances to amateurs using frequencies around 1.9 MKz. The cordless 'phones use narrow-band frequency modulation and produce wide signals, both during dialling and during conversations. While it has always been illegal under the Wireless Telegraphy Acts to listen deliberately to these conversations, it would be an interesting test case under the new Interception of Communications Act 1985 if a case were brought as the result of a complaint by someone using an illegal cordless telephone! But then it would appear that very few users of these devices realise how far their private conversations can be heard by anyone with a suitable communications receiver! The "base" transmitter normally radiates both sides of the conversation. It is thus possible, I am told, "accidentally" to listen to some very private conversations. Meanwhile British Telecom are developing units operating at around 900 MHz with digital modulation techniques in the belief that by the year 2000 something like 10 per cent of all British telephones could be of the "cordless" variety.

INTERCEPTION

From April 10, it became a criminal offence, under the "Interception of Communication Act 1985", for any unauthorized person intentionally to intercept "a communication by post or by means of a public telecommunication system".

This Act Covers transmissions by "wireless telegraphy" although an exception is made where such communications are intercepted, with the authority of the Secretary of State, "for purposes connected with the issue of licences under the Wireless Telegraphy Act 1949 or the prevention or detection of interference with wireless telegraphy." On conviction under indictment, an offender can be sent to prison for up to two years and/or fined.

While the primary purpose of the Act is to provide safeguards against unauthorized telephone tapping and similar activities by private investigations and also by the police, the secret services and the customs (organizations that can be authorized to intercept communications), there are implications affecting anyone who tunes his radio receiver to other than broadcast or amateur radio transmissions. The Act covers not only telephones but telex and electronic data transmission, although it does not apply to the planting of radio or tape-recorder or tracking "bugs", (these may come under the less savage Wireless Telegraphy Acts) nor, it would appear, to the release by British Telecom of information collected by the machines that can list incoming and outgoing dialled numbers.

Amateur Radio

Although the number of stations equipped for amateur television transmission on the 10 GHz microwave band is believed to be increasing, very little has been published on the results so far achieved. An appeal for more information appears in the current issue of *CQ-TV*, the journal of the British Amateur Television Club. An amateur tv "repeater" located on Mow Cop began operation in the Stoke-on-Trent area early this year accepting frequency-modulated vision signals on 1249 MHz and retransmitting them on 1318.5 MHz. It was "officially" opened on April 9. Initially with an output power of only 200mW it has been received in the Birmingham area. A number of amateurs have successfully build 11 GHz systems capable of receiving the low-power distribution satellites carrying the cable tv programmes. Stuart Jones, GW3XYW, for example, has drawn attention to availability of the Mitsubishi FO-UP-11K oscillator/mixer module, with a stabilized dielectric resonator oscillator developed initially for radar and retailing for less than £30. It would also appear possible to adapt this unit for the 10 GHz amateur band for either speech or television communication. The Swiss national society USKA is opposed to the use of the limited 70 cm amateur band for television transmissions, but there are still more than 20 amateur tv stations using the band compared to only one in 1255 MHz. Swiss amateurs have adopted the small-deviation f.m. vision transmission system originally proposed by the French amateur F3YX.

RIS POLICY UPSETS AMATEURS

Important changes in the policy of the Radio Investigation Service with the DTI now tending to put the onus on the radio amateur to clear up any cases of television or radio interference in his locality, whether caused by spurious signals or (far more likely) by lack of immunity of the domestic receiver or lack of an effective receiving aerial, have followed the Parliamentary reply by Mr. John Butcher, Secretary of State at the DTI (reported in the May C.C.). Since the end of January, according to the RSGB, several licensed amateurs have received "form" letters advising them of complaints of local interference, suggesting remedies but ending with the warning: "Let me know within the next month if you have resolved the problem... to your neighbour's satisfaction. If this is not the case, the RIS will visit you to inspect your station and determine what action should be taken. In certain circumstances the Department may need to consider varying your licence." The complainant receives a copy of this letter which cannot fail to convey the impression that the fault is primarily that of the local transmitter and that it is the responsibility of the amateur to overcome the problem, a reversal of the accepted procedure over many years. The RSGB, have told the DTI that these new guidelines are "hopelessly out of touch with reality". It is also opposed to the new DTI policy of adopting the CENELEC standard for receiver immunity, rather than BS905 as announced last year. The European standard requires that a set should not show noticeable interference only up to an out-of-band field strength of about 1.8 V/m. A local transmitter of even low power can produce higher field strengths than this in its immediate locality. While interference to a set complying with the CENELEC standard could probably be cured in many cases by the fitting of a simple filter it is not unknown for viewers to refuse that this be done even when the local amateur offers to pay the cost.

IN BRIEF

An enlarged new fifth edition of *RTTY-The Easy Way* is published by British Amateur Radio Teleprinter Group (Peter Adams, G6LZB, 464 Whippendell Road, Watford, Herts WD1 7PT).

A 144 MHz beacon transmitter on Iceland (TF8VHF on 144.930 MHz) is now operational.

The refusal of the DTI to permit Class B licensees to operate on the new 50 MHz has proved extremely unpopular among those affected. It was apparently the "primary user", the Ministry of Defence, that objected. Under the International Radio Regulations a morse test is mandatory in respect of licences permitting operation below 30 MHz, although a few countries including Spain, France and the UK have made some exceptions to this ruling. In the UK some handicapped or disabled applicants have been exempted on a case-by-case basis from the Morse Test although this never appears to have been announced officially.

Mobile radio on the move

April's annual conference of the Mobile Radio Users' Association in Oxford was the first major meeting since the government announced plans for the new Band III networks

The new allocations herald mobile radio's last big expansion for the foreseeable future. Band III accordingly figured prominently in the agenda and two of the new licensees were on the list of speakers. But another significant development discussed at the conference was the news that the industry for the first time is to take over some of the responsibility for regulating itself.

The plans were outlined by the head of the Department of Trade's Radio Regulatory Division. In the opening speech of the conference, Tony Nieduszynski explained that RRD was looking for more a flexible approach to type-approving radio equipment.

In particular, it was considering proposals for self-certification by manufacturers. Under certain conditions, makers would be able to do their own testing, he said, and so reduce delays in getting their products on to the market. To help them, the RRD planned to make its laboratory facilities at Kenley commercially available.

A further result of the new spirit of co-operation between the DTI and the industry was to be the setting up of a civil land mobile radio committee under the chairmanship of Mike Coolican of the DTI, with a membership drawn widely from the industry and users.

Spectrum pricing

Mr Nieduszynski announced that RRD was about to begin its first spectrum review (following a recommendation of Merriman). The bands under scrutiny were those between 470MHz and 3.4GHz; and the department would seek to establish how fully they were used, what future requirements there might be for services in them, and what scope there might be for redeploying frequencies more effectively. Details of a parallel review covering the defence bands would be announced by the government shortly.

A feasibility study of spectrum pricing was also under way. "But the object is not to help RRD raise more licence money", said Mr Nieduszynski, "RRD is not a revenue-raising body". The aim was efficiency in allocating spectrum; but the government would ensure full consultation and debate before any radical changes were made. RRD recognized the concern over the shortage of mobile radio channels and in particular the degree of congestion in London. Solutions had to be found.

A high priority was the development of two-way data communication systems, in which the rate of progress was disappointing. "The doors of Waterloo Bridge House are open to anyone with ideas and proposals", he said; but added that they might not necessarily get their first choice of frequency. Another new possibility was that of the telepoint, which would enable owners of cordless telephones to make calls through a network of public base stations.

Training for p.m.r.

One of the first steps towards self-regulation by the industry was a dealer accreditation scheme sponsored by the MRUA, and to this Mr Nieduszynski gave a warm welcome. The scheme, in which the DTI would participate, was described in detail by Gerald David of Aerial Facilities Ltd, project leader for the MRUA.

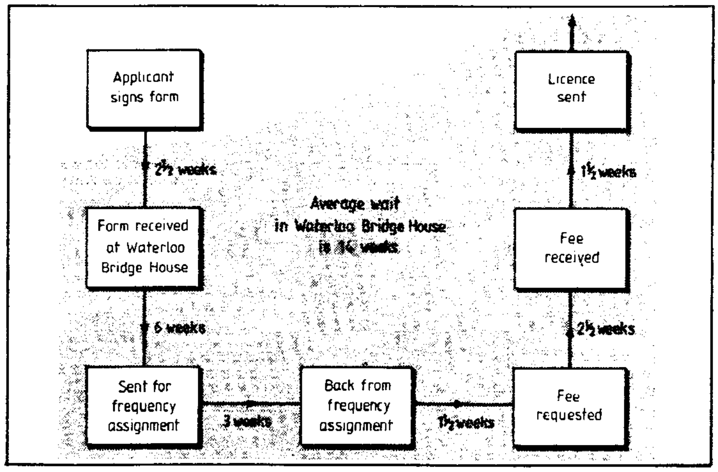
A parallel scheme for employment training in land mobile radio was presented by Colin Smith of PMR Ltd and the MRUA. At present, he said, there was a lamentable shortage of well-qualified technicians for installing and servicing p.m.r. equipment. And he told some horror stories: "I ask applicants how do you accurately measure the frequency of a v.h.f. transmitter. And the usual reply is an oscilloscope. If he says a frequency counter, the applicant is usually an amateur radio enthusiast."

Mr Smith had met degree students who were sound on microprocessors, but who imangined they could measure the impedance of an aerial with an Avo meter. Academic courses had for a long time been biased away from analogue techniques and the balance towards radio communications had yet to recover. The MRUA was therefore negotiating with the Association of Marine Electronics and Radio Colleges to set up, with the DTI's support, two courses leading to a nationally recognized qualification.

Band III

GEC Communications is one of the dozen winners in the race for Band III licences, and plans for its national network were described by technical director Peter Delow.

The system would be founded on common base stations which shared automatically a pool of frequency pairs among many users – a trunked system. Mobiles would be able to contact one another throughout the area covered by the network. The new feature added by GEC was the large-scale networking of base stations, which would be linked by a digital voice and data switching network. Mobiles would communicate with the network by digital signalling on control channels or, when a call was in progress, through 1200bit/s data bursts.



Waiting for that mobile radio licence to come through: some applicants have to wait longer through failing to give essential details such as the national grid reference of their base station.

The MRUA aims to represent all users of mobile radio, including cellular radio. For details, contact the association at Orient House, 42/45 New Broad Street, London EC2M 1QY, tel. 01-628 0898.

GEC hopes to begin a service in the second half of 1987. Facilities offered will include conventional mobile radio features including dispatcher-type operation and selective or fleet calls, plus some new ones such as interconnection with p.a.b.xs and the ability to dial out on the public telephone network. Also available will be data services, including access to public networks, store-and-forward message handling and vehicle-tracking.

The system will conform with the MPT1327 draft standard, which sets out a unified air interface for Band III trunked systems. This common signalling specification should benefit users by bringing down the cost of equipment and could indeed form the basis of an international standard.

Asked whether GEC's 100-channel allocation would be sufficient, Mr Delow replied that it was not clear yet what sort of service 100 channels would give. The company had applied for many more.

Speaking for the National Radiofone Company (another of the new licensees) Robert Condon reviewed, with a mass of statistics, the growth of mobile communications during the past few decades and examined the commercial opportunities the new frequency assignments would bring.

Mr Condon estimated a demand by 1992 of some 200 000 subscribers, of whom about a quarter would be accommodated on regional networks. The true requirement for national coverage was quite small and most subscribers would be satisfied with interzonal coverage.

National Radiofone had been offered a licence to run regional services in London, Birmingham and Manchester-Merseyside, with a capacity of about 2500 subscribers each; and, in conjunction with Tactico, in Glasgow, Edinburgh and Aberdeen, for a further 7500. The company planned to launch these services simultaneously in the first quarter of next year. Live demonstrations for interested parties would begin in September.

To obtain the necessary coverage, multi-site 20-channel trunked systems would be needed. In London, five sites would be required. No handover between base stations was envisaged since calls would normally be short and mobiles unlikely to travel out of range during conversation. As they passed from one service area to another, mobiles would lose the first site's control channel and would be reregistered on the new site as they picked it up.

Coming soon...

The new licensees will occupy only a fraction of the former television band and space remains available for further developments. Robin Daniel of British Telecom looked at future needs for mobile communication, and foresaw a very large potential demand which could be satisfied only if we could find more efficient ways of using the spectrum. For example, there

Mobile Radio at CeBIT

Nigel Cawthorne reports on Germany's new cellular car telephone network: C Netz

This year for the first time the Hanover Industrial Fair was split into two events: CeBIT (Centre for Office, Information and Communications Technology), held in Hanover on 12-19 March, and the traditional Hanover Industrial Fair which ran a month later in April.

Nearly a quarter-million visitors attended the first stand-alone CeBIT. Two of the 11 halls were devoted to telecommunications and related topics such as satellite communication and broadband networks. Mobile communications included paging, cordless telephones and car telephones.

Following the recent trial launch of Germany's new C-450 cellular car telephone network, there was considerable interest at the show in this new mobile service.

German C-450 cellular

Germany's Siemens-designed C-450 cellular network opened on a trial basis in September 1985. The official full opening of the network was planned for May 1986. During the six-month test period, users are not being charged any monthly subscription by the Bundespost. The monthly charge of DM120 will only be applied once the system is fully operational.

Two reasons were being offered at CeBIT for the partial opening. Firstly the Bundespost said they did not want to charge customers the monthly subscription until full national coverage could be provided. A second reason is that the trial period is being used to sort out possible bugs in the system.

Mobile car telelphones currently using the network, which number less than 2,000, may have to be called in once the system becomes fully operational for minor software changes. Suppliers at CeBIT were saying that this should involve no more than just "popping in a new prom".

An important operational feature of C-450 that sets it apart from other European cellular systems (NMT, TACS) is the use of a card indentity system. A subscriber's individual number is recorded in the credit-card sized plastic card which slots into the mobile unit before it can be used.

The card identifies the user. So no matter which (or whose) car telephone you are using, it will respond to your own number. In other systems the car telephone itself is identified rather than the specific user.

Another standard feature on C-450 is the use of band inversion scrambling to guard against casual eavesdropping. The scrambling facility can be switched out by the mobile if signals are weak.

C-450 Summary data

Clear speech, frequency range	300 to 3400Hz
Scrambled speech method	Band Inversion
Data rate	4.8kbit/sec
Number of MSCS	8
Number of speech channels per MSC	max 1,500
Number of radio zones per MSC	max 150
Size of radio zone (cell)	2 to 30km
Frequency ranges	461.300 to 465.740 MHz Base to Mobile 451.300 to 455.740 MHz Mobile to Base
Transmit/receive separation	10MHz
Channel spacing starting from fictitious channel 0 (455.74/465.74)	20kHz
Electrically switchable steps	10 or 12.5kHz
Number of radio channel pairs	max 222
Modulation method	phase modulation (14F3)
Frequency deviation	max +/− 4kHz
Output power*	base-station 26W mobile 16W

*both power levels can be reduced in steps on instruction over the channel by a maximum of 35dB.

The Post had issued, up until early April, 11 type-approval numbers for C-450 car telephones. (Although there are 11 type-approved sets, there are only four manufacturers – AEG, Philips, Siemens, Storno). The other equipments are branded versions of the same products. There were no Japanese C-450 mobile car telephones at CeBIT, although Japanese suppliers are expected to make an early entry into Germany's new cellular market.

List prices quoted for a German vehicle-mounted cellular car telephone were around DM11,000 (£3190). Installation was quoted as DM300-500 (£87-145). Storno was quoting a list on-the-road price of DM11,500 (£3335). At this level, a German cellular car telephone is more expensive than corresponding equipment on other European networks.

System design

The present C-450 network is designed to handle 300,000 mobile subscribers when it reaches full capacity. It is also capable of being expanded to 400,000 subscribers.

The Bundespost plans to install a total of eight mobile switching centres (MCS) that can handle up to 150 radio zones (cells). The radio zones in the coverage area of one switching centre form a radio traffic area. In the fully developed network, a radio traffic area is connected via a mobile centre to each of the eight regional exchanges of the direct-was a mass market for messaging systems among such groups as baby-sitting circles and parents collecting children from school, if only the cost could be brought low enough.

The issues to be resolved might not be purely technical ones. For example, a typical p.m.r. contact lasted about 20 seconds whereas a telephone call averaged three minutes. Was it the character of the medium that led to the difference, or the type of business transacted?

Happenings at RRD

The pace of change in mobile radio depends very much on the radio regulatory division of the DTI, a body which, since its emergence from the old GPO engineering department has been transplanted regularly from one ministry to another. Dr John Durkin, its new director-general, brought delegates up to date with the latest reorganisation.

The department's recruitment and morale problems, which at one time caused serious delays in processing applications, seem to have been solved by the expedient of upgrading everyone's status and salary by a dB or two. The result is that the division now comprises six branches, of which the three devoted to engineering matters, covering broadcasting (RRD3), planning, spectrum review and research (RRD4) and type approval, monitoring and interference (RRD5) all come under Dr Durkin. Other branches deal with international policy, computer services and mobile licensing. And it was the head of this last, Mike Coolican, who spoke next.

The average time taken to process a mobile licence was now about 14 weeks, said Coolican, though not all of that could be blamed on his staff. P.m.r. firms tended to post their applications off in batches, which led to delays for early comers. However, forms often arrived with basic information missing or incomplete and had to be sent back. RRD aimed to be as liberated and flexible as it could. "But the more liberal you get", he said, "the more important the remaining rules become." And he mentioned that RRD was increasing its efforts to enforce licence conditions. One of the commonest irregularities concerned transmitting sites not at the position specified in the licence.

Coolican ended by warning that mobile licence fees could be expected to rise soon. Even though charges had not kept pace with inflation, users would undoubtedly dislike the latest increases. But they had better not protest, he added, to laughter: all letters of complaint and questions asked in the House ended up on his desk and distracted him from the important business of issuing further licences.

Asked about RRD's treatment of licence transgressors, Mr Coolican said that some had been prosecuted. But a licence could be cancelled only if the person was unfit to hold it under the Wireless Telegraphy acts. He could not revoke a licence just because the holder had been caught doing what he described as 'naughty things': livelihoods might depend on it.

Cellular

Two British cellular networks have now been in operation for more than a year, and their representatives brought the latest news from them. Each is getting between two and three thousand new registrations per month; of these about half are in the London area, where steps are already being taken to combat congestion. The biggest problem, said Mike Pinches of Racal Vodafone, was in commissioning new cell sites: it could take as long as 15 months to obtain the necessary clearance.

An interesting presentation on data communications over cellular radio came from Dr Bev Ewen-Smith of Spectronics Microsystems. Data communications scored over speech in many ways: for one thing, calls were much shorter and so spectral efficiency was high. If vehicles had a printer or other storage device on board, a driver on the move could receive instructions hands-free – which was safer than asking him to take notes on his knee. And privacy would be greater: there would be little risk of eavesdroppers overhearing a service engineer being told where to find the keys of unoccupied houses.

By giving vehicles direct access to the company's computer, jobs could be allocated more efficiently, fleets could be better managed – and, with information entered by delivery men, invoices could be generated more quickly.

Error correction was essential in data communication by radio, and Dr Ewen-Smith outlined the protocols used in his company's radio modems. With binary data, even under conditions of total corruption, half of the bits would still arrive correctly, so the problem of recovery was not as severe as it seemed at first sight. His Sesquiplex system, a combination of automatic retransmission and forward error correction, operated at a raw data rate of 2400bit/s, giving a through rate for the user of 1200bit/s.

Radio in the channel tunnel

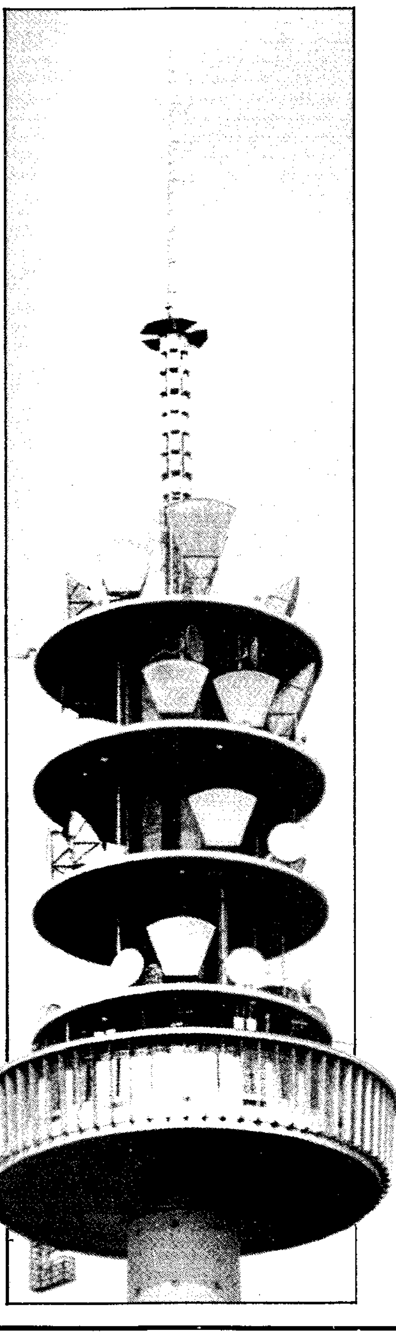
Dr David Martin of Martin, David and Partners presented a paper on leaky feeders and radio communications in tunnels, a subject he dealt with in these pages a few years ago*. But he ended with some interesting speculation about communications in the channel tunnel now being planned.

During the construction phase, standard mining practice – high-band v.h.f. – would be appropriate. But when the tunnel was ready for service, problems would arise. Railway operators in Belgium, France and Britain, all use u.h.f. for communication with trains and would want to do so in the tunnel too. The public would expect national and local radio broadcasting from both Britain and France, plus the public radiophone services. And the police and emergency services would need their v.h.f. repeater systems.

Dr Martin said that there was no experience of equipping a tunnel of this length (50km) and that severe intermodulation problems would have to be tackled. It was possible that six leaky feeders would be needed in each direction, with separate ones for the service tunnel.

Cellular radio posed special difficulties, since the cars would be shielded by railway wagons. One answer might be to carry signals through the tunnel at v.h.f. and to transpose them on board each shuttle train to a 900MHz leaky feeder running within the train itself.

*D.J.R. Martin: Leaky feeder communication in tunnels. *Wireless World* June 1982 p.70 and July 1982 p.33.



dialling public telephone system. They are interconnected to both telephone and data lines, the last-mentioned used for nation-wide automatic location of the mobile subscribers.

There are 222 radio channel pairs with a channel spacing of 20kHz available for radio network operation in the upper and lower band of the 450MHz range. Transmit and receive frequencies have a duplex spacing of 10MHz. Channel spacing is switchable in both 10kHz and 12.5kHz steps. This permits intermediate channels to be created which provides both for the best usage of the frequency spectrum and for frequency coordination with neighbouring countries.

Each base station is assigned a check-in file and each ASC is assigned a home data file and a visitor's data file. The active file acquires all switched-on mobile subscribers located within the radio zone (cell) and reports these to the centre. If a mobile subscriber is located in his home MSC area, an active entry is made in the MSC's home file. However, if the mobile subscriber belongs to another MSC, an active entry is stored in the visitors' data file. At the same time, the visitors' data file determines the mobile subscriber's home MSC, from his number, and initiates an entry in the home data file of the mobile subscriber. In doing this, the host MSC reports the location of the mobile.

There is a once only set-up charge of DM100 (£29). The DBP's monthly subscription charge is DM120 (£35). Call charges are based on a DM0.23 unit. At full rate this is for eight seconds, and at cheap rate this is for 20 seconds (corresponding to 50p/min and 20p/min respectively.

Predictions at CeBIT for the likely number of subscribers on Germany's new cellular car telephone network by the year end varied between 10,000 and 15,000.

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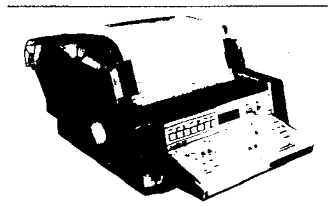

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CIRCLE 52 FOR FURTHER DETAILS

Low-cost low-pass filter design

by T.F. Scharf

Tom Scharf describes circuit realisations that offer optimum trade-off between hardware simplicity and design complexity

Tom Scharf is presently working for IQD Ltd where he has set up a sound studio for speech synthesis and is currently developing speech synthesis systems for d.t.m.f. products such as Phonecontrol and Phoneback.

At Smiths Vehicle Instrumentation Division, Witney (later Lucas E, E & S) he was involved in the design of the successful Rover trip-computer. He then became concerned with speech synthesis and was responsible for the design of the speech synthesis equipment on the Maestro and Montego cars.

Tom Scharf obtained a B.Sc. (Hons) in electrical engineering at Bath University in 1976.

Background reading

Gain of two simplifies l.p.-filter design. Delagrange *EDN* March 17, 1983, pp224-228

Analog Filter Design, by M. E. Van Valkenburg, Holt, Rinehart and Winston, 1982

Network Analysis and Synthesis, by F. F. Kuo, F.F. Wiley, 1966

In common with many engineers and hobbyists, I would rather design a filter quickly by referring to a table of normalized values than by plodding through complex textbook derivations and calculations. The main aim of this article is to present such a table and the necessary minimal knowledge required to use it.

Possibly the most economical solution to active low-pass filter design is to use Sallen and Key, and Geffe* circuits with unity-gain buffers. The benefits of using this approach are two-fold:

- The sensitivity to circuit values is low i.e. settling for the nearest preferred values will not degrade the filter response as much as with other realisations.
- The minimum number of passive components is used. This is helpful when trying to produce a good filter layout around a quad op-amp.

The equal-resistor realisation was chosen as this makes it easy to alter the filter cut-off frequency by using ganged pots, switched resistor chains, or by swapping standard resistor packs without affecting the response of the filter.

The general two-pole Sallen and Key filter, shown in Fig.1 (a), has the transfer function of equation 1 (see Appendix), and setting the gain G to 1, Fig.1(b), and normalizing the resistors to 1 simplifies it to

$$T(s)=\frac{1/C_1C_1}{s^2+\frac{2s}{C_1}+\frac{1}{C_1C_2}}.$$

Adding another RC network to the Sallen and Key circuit Fig.1(b) turns it into a three-pole Geffe filter, Fig.2, whose transfer function is more complicated, equation 2, but on normalizing resistance to unity this simplifies to equation 3 (Appendix).

* Pronounced Geffee, G as in Golf.

Choice of filter response

The ideal 'brick wall' filter with no phase delay, or transient distortion does not exist. In general, filter design is a trade-off between conflicting parameters: the sharper the cut-off the worse the transient and phase responses become.

The formulae given below are easily solved using a good scientific calculator.

Chebyshev filter. In designing an anti-aliasing filter the passband might be required to be as large as possible consistent with high attenuation in the stop-band. If transient response and phase distortion are of a secondary importance, a Chebyshev filter would be used (Fig.3). The amplitude response of the Chebyshev l.p. filter is characterized by ripples in the passband caused by the cascading of high-Q second-order stages having different cut-off frequencies (plus first-order network for odd-order filters, Fig.4). For a given order of Chebyshev filter, the larger the ripples the steeper the cut-off slope becomes. The transient response also becomes more oscillatory as the ripple depth increases.

For a Chebyshev filter of order n, the attentuation α(dB) may be found at any frequency ω using the formulae:

$$\alpha=10\log\left(1+\epsilon^2C_n{}^2\left(\frac{\omega}{\omega_0}\right)\right)$$

$$\epsilon=\sqrt{10^{\alpha_R/10}-1}$$

where α_R is ripple amplitude in dB and $C_n(\omega/\omega_0)=$

$$\cos\left(n\cos^{-1}\left(\frac{\omega}{\omega_0}\right)\right)\qquad 0<\frac{\omega}{\omega_0}<1$$

$$\cosh\left(n\cosh^{-1}\left(\frac{\omega}{\omega_0}\right)\right)\qquad 1<\frac{\omega}{\omega_0}$$

$$\approx 2^{n-1}\left(\frac{\omega}{\omega_0}\right)^n\qquad 1\ll\frac{\omega}{\omega_0}$$

where ω_0 is at the end of the ripple band.

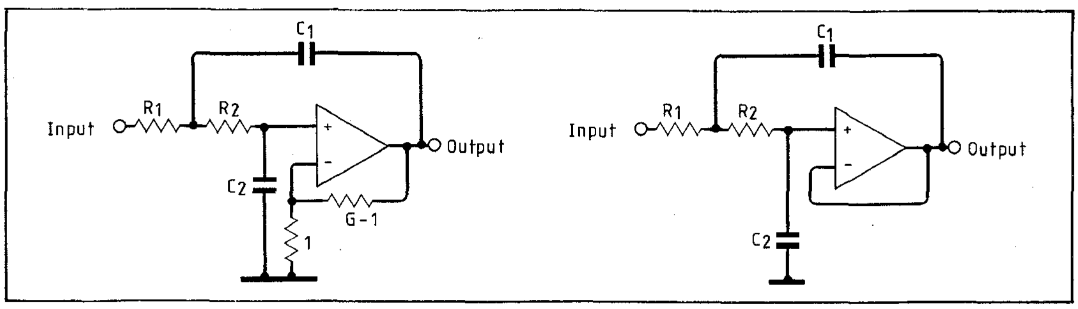


Fig.1. Gain G must be set as accurately as the component values in this generalized Sallen and Key low pass filter (a). Sallen and Key filter using unity gain buffer must be the simplest possible two-pole filter giving output buffering (b).

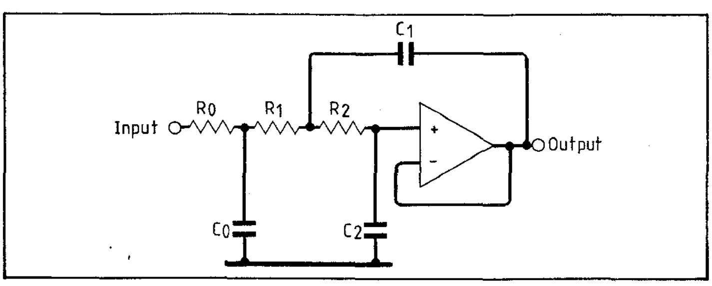


Fig.2. Coupled to Sallen and Key this Geffe filter using unity gain buffer allows the economical design of odd-order filters.

Butterworth filter. For audio applications where transient response is as important as amplitude response, the Butterworth filter is generally chosen. The amplitude response is maximally flat (Fig.5) before rolling off into the stop band. For a given order of filter, the Butterworth cut-off slope is not as steep as the Chebyshev slopes.

For a Butterworth filter of order n, the attentuation may be found at any frequency ω using the formula

$$\alpha=10\log\left(1+\left(\frac{\omega}{\omega_0}\right)\right)\text{dB}$$

where ω_0 is the −3dB frequency.

Bessel filter. One of the first to study this type of filter was W.E. Thomson of the Post Office Research Station and is therefore also known as the Bessel-Thomson filter. It is generally used to delay signals by a known amount and is the lumped circuit equivalent of the known-length transmission line. The phase shift through the filter changes linearly with frequency over a range of frequencies which increases with the order of the filter. Over this range of frequencies, each signal component is delayed by the same known time (Fig.6).

Since the amplitude response of the Bessel filter is not maximally flat and because higher, more attenutated, frequency components experience less delay, a step input to the filter produces a smeared 's' shaped output signal – Fig.7.

The characteristics of the above filter types are summarized in Fig.8. Also worthy of mention are the Inverse Chebyshev and Cauer low pass filter responses shown in Figs 9&10, realised by means of low-pass notch circuits and therefore beyond the scope of this article.

Design your own filter

In the Table, it is assumed that even-order filters are made up from cascaded Sallen and Key filters, and that odd-order filters are made up of one Geffe stage followed by the requisite number of Sallen and Key stages, Figs 11 & 12. For certain orders of filter, n = 6,8,9, an even more efficient realisation can be obtained by the use

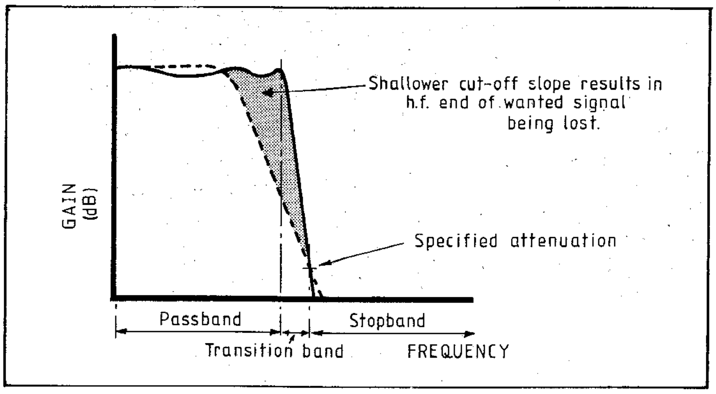


Fig.3. To achieve a specified attenuation at beginning of the stop band in this anti-aliasing filter a shallower cut-off slope results in the cut-off frequency being lowered to compensate.

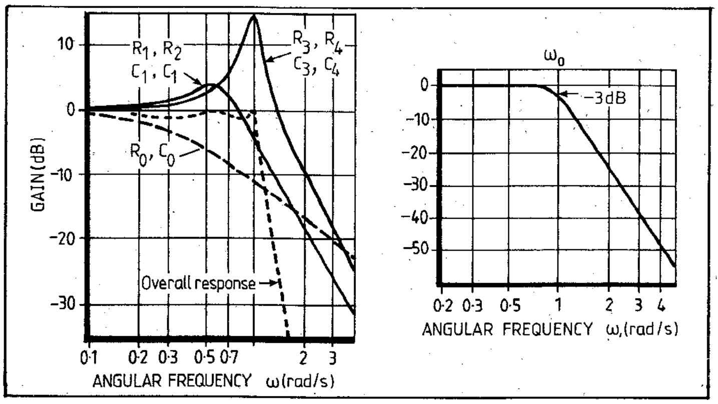


Fig.4. How the fifth-order Chebyshev amplitude response is made up from the individual stage responses.

Fig.5. Fourth-order Butterworth filter has a Maximally flat amplitude response.

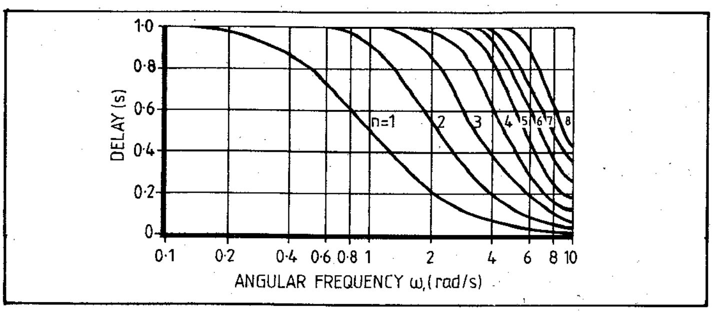


Fig.6. Time delay versus angular frequency for several orders n of Besel filter shows that as n increases, the frequency range over which the delay is maximally flat and constant increases.

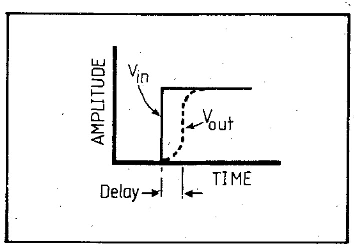


Fig.7. Notice the complete absence of overshoot in passing a step through a Bessel filter. As order of the filter increases, output signal becomes a squarer, more accurate copy of input step.

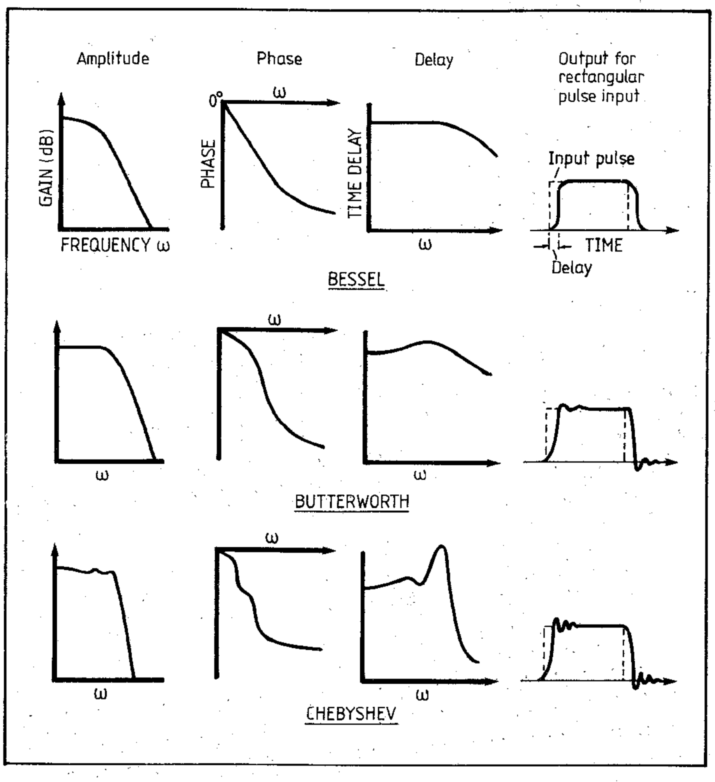


Fig.8. Comparison of amplitude, phase, delay, and rectangular pulse responses shows progression from docile Bessel filter to high-Q Chebyshev.

Fig.9. For a given order, the Inverse Chebyshev response produces a flatter passband response than the Butterworth and quicker transition to the stopband than the Chebyshev.

Fig.10. Cauer filter, with Chebyshev ripple in both passband and stopband, has an even faster transition to stopband.

Fig.11. Sallen and Key stages are cascaded together to produce an even-order multipole filter. All resistors are normalized to unity.

Fig.12. Geffe stage is followed by Sallen and Key stages to produce an odd-order multipole filter. All resistors are normalized to unity.

Fig.13. At last! A real filter designed using the Table. Other values of R may yield more convenient values of C_0-C_2.

Table 1. Normalised low pass filter values

Order	C_0	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	3dB BANDWIDTH
2		1.4142	0.7071							
3	1.3926	3.5468	0.2025			BUTTERWORTH				
4		1.0824	0.9239	2.6132	0.3827					
5	1.4077	10.1349	0.0701	1.2360	0.8090					
6		1.0352	0.9660	1.4142	0.7071	3.8638	0.2588			
7	1.3799	2.5072	0.2890	4.4940	0.2225	1.1100	0.9010			
8		5.1255	0.1951	1.8000	0.5555	1.2026	0.8315	1.0196	0.9808	
9	1.3926	3.5468	0.2025	5.7588	0.1736	1.3056	0.7660	1.0642	0.9397	
2		0.8430	0.3580							1.9432
3	1.3146	4.7924	0.0969			CHEBYSHEV - 0.1dB ripple				1.3890
4		1.5680	1.0238	3.7856	0.1986					1.2131
5	2.2210	3.9185	0.3353	6.0048	0.1393					1.1347
6		2.3362	1.6253	3.1914	0.4500	8.7188	0.1016			1.0929
7	3.1104	4.8460	0.5332	4.2568	0.3119	11.9274	0.0767			1.0680
8		3.1090	2.2090	3.6672	0.6552	5.4884	0.2280	15.6298	0.0598	1.0519
9	3.9979	5.9510	0.7187	4.4942	0.4472	6.8856	0.1740	19.8262	0.0478	1.0410
2		1.4028	0.4702							1.3897
3	1.9207	9.4512	0.0770			CHEBYSHEV - 0.5dB ripple				1.1675
4		2.3622	1.1878	5.7028	0.1649					1.0931
5	3.1355	6.4370	0.2868	8.9316	0.1081					1.0593
6		3.4508	1.8459	4.7138	0.3600	12.8782				1.0410
7	4.3532	7.7420	0.4562	6.2610	0.2360	17.5428				1.0301
8		4.5602	2.4905	5.3790	0.5183	8.0502	0.1675	22.9252	0.0431	1.0230
9	5.5804	9.3944	0.6149	6.5794	0.3358	10.0804	0.1256	29.0252	0.0341	1.0182
2		1.8220	0.4978							1.2176
3	2.5613	9.6394	0.0824			CHEBYSHEV - 1dB ripple				1.0949
4		2.9686	1.2057	7.1666	0.1414					1.0530
5	3.8818	8.2414	0.2515	11.1784	0.0905					1.0338
6		4.3092	1.8608	5.8864	0.3046	16.0820	0.0627			1.0234
7	5.2926	10.1181	0.3945	7.8080	0.1960	21.8776	0.0460			1.0172
8		5.6818	2.5049	6.7022	0.4377	10.0306	0.1378	28.5648	0.0352	1.0132
9	6.7818	12.2049	0.5326	8.1930	0.2783	12.5526	0.1027	36.1436	0.0278	1.0104
2		0.6667	0.5000							1.36
3	0.5647	0.8136	0.1451			BESSEL				1.75
4		0.3453	0.3169	0.4753	0.1831					2.13
5	0.3682	0.4065	0.1283	0.5017	0.1280					2.42
6		0.2354	0.2260	0.2677	0.1791	0.3975	0.0949			2.70
7	0.3054	0.2519	0.1019	0.2457	0.1407	0.3723	0.0734			2.95
8		0.1790	0.1747	0.3522	0.0586	0.2289	0.1133	0.1921	0.1534	3.17
9	0.2619	0.4331	0.0226	0.2156	0.0932	0.1784	0.1284	0.1631	0.1510	3.39

of cascaded Geffe filters (plus Sallen and Key if necessary).

A nine-pole filter would then require three op-amps instead of four. The component values can be derived from the Table using the preceding formulae.

For the three classes of normalized filter parameters tabulated, the normalized frequency $\omega_0 = 1$ has a different meaning. In the case of the Butterworth filter, it marks the −3dB point. In the case of the Chebyshev filter, it marks the end of the ripple band i.e. the point at which the attenuation becomes greater than the ripple attenuation for the last time. For the Bessel filter, ω_0 is the inverse of the delay time through the filter. The Bessel filter parameters are, in effect, normalized for a delay of one second. For the last two cases, therefore, the normalized −3dB bandwidths are also tabulated.

The order and type of filter response are required to select the right line of normalized values. ω_0 ($\omega = 2\pi f$) is also required. Select a suitable value of R (for instance, 10kΩ). The real value of C, C_R, is found from:

$$C_R = \frac{C}{\omega_0 R} = \frac{C}{2\pi f_0 R}$$

This calculation may be tried with alternative values of R to find capacitor values closest to the preferred values.

Example

A third-order Chebyshev filter with 0.1dB ripple and f_0 = 4kHz is required. A 15kΩ standard resistor pack will be assumed for the resistances.

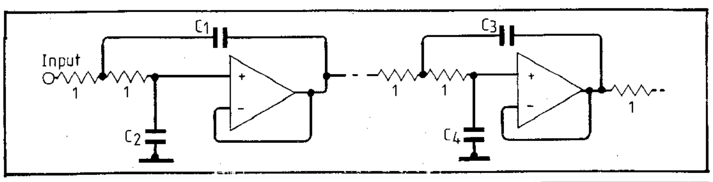
The required line of normalized data is:

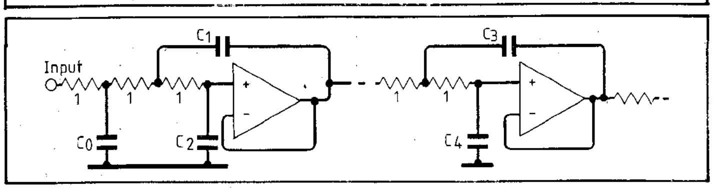
Order	C_0	C_1	C_2
3	1.3146	4.7924	0.0969

The real value of C_0

$$= \frac{1.3146}{2\pi 4\times10^3\times15\times10^3} = 3.487\text{ nF}$$

Likewise, the real values of C_1 and C_2 are 12.71nF and 257pF respectively. The −3dB bandwidth of this filter, shown in Fig.13, is 5.55kHz. To design a Bessel filter for a given delay D, use the relationship D = 1/ω., i.e a delay of 100μs corresponds to ω_0 = 10000 rad/s.





Appendix

Equation 1:

$$T(s) = \frac{G/R_1R_2C_1C_2}{s^2 + \left(\frac{1}{R_1C_1} + \frac{1}{R_1C_1} - \frac{(G-1)}{R_2C_2}\right)s + \frac{1}{R_1R_2C_1C_2}}$$

Equation 2:

$$T(s) = \frac{1/R_0R_1R_2C_0C_1C_2}{s^3\left(\frac{1}{R_0C_0} + \frac{1}{R_1C_0} + \frac{1}{R_1C_1} + \frac{1}{R_2C_1}\right)s^2 + \left(\frac{R_0+R_1+R_2}{R_0R_1R_2C_0C_1} + \frac{1}{R_1R_2C_1C_2}\right)s + \frac{1}{R_0R_1R_2C_0C_1C_2}}$$

Equation 3:

$$T(s) = \frac{1/C_0C_1C_2}{s^3 + \left(\frac{2}{C_0} + \frac{2}{C_1}\right)s^2 + \left(\frac{3}{C_0C_1} + \frac{1}{C_1C_2}\right)s + \frac{1}{C_0C_1C_2}}$$

Faster Fourier transforms

by Weysel Omer

The Fourier transform is established as a major analysis tool in many branches of science and engineering. Here is a machine language implemetation of the FFT algorithm evaluating a sequence of 128 sampled data points with 32-bit accuracy in about one second.

Weysel Omer is completing an honours B.Sc course, for which this article represents the first part of a final year projects, and hopes to continue with work in applied signal processing after graduation. He enlisted for the Brighton course after obtaining a TEC diploma from Carshalton FE college. He enjoys cross-country running as well as electronics as a hobby.

Graeme Awcock is supervisor for this project and lectures at Brighton Polytechnic whilst reading part-time for a doctorate on computer vision in low-cost robotic systems. Previously he worked as design engineer at Computing Devices, where he went after graduating with a first from the Polytechnic.

The fast Fourier transform algorithm provides rapid computation of the frequency spectrum of a sampled time-related waveform. The classical solution for a waveform using equation 1

$$X(f)=\int x(t).\exp(-j2\pi ft)dt$$

may be time consuming and, being analytic, it is not amenable to machine computation. An approximation to it is obtained by sampling the waveform at a sufficient number of points, see Fig 1. Fourier analysis using equation 1 for a *sample* sequence yields the general expression given by equation 2, know as the discrete Fourier transform or DFT

$$X(m)=\sum_{k=0}^{N-1} x(k).\exp(-j2\pi mk/N)$$

The waveform should be sampled and the amplitude at each sample point (from $k=0$ to $k=N-1$ where N is the total number of samples) be placed in the array $x(k)$. Applying equation 2, the Fourier coefficients of each frequency component are left in array $X(m)$ for values of $m=0$ to $m=N-1$. For N samples in the time domain representation of a waveform, there are N corresponding frequency components in the frequency domain representation. An approximation to the original is reconstructed by summing the frequency harmonics. By analysing the DFT equation, as in the theoretical discussion on the next page, the fast Fourier transform or FFT is produced. The analysis, however, is not a prerequisite to being able to use the FFT effectively.

Basic concepts: sampling

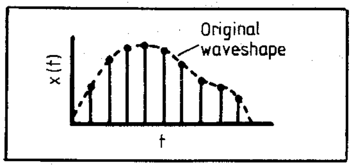
Before discussing the use of the FFT, an appreciation of sampling concepts is desirable. The waveform to be transformed into the frequency domain has first to be acquired and then sampled, and the interval over which this takes place defines a 'window'. This window contains a sequence of events which are assumed to be periodic, as illustrated by Fig. 2; an integral number of cycles of the periodic waveform must be sampled in the window. If this condition is not met, discontinuities will be assumed to exist by the FFT algorithm at the ends of the window, as shown in Fig. 3. The transform will faithfully produce the frequency spectrum of the window contents, but this will not represent the original waveform function.

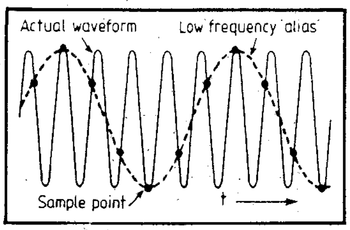
Since the implementation of the algorithm demands that the number of samples in the window is always constant, the sampling period can be increased to reduce resolution or reduced to increase resolution of the waveform. Minimum sampling period is equal to the period of the waveform. Maximum sampling interval is subjected to the constraints of the sampling theorem, which states that a waveform be sampled at least twice in each cycle Nyquist frequency. If this is overlooked, aliasing will occur, which arises due to time domain resolution deteriorating to such an extent as to make its frequency domain representation meanlingless. Figure 4 illustrates this effect.

If n cycles of period T of the waveform to be transformed are contained within the window, the period of the window is equal to nT and the separation in time between samples is

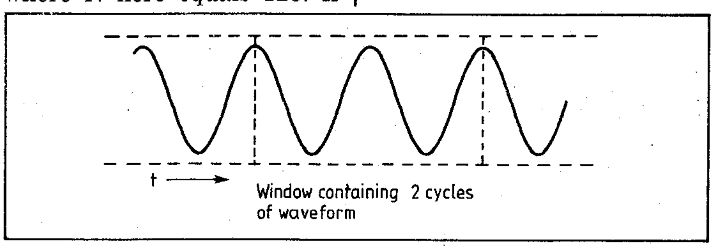
$$\Delta t=nT/N$$

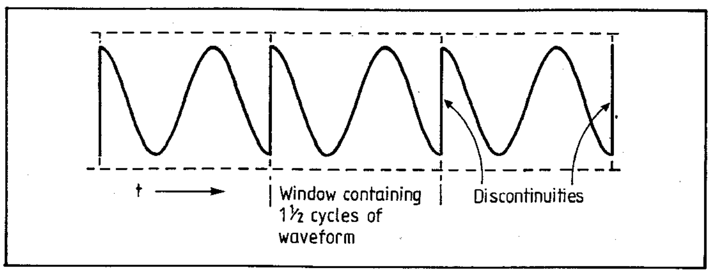
where N here equals 128. If





Sampling at regular intervals approximates to the original waveshape (Fig. 1, top). Windowed portion of periodic time function which is itself periodic is two cycles long, Fig. 2.





Incorrect sampling period containing a non-integral number cycles produces effect shown, Fig. 3.

Aliasing effect caused by insufficient sampling, Fig. 4.

this sampled window is treated as the 'time spectrum' (Fig. 5) then the corresponding, frequency spectrum relates to the parameters n,T and N in the way shown by Fig. 6. The bandwidth of the result depends on the sampling interval and each spectral line is separated by 1/nT; these relationships are referred to as 'normalized'.

Implementation

The operations required to evaluate the DFT depicted in the signal flow graph of fig. c (see panel) are abbreviated in the general flow diagram of Fig. 7. This relates directly to listings 1 to 4. Listing 1 is the source code for the main FFT algorithm of 128 sample points represented by block 3. Refering to figure e the index k, identifying the elements of x(k), is required to be bit-reversed. Two bit-reversal routines are included in this implementation, provided for processing digital data (included within the main FFT listing) and for analogue data which is produced by the source code of listing 2. These appear jointly in block 2. This process is either carried out at run-time, or as in this version using a data table (produced by routine BRVSL prior to run-time) containing the bit-reversed values of k over the range k=0 to k=N–1. For the eight-point transform of fig. c three ($\log_2 8$) stages of computation are required. In this particular case, seven ($\log_2 128$) stages of computation are carried out, but rather than calculating the combining coefficients (W_N^{mk}) during program execution, they are also calculated prior to run-time (by routine SINGEN) and referenced during execution at the various stages. In fact, much can be said for the use of data tables as they provide a significant speed advantage over run-time computation methods; their drawback is the memory required to hold the data table which may prove restrictive for large values of N.

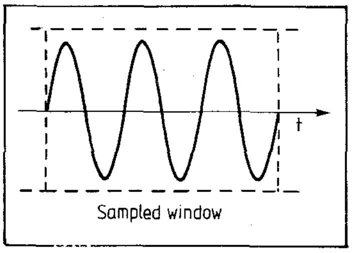
The listings should be typed in and saved separately using the appropriate names of the files ("listings" 1 to 4): FFTMAIN, UNIVERS, SINGEN, and BRVSL. Once saved, the FFT routine is formed by executing

CHAIN "FFTMAIN".

An object file is created named "FFT" which should subsequently loaded as

*LOAD "FFT".

The memory map formed is shown in Fig. 8. Implementation is in 2's complement fixed-point integer format using 32-bit data elements stored in the BBC-Micro integer arrangement with the least significant byte first: the routine therefore requires that input data be in



Time spectrum of a windowed waveform, Fig.5.

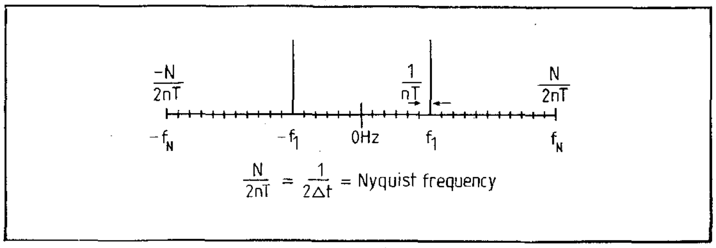


Fig. 6. Frequency spectrum corresponds to Fourier transform of Fig. 5.

this format. The range of input values represented as integers should be in the range of ±16384 to ensure that overflows do not occur during execution; i.e. if sampled data varies between +1 and −1 then multiplication by a suitable constant will ensure that the number input is an integer. The choice of constant should allow for representation of a sufficient number of decimal places without danger of causing an overflow, which in the example cited above would be 16384. This would give a resolution of four decimal places (16 bicimal places, where the "bicimal place" is the binary equivalent of decimal place). Rotation factors are multiplied by a scaling constant initially set to 1024 (see line 40 of SINGEN) which gives an accuracy of up to three decimal places.

Using the routine

The waveform is assumed to have been sampled either using a hardware scheme or by software generation. The map of Fig. 8 defines the input buffer storing the values of x(k) at location &2200 through to

Development of the FFT from the DFT

The discrete Fourier transform is

$$X(m)=\sum_{k=0}^{N-1} x(k).\exp(-j2\pi mk/N) \quad m=0,1,2,...N-1$$

For each value of m, N complex multiplications and N complex additions are required to solve X(m). The complete solution of N values therefore necessitates N^2 complex multiplications and N^2 complex additions.

Altering notation so that

$$W=\exp(-j2\pi/N),$$

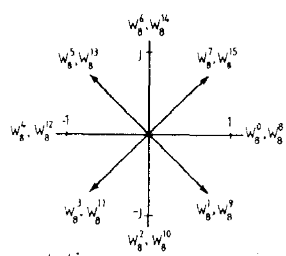
the DFT becomes

$$X(m)=\sum_{k=0}^{N-1} x(k).W_N^{mk} \quad m=0,1,2,...N-1$$

from which

$$W_N^p=\exp(-j2\pi p/N).$$

This Equation represents a phasor having unit magnitude and a phase angle given by, $\Theta_P=-2\pi P/N$. For N=8, the solutions are plotted on the Argand diagram:



From this representation,

$$W_N^{N-P}=(W_N^P)^*$$

which implies that multiplications are repeated thus reducing the efficiency of the alsorithm. By dividing the time sequence into odd and even sample sequences, this computational redundancy can be reduced

$$\begin{array}{ll}\text{even } x(k): x_1(k)=x(2k) & \\ \text{odd } x(k): x_2(k)=x(2k+1) & k=0,1,2...\tfrac{N}{2}-1\end{array}$$

and the DFT can be re-written as:

$$X(m)=\sum_{k=0}^{\frac{N}{2}-1} x(2k).W_N^{2Km}+\sum_{k=0}^{\frac{N}{2}-1} x(2k+1).W_N^{(2k+1)m}$$

Because

$$W_N^2=(\exp j2\pi/N)^2=\exp(j2\pi/N/2)=W_{N/2} \qquad \text{(i)}$$

the DFT expression becomes

$$X(m)=\sum_{k=0}^{\frac{N}{2}-1} x_1(k).W_{N/2}^{mk}+W_N^m.\sum_{k=0}^{\frac{N}{2}-1} x_2(k).W_{N/2}^{mk}$$

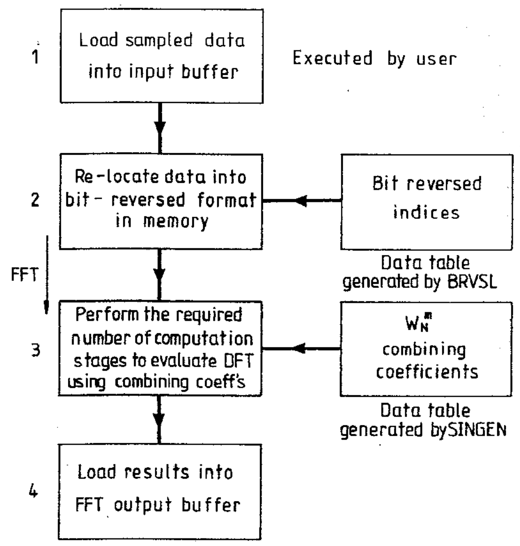
in which $X_1(m)$ is the $\frac{N}{2}$-point DFT of $x_1(k)$ and $X_2(m)$ is the $\frac{N}{2}$-point DFT of $x_2(k)$. Therefore

$$X(m)=X_1(m)+W_N^mX_2(m) \qquad \text{(ii)}$$

Thus the N-point sequence can be decomposed into two $\frac{N}{2}-1$ point sequences, and after evaluation recombined by using equation (ii). The X(m) sequence is defined for $0\leq m\leq N-1$ and the sequences $X_1(m)$ and $X_2(m)$ are defined by $0\leq m\leq \frac{N}{2}-1$. A rule governing the use of equation (ii) is established for $m\geq N/2$:

$$X(m)=\begin{cases}X_1(m)+W_N^mX_2(m) & 0\leq m\leq\frac{N}{2}-1\\ X_1(m-\frac{N}{2})-W_N^{m-N/2}X_2(m-\frac{N}{2}) & \frac{N}{2}\leq m\leq N-1\end{cases} \qquad \text{(iii)}$$

Rabiner and Gold describe an eight-point DFT in the signal flow graph shown next:



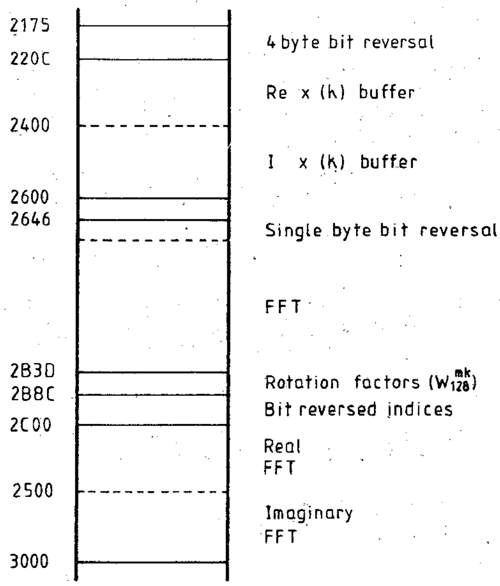


Fig. 7. Abbreviated flow diagram shows stages in evaluation of the discrete Fourier transform.

Fig.8. Memory map of the FFT routine.

&25FF. This area is divided into two parts which represent the sampled time sequence, x(k) as

$$x(k) = \text{Re}\,x(k) + \text{Im}\,x(k).$$

Signals encountered in practical situations are always real (in the mathematical sense) and Im x(k) = 0. In such cases the imaginary area defined in the buffer from &2400 through to &25FF is set to zero before transformation. Thus it would appear that assuming a real signal renders consideration of x(k) as a complex quantity meaningless, however it is to be recalled that Fourier transformation produces a complex result and therefore, in the consideration of inverse transforms, a complex buffer is required.

The BBC operator '!' provides a useful means of a defining a number consisting of four bytes. The elements of the array, x(k) are stored in this form for values of k from 0 to 127(N-1), which therefore required 128 4-byte elements in the case of real signals.

A program to initialize a pulse waveform in the input buffer may be written as follows:

```
10 FOR I = &2200 TO &22FF
STEP 4
20 !I = 256
30 NEXT I
40 FOR I = &2300 TO &25FF
STEP 4
50 !I=0
60 NEXT I
```

This corresponds to a pulse of amplitude 256 with a period equal to the length of the sampling window. The frequency spectrum of this pulse may be generated by adding a line which calls the FFT routine

```
70 CALL &2175
```

After execution of this line, the time domain data has been Fourier transformed leaving the results in the locations &2C00 through to &3000 corresponding to the array X(m). Again, the buffer is divided into two parts representing the real and imaginary parts of the into two parts representing the real and imaginary parts

locations &2C00 to &2CFF

x to $\frac{N}{2nT}$ Hz

locations &2D00 to &2DFF

$-\frac{N}{2nT}$ to $-\frac{1}{nT}$ Hz

where N=128. This ordering is for the real part, and the imaginary part is similarly arranged, thus:

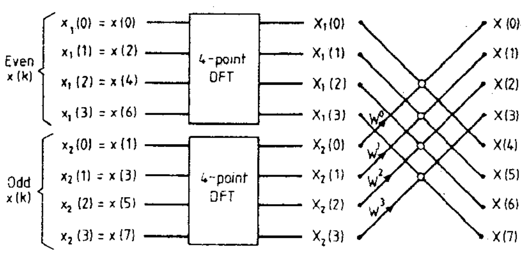
locations &2E00 to &2EFF

x to $\frac{N}{2nT}$ Hz

locations &2F00 to &2FFF

$-\frac{N}{2nT}$ to $-\frac{1}{nT}$ Hz

These results are obtained in rectangular form, but it is possible to present them in polar form. *To be continued.*



The even and odd values of m are shuffled to obtain $x_1(m)$ and $x_2(m)$ which after transformation give $X_1(m)$ and $X_2(m)$. The two $\frac{N}{2}$ DFTs can be broken down into four $\frac{N}{4}$-point DFTs

$X_1(m)$ in the form of equation (ii) is represented by

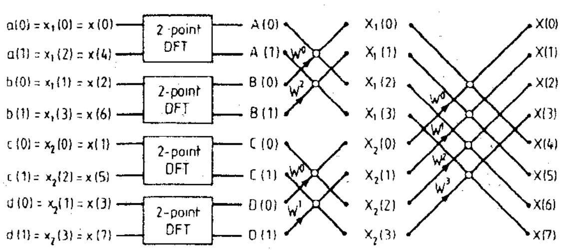
$$X_1(m)=X(m)+W_{N/2}^m.B(m)$$

Equation (i) allows $X_1(m)$ to be written

$$X_1(m)=A(m)+W_N^{2m}.B(m)$$

where A(m) is the $\frac{N}{4}$-point DFT for even elements of $X_1(m)$, B)m) is the $\frac{N}{4}$-point DFT for odd elements. Similary for $X_2(m)$, even and odd elements are identified as C(m) and D(m).

The signal flow graph below shows how the two four-point DFTs above can be broken down into four two-point DFTs.



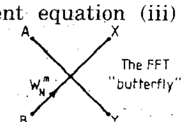
For an N-point DFT, where N is a power of 2, the DFT can be broken down until two-point DFTs remain. The results of the four DFTs are combined using the principle of equation x. The number of combining stages is equal to $\log_2 N$ with $\frac{N}{2}$ multiplications in each of these stages; the number of multiplications required in the complete evaluation is therefore $\frac{N}{2}\log_2 N$. As the majority of processing time is taken in multiplications, the relative efficiency of the DFT and FFT can be established by comparing the number of multiplications required in the evaluation of each, i.e.

$$Q=\frac{N^2}{\frac{N}{2}\log_2 N}=\frac{2N}{\log_2 N}\approx 36 \text{ for } N=128$$

For moderate values of N, the saving of time is appreciable.

The combining nodes represent equation (iii) rewritten as follows:

$$X=A+W_N^m.B$$
$$Y=A-W_N^m.B$$



$W_N^m.B$ is computed for each node and saved to obtain X and Y. Results X and Y can be stored back into the locations previously occupied by A and B. This type of arrangement is termed "in-place computation".

The arrangement of data elements, x(k), had to be shuffled to obtain the even and the odd sequences for the two $\frac{N}{2}$-point DFTs. The value of indices for k have to be converted from the natural order from 0 to N−1 to a shuffled order. By representions the natural order index in its binary form and bit-reversing this value, the required shuffled order index is obtained. Consider the case where N=4:

Index (natural order)	Binary	Bit reversed binary	Index (shuffled)
0	00	00	0
1	01	10	2
2	10	01	1
3	11	11	3

The computed values will be in natural order when processed after the final combining in the algorithm.

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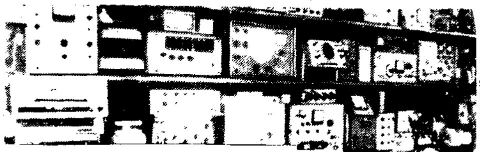

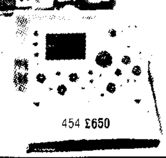

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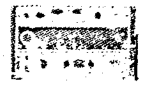

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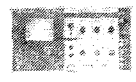

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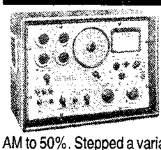

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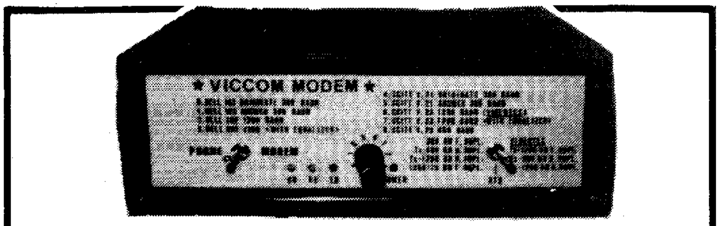

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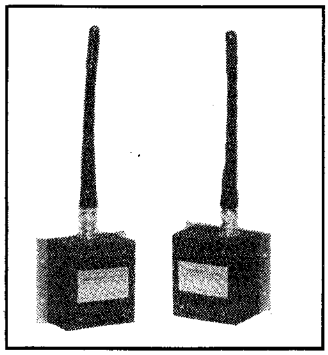

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7439 0.36

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CIRCLE 53 FOR FURTHER DETAILS

FEEDBACK

TELEPHONE RECORDING

I am interested to see that my circuit idea (November 1985, p.75) for automatic telephone recording on cassette has stimulated Mr O.F. Carter to a response (*EWW* March 1986, p.63) but I regret he is mistaken in some of his technical points.

Isolation of the recorder, the circuit and the telephone line from the mains (if indeed, the recorder is mains and not battery powered) is provided by the mains transformer of the recorder, by the contacts of the relay and bypass switch which are isolated from the rest of the circuit, and by the audio transformer. A further improvement in isolation could be made by including a second 100nF blocking capacitor in the connection between the B line and the audio transformer. The value of these capacitors could be reduced well below 100nF at some prejudice to lower audio frequencies, and the voltage rating of the capacitors should exceed 240V a.c. It would be useless to connect the circuit to the telephone lines via a 600 ohm isolating transformer of 1:1 ratio (or any other transformer), as this would prevent the circuit from sensing the d.c. voltage levels on the telephone lines. Naturally, I would agree with a fuse in the mains supply to the recorder.

The risk of shock due to ringing voltage has been greatly exaggerated, and is no worse than with any other telephone apparatus. The step-down audio transformer makes the speech connection safe from shock. No harm has been done to the recorder input by telephone ringing, partly because of the blocking effect of the 100nF capacitor at the low frequency (25Hz) involved, and partly because of the step-down transformer. A suitable diode clipping circuit could be added in shunt with the audio transformer primary or secondary, if desired.

Recording level may be adjusted (as orginally suggested) by an attenuator between the transformer and the recorder input, but it may be sufficient to rely on the automatic recording level system commonly provided in recorders, as this can make adjustments for both remote and local speech levels.

Lastly, due to its high impedance, this circuit will not short out or in any way affect normal telephone use.

It may be mentioned that comparable automatic telephone recording circuits are now on retail sale from telephone shops and the Tandy chain of stores, although I have no details of the circuit designs involved.

H. T. Wynne
Glasgow

EARTHING

With reference to the long-standing debates as to the best methods for earthing, may I add further information.

The necessity for providing a non-corrosive earth-connector only applies when there is a d.c. component in the earth-current, or when the a.c. component is of a low frequency.

Otherwise, the earth-plate may be coated with any suitable substance to prevent corrosion, or else merely left plain (providing its adequate thickness prevents total disintegration). This latter case still allows for capacitive coupling to earth; but of course a plate is now better than a rod.

Alternatively again, a metal cylinder can supplant the plate so that the coupling is that of a cylindrical capacitor.

The only drawback to this scheme (which is also a limitation in the normal case), is that the immediate earth surround must be wet.

R. N. Barr
Bournemouth
Dorset

COMPUTER TESTING

G.B. Williams' article "Simple test equipment for microcomputers" in your April, 1986 issue was of considerable interest and was studied carefully for comparison with the method adopted here in d.i.y. computer manufacture for applications equally intensive. These Z80A computers are built around a 10k-to-earth framework from each address/data pin, reduced to 1k for certain higher address members. For simple programs in eprom which begin with an Exchange Block Transfer to ram, the inital working of the unit can easily be checked by resetting the Z80A, switching to ram, and examining the data lines at various d.c. addresses from a multiway switch, using a display system. With a suitably constructed program, inputs and their consequences can all be recorded in ram as they occur, so that by switching to ram at any point the complete "state of the art" at that point can be ascertained. One example of the memory map for such a system is for the Z80A to work the eprom at addresses from 0000 to 0FFF, and to engage the ram when A12 is high, i.e. at addresses 1000 to 1FFF. After reset, a double-pole switching putting 10k between CE and earth, and OE and earth of the ram permits data stored on the latter to be displayed, whilst eprom is disabled by the high on RD joined to OE.

The only additional apparatus required for test, apart from a voltmeter, is a display & address-setting unit * with long leads for attachments to the 10k address/data framework, most simply by a few minute's work with a soldering iron (earthed to the earth of the equipment, and with the power supply switched off).

This method avoids the 74374 octal D-type flipflops of William's data-bus analyser, and also the 74688 8 bit comparators, which can be expensive for humbler workers of the d.i.y. engineering type.

*available from me at this address.

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28 Llanvair Drive
South Ascot
Berks

STEREO HISS

It is interesting to compare Mr Price's concern with compatibility with existing equipment (*EWW* March 1986 p.36) with the BBC's previous performance in respect of their programme labelling system, currently being used experimentally, and due to come into service in the Autumn of next year, according to the *Financial Times* (25 March, 1986, p.9).

This system gives rise to objectional background noise in certain older receivers such as my own, and I wrote to you about it in 1980, as the BBC had been attributing it to continental interference (my letter and Dr Leggat's reply *WW* October, 1980, p.49).

While I did get a personal reply from Dr Leggat at that time along the lines of his letter to you, I have had no constructive suggestions as to how to eliminate the noise, and I now usually have to listen in mono.

R. Camp
Brentwood
Essex

'INTELLIGENT' MACHINES

I have just read Tom Ivall's interesting article "Human responses to 'intelligent' machines" in your March issue. His argument that human factors engineering will have to be extended to include human psychology must surely be right. It has bothered me for some time that the human-factors engineering people, or many of them, have been largely ignoring AI, while the AI people have been so excited with what they are doing that they for the most part have not taken human factors or psychology seriously – and the more powerful and subtle the computing capability, the subtler and more difficult the mismatch and possible damage.

Your contributor's thoughts seem to have been running almost parallel to mine about the Turing test. In a letter to the *Applied Artificial Intelligence Reporter* I have argued that the test is simply invalid, precisely because it was framed in a way that took no account of human psychology.[1] However, I have found that AI people do not react sympathetically to an argument that in effect removes a pet theory that intelligence can be isolated from the rest of the human mind. Rather, they ignore it (with the obvious exception of the editor of the *Applied Artificial Intelligence Reporter)*; which is a pity, for the lure of the Turing test is, I judge, likely to divert AI efforts directed at real machine intelligence away from the most useful directions. Another way to put it, perhaps, is that a machine process that can be expressed in mechanical logic may be vastly useful and powerful but should not be considered as intelligent in any way that can be directly compared with human intelligence (for example, a machine that could type better than I can). On the other hand, any process subtle and complex enough to be comparable in 'intelligence' to a human mind had better be given a background of knowledge and 'experience' similar to that of a human, if we are to recognize it – and that will be a major problem all on its own.

Roderick Rees
Kirkland
Washington USA.

LIGHT, DISTANCE, TIME AND RELATIVITY

It seems to me that Alex Jones (April) is limiting his thinking to light being a solid particle rather than a packet of energy shunted linearly by successive l.s.ms: such a packet is just as corpuscular as the limiting sub mass which eventually delivers it, and it is the packet which we call a photon. If his "particle" is small enough it appears possible that it could be hammered successively by the same l.s.m. at the frequency of radiation.

On the other hand, if the particle is large enough to be entered by the l.s.m., then the spin energy of the latter would wind it up and so increase its relativistic mass by accelerating it gravitationally, and that in the opposite direction to the hammering if both effects came from the same massive source.

I suggest that Mr Jones is only totally correct about e.m. Doppler and the propulsive effect of the radiation if the spin energy of the l.s.m. which carry it be zero, something which is of very low probability and certainly a degree of freedom which must not be denied.

Nor am I happy about the time dilation quoted by Alan Watson (also April) as being unequivocally shown: movement can be considered to be throughput of energy and is only distance per unit time in terms of classical mechanics. Certainly I accept the apparency of time dilation, but it could equally well be an accelerative effect due to a gravitational gradient of spinning l.s.ms.

As to Prof. Archibald Medes standing on his hairless head down under, the specialist sciences differentiate by probing linearly (and thus radially) into little bits of totality (can we apply a specific date in April?) and we have to integrate their findings in order to discover the nature which is within us: self-analysis is limited to and by our own experience. Mathema is an athema, and devoid of causality as every monetarist should have learned by now.

Therefore, if we are to tidy up the matter, we must first accept that energy has two degrees of freedom whence the picture seems to become clear: time is the constant "rate" by which we judge changes in energetic behaviour and measure the life of mass between its creation and its catastrophe, but because energy is only deduced to exist it appears that time dilates: this seems to me to be the working basis for Relativity.

James A. MacHarg
Wooter
Northumberland

I have now had the chance to study in more detail the very important paper that I mentioned in a footnote in my recent letter (February, p.42). The author, Prof. Michael Sachs, quotes only extracts from Einstein's own published writings. These confirm Sach's impression from personal discussion that Einstein had changed his mind: he no longer believed that the mathematical space-time transformation of relativity implied physical consequences such as length contraction, time dilation, and the assymmetric ageing of the Twins Paradox.

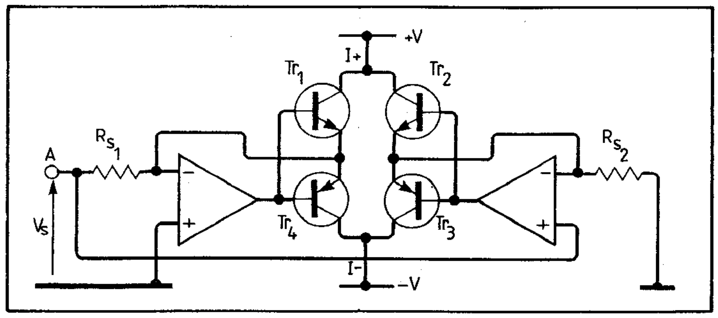
G. Burniston Brown
Padstow
Cornwall

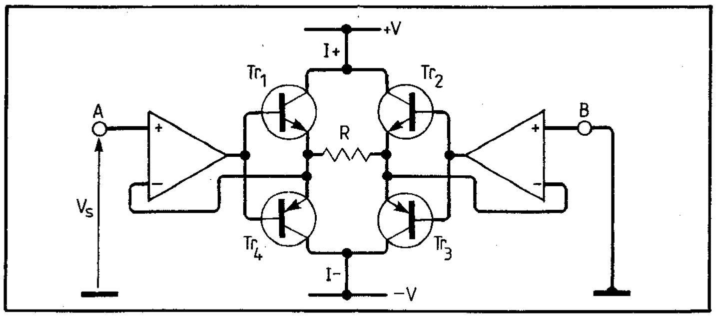
TRANSISTOR FULL-WAVE RECTIFIER CIRCUITS

Mr Lewis (*E&WW*, March 1986, pp.22-24) rightly draws attention to the value of using transistors with op-amps to perform full-wave rectification or, to give the operation its less specific description, absolute value generation.

The circuit shown in Fig. 1 is Mr Lewis's final circuit, while the circuit shown in Fig. 2 is a related circuit developed by the authors several years ago and described in detail elsewhere ('Versatile precision full-wave rectifier', R.W.J. Barker and B.L. Hart, *Electronics Letters* 13, No. 5, March 1977, pp.143-144). We would like to comment on the relative performance of the two arrangements.

In the circuit of Fig. 1, the output waveform symmetry for both I^+ and I^- is critically dependent on the matching of resistors R_{S1} and R_{S2}. It is true that one of these may be made variable for 'trimming' purposes. However, this does mean the complication of a setting-up procedure. Furthermore, the trimming will be dependent on the source resistance at A.





In the case of the circuit of Fig. 2, no resistor matching is required, because only a single resistor is used. Thus, waveform symmetry is assured without the requirement of a setting-up procedure. As the input impedance seen at point A is very high, the circuit operation is virtually independent of the source resistance at A. In addition, different values of R can be switched in to give a programmable transconductance, if required.

Finally, it should be noted that both arrangements can provide for differential input operation. Thus, if a second input is applied in both circuits at point B, the output current is a function of the absolute value of the difference between the signals. We have used this property to remove unwanted mains interference in the rectification of a low-level signal.

R. W. J. Barker
B.L. Hart
Trent Polytechnic
Nottingham

CLASS B OUTPUT

I thank Mr Wrigley for his interesting comments (May, p.22). Yes, my circuit does seem superficially similar to the design published by Mr P. Lambrechts in *Hi-fi News* in October 1971. But there are major differences.

My purpose was to design an amplifier that did not require (skilled) bias adjustment and at the same time to avoid low-level non-linearities. This was not a design feature of the 'Edwin' amplifier although it had a fixed bias.

My design uses fairly high-power transistors in the driver stage at the highest practical current. The 'Edwin' amplifier uses standard driver transistors at a current not that much greater than a typical Class B amplifier.

My design requires the driver transistor to be mounted on the same heat sink as the output devices. This not only dissipates the heat, but also reduces temperature-generated distortion. T.g.d is the distortion that occurs when a transistor junction heats and cools rapidly due to fast changing variations in current × voltage. It can be reduced by heat sink, which can dissipate the heat quickly, and by better temperature tracking between devices which are closely related in the circuit.

I found Mr Wrigley's comments on the sound quality of his amplifier very revealing. I do not think the Edwin output stage would sound better than a typical Class AB stage with other stages being equal, but in a couple of ways that design was far ahead of its time. One very advanced feature, possibly not realised at the time, is the lack of electrolytic capacitors. The other is the use of a dual matched input differential (CA 3046) which permits close temperature tracking between Tr_1 and Tr_2. I wonder how much this improves the sound.

I am grateful to Mr Wrigley for his comments on the sound of his amplifier. If he would like to improve the sound quality of his amplifier, I would like to recommend that he replaces his driver transistors with BD139/BD140, replaces bias diodes with a transistor (BD139) and two resistors and mounts all three extra transistors on the same heat sink as the output devices. I am willing to bet that he will notice and be very pleased with the difference.

Graham Nalty
Borrowash
Derby

'PRECISION' PREAMPLIFIER

Mr Self has, alas, skipped a few details in his letter published in *EWW*, February 1986.

In the real world, music signals differ from sinewaves in that they're predominantly composed of harmonics. In the time domain, this may be expressed as a continuously varying assymmetry. The nett effect is a variable d.c. component. Aside from its unpleasant liaison with electronic capacitors, Rock music's assymmetry in particular does naughty things to speaker cones when driven by bridged power amplifiers. For example, in the US I witnessed a DL12X 12in drive unit which had been offset ½in (200%!) from its neutral axis, the result of an OTT Funk bass-line.

In Mr Self's version of John Curl's venerable capacitative error analyser, his square-wave test pulse is clearly symmetrical, and lacks the variable d.c. sub-component. *Ergo* the error component can only be raised in a puny fashion at high voltages, whereupon Mr Self has explained the phenomenon away, as the sort that have "no relevance to property designed audio..."

If Mr Self repeats his tests using an assymmetric waveform[1] (i.e. where the area-under-the-curve of the + and − components sums to a figure > or < zero, he'll discover that even 160 volt non-polarized electrolytics get mighty upset with just +/− 0.5V of assymmetric excitation.

I don't know when Mr Self penned his letter, but in calling for proper double-blind tests, rigorous statistics, measurements, rational explanations *et al.*, he's omitted to mention work of this nature by Martin Colloms[2], and John Atkinson[3]. More to the point, if Mr Self would cast open the window in his tower, and volunteer to offer some of his undoubted statistical and conceptual skills to the work being done on capacitors at present in the UK, then we'd sooner have some results in the 'scientific' format.

Last, on the topic of gold-flashing, I do agree with Mr Self: gold-plating isn't the sole way to attain a good contact. Nevertheless, he has missed Mr Armstrong's point. There's a clearcut correlation between reliability and perceived sound quality: one is an extrapolation of the other. If a sound-system component is unreliable, the music will tend to get groggy or disappear altogether after a while, and the perceived sound quality then falls to nil. Now tying in with David White's masterly exposition of sonic FX, gold-plated contacts may 'sound better' because their confidence level for working at 99.9% of their best is high, at say 98% in contrast with tin-lead-nickel, where the confidence gets tricked by a smart oxide film. Ask Dr Marlowe.

References

1. Martin Colloms, 'A passive role?' *Hi-Fi News & Record Review*, October 1985.
2. 'A capacity for change', *HFN RR*, December 1985.
3. John Atkinson, 'Listening & hearing' (Reports on public double-blind capacitor tests), *HFN RR*, January 1986.
4. Rauch, Dr Anton J., "POWERFET block uses advanced capacitor technology to defeat assymetric burnout in powered monitor wedge" (Monitor system Technology UK) DVT bulletin 019, May 1984.

Ben Duncan
Tattershall
Lincoln

DTMF – WHY NOT JAM TODAY?

With the rapid introduction of electronic telephone exchanges I have wondered for some time why British Telecom, with all the publicity and emphasis on the 'hi-tech' appeal of today's telephone system, seems so against the introduction of DTMF (Dual Tone Multi-Frequency) dialling. I live in Kingston-upon-Thames, where all three exchanges have the new dial tone and are of the TXE-4 type. Following many phone calls to different departments in BT it was confirmed by engineers at the exchange that they would all accept DTMF dialling on any lines that were so programmed at the exchange. They could only be programmed to accept both DTMF and loop disconnect. However, once the sales department gave the go-ahead the sales people were very reluctant to admit that this was so, and even more reluctant to confess that it would be done at no charge. They were adamant that there was 'no benefit', that it would be no faster, and that BT policy was that no DTMF phones would be installed until the whole country is System-X in the late 1990s.

With vast numbers of telephones now being bought outright, it seems very irresponsible of BT not to make the public aware of the fact that DTMF dialling is available on many exchanges with the new dial tone, before the unwary subscriber invests large sums of money in apparatus that will soon be obsolete.

Moreover, I would like to know why BT is not installing rented DTMF telephones as standard when available at the exchange. If this policy was adopted, it would only be beneficial for BT because of superior service that it provides. It also would mean that the pocket DTMF generators used for services such as voice mailboxes would become a thing of the past.

When my telephone line was eventually converted to accept DTMF, the engineer told me that I had the dubious honour of being the first DTMF subscriber in Kingston. The service is much faster, and when the new 'star' services become available, I shall not have to go out and buy another telephone.

T. J. Robinson
Kingston-upon-Thames

68000 board

Several important improvements have now been made in this project. The original software release was documented fully in our January and February issues; but in version 2.0 many useful commands and facilities have been added and some problems have been eliminated. The additions include a disassembler, a useful single-stepping facility, printer controls, and up for four user-defined commands.

Both serial ports now permit hardware handshaking, enabling port B to be used for a printer. Default baud rates for the two ports can be set independently. The monitor now supports the alternative 68010 virtual memory processor.

The assembler too has undergone improvement: it now gives descriptive error messages and allows comments to be entered.

Components for the 68000 board, including a double-sided p.c.b., are available from Magenta Electronics, 135 Hunter Street, Burton-on-Trent, Staffordshire.

Literature received

A whole library of **databooks** came to us from Samsung. Full details are given of logic families and linear i.cs. Mos products include watch and clock circuits as well as microcomputers. The company also manufacturers discrete transisitors and n-mos c-mos memory i.cs. Samsung UK Ltd, Victoria House, Southampton Row, London WC1. **EWW 250 on the reply card.**

Included in Harwin's 67-page **connector** catalogue are plugs and sockets for data transmission, modular connectors for mother/daughter boards, p.c.b. and i.c. sockets and a variety of hardware. Harwin Engineers S.A., Fitzherbert Road, Farlington, Portsmouth, Hants P06 1RT. **EWW 251 on the reply card.**

Mos memory designers guide comes from Hitachi. It is intended to acquaint users with memory devices and gives examples and advice on their use. Hitachi Electronic Components (UK) Ltd, 221 Station Road, Harrow, Middlesex HA1 2XL. **EWW 252 on the reply card.**

Lambda have completely revised their **power supply catalogue** which includes switch-mode, linear, rack and bench supplies, d.c./d.c. converters and many other products to do with protecting and filtering supplies. Lambda Electronics, Abbey Barn Road, High Wycombe, Bucks HP11 1RW. **EWW 253 on the reply card.**

Items from complete **computer systems** to semiconductor components are supplied by Midwich and detailed in their catalogue, which also has descriptions of disc drives, network components and many peripherals. Midwich Computer Co. Ltd, Gilray Road, Diss, Norfolk IP22 3EU. **EWW 254 on the reply card.**

Linear and data conversion products are listed in a product selection guide. The PMI products include ics, precision op-amps, d-to-a converters, analogue switches, multiplexers etc. Available from RR Electronics Ltd, St Martins Way, Cambridge Road, Bedford MK42 0LF. **EWW 256 on the reply card.**

Data acquisition and control interfaces are available as plug-in boards for IBM-PC/XT/AT computers or compatible clones and for the Apple PC computer. They are made in USA by MetraByte and detailed in a catalogue available from Keighley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL. **EWW 257 on the reply card.**

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Telephone: (331) 4790 6215 Telex: 610471 Fax: Paris (331) 4733 1131

CIRCLE [illegible] FOR FURTHER DETAILS

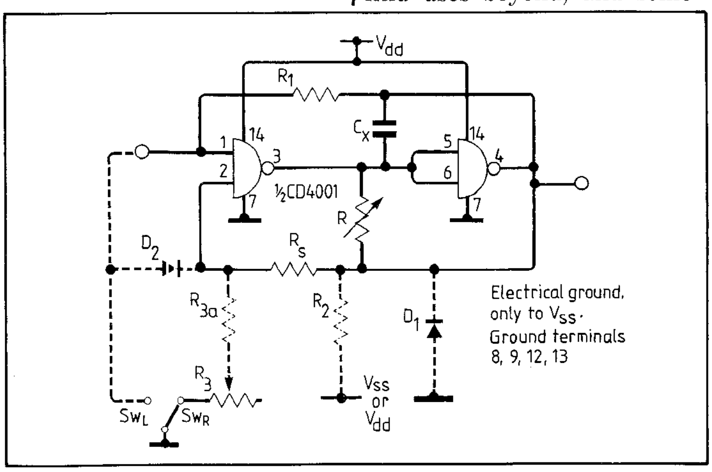
By J. H. Owens

Improving 4000 series oscillators

Enhanced cmos oscillator circuitry has application in tv, data processing and facsimile transmission, as well as keying

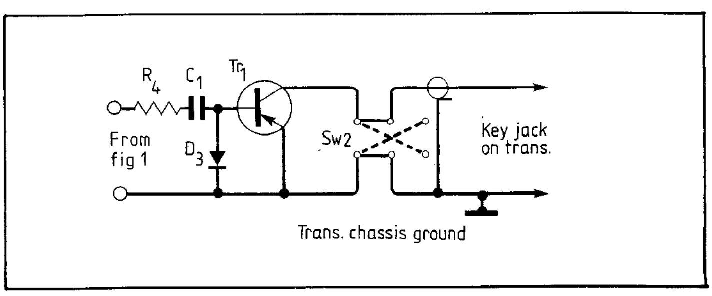
Jim Owens, retired from RCA after 44 years, held positions in sales, engineering, marketing, advertising, and market research. He has eight US patents, and in 1968 received the coveted RCA Engineering Achievement Award. He has been a licensed Ham since 1931, call sign W5JQE.

This describes some newly developed circuit refinements for use with the 4000 series cmos integrated circuits, specifically the CD4001 and CD4013 types. Like most discoveries, the ones described resulted from the pursuit of redesigning a piece of equipment in the interest of superiority, simplicity and savings. The end-result, if the design work is successful, is the creation of circuits which find uses beyond, and sometimes unrelated to, the project that originally stimulated the engineering effort.



Component values for Fig.1 (above) and Fig.2 (below): R 100kohm plus 20k limiter, R_s 1M, R_1 470k, R_2 330k, R_{3a} 270k, R_3 500k, R_4 47k, C 1μ, C_1 4.7μ, IC CD3001, Tr SK3715. Diodes are 1N914.

In this case, the target was what is known as a 'fully automatic keyer', used to key radio transmitters on and off in relatively short or long intervals, on dots and dashes, which can be decoded into intelligence by machines or by persons trained in the art. Similar coded bursts of electrical energy are to be found in many fields, such as television, data processing and facsimile transmission.



Typical keying machines, used in the communications field, comprise four functions, a keyable squarewave generator, a flip-flop divider, a mixer-inverter, and an output driver used to key the radio transmitter. Theoretically, these functions could be obtained from two gates, one flip-flop divider, one mixer-inverter, and one discrete transistor as the output stage. But practically, keying instruments in use now contain a separate clock and inverter for the generator, two or more flip-flop dividers, two or more mixer/inverters, and two output drivers, with occasionally an electromechanical relay. These differences between the theoretical and practical suggest an opportunity for many improvements.

Every project has a starting point, as well as a finishing point. This one started with the circuit shown in Fig.7 on page 732 in the RCA SSD-250C Data-Book, which is reproduced here in bold lines in Fig.1. The operation of this circuit is well known, so it will not be further described here, except as inference to its limitations and deficiencies. For example, if a negative (low) gating pulse is applied, as by closing and releasing the switch Sw_L, a corresponding high pulse will appear at 3, together with a low pulse at 4; then both terminals will return to their quiescent state positions instantly when the switch is opened. The insertion of a resistor, R_1, between 1 and 4, will make the pulses self-latching and self-completing. Self-latching means that before the switch contact reaches zero resistance, or has a chance to bounce, the 'lo' pulse at 4 will drive 1 to its lo state. Self-completing means that the lo pulse at 4, through R_1, will hold in its lo state until R and C have gone through their discharge-recharge cycle and have returned to their original quiescent position. The end result is that the circuit will make one or more *complete* dots (square waves), having a nearly perfect 50% duty factor, and without keying transients at either the make or break end, nor a fraction of a pulse under any condition.

Another imperfection of the SSD-250C circuit is that the first pulse (dot) will be longer than the ensuing dots in a string. This is caused by the fact that C is charged to the full V_{dd} voltage while in the quiescent condition; so when 4 goes lo, it will drive the RC junction that same amount more negative than V_{ss} before 3 brings it back and up to the 5 and 6 transfer voltage. After the first pulse is completed, the average RC junction voltage restabilizes at a higher than ground voltage, therefore less time is now required for each of the discharge-recharge cycles, so the succeeding dots are uniform in their time-cycle, and faster than the first one.

Insertion of diode D_1 into the circuit as shown in Fig.1 clamps the first pulse at the RC junction near V_{ss} level, and so makes the first dot almost exactly the same length as the succeeding dots. A very slight improvement can be made by substituting a zener diode for the simple diode, one which has a zener voltage approximately equal to the 5-and-6 transfer voltage. However, this very slight improvemnt is realized only if the V_{dd}-to-V_{ss} voltage is constant, a condition that is not compatible with this design which has to operate over a battery voltage range of 2-to-1.

In some instances there would be a desire to make the dots slightly lighter or heavier than the normal 50% duty factor. Such correction can be made by adding R_2 to the circuit. Connecting R_2 to V_{ss} will make the dots heavier... to V_{dd}, lighter. In this circuit, there is already a d.c. path from the RC junction to V_{dd}, so the dots will be on the light side. For this reason, R_2 will probably be connected to V_{ss}.

The Fig.1 circuit becomes a semi-automatic keyer by the addition of R_3, R_{3a}, D_2, and Sw_R which in combination comprise an override facility for making manual dashes. If the value of R_2 is selected for a 50% duty-factor, R_3 can be adjusted so that the elapsed time between dots and dashes and dots will be exactly the same as the time between dots. Suggested relations are as follows: R_3 will equal R_1; R_{3a} will be half of R_1; R_s will be twice R_1; and R_2 will be three-quarters of R_1.

A semi-automatic keyer has little interest in today's world, but the override facility does perform a special aid to those operators who use manual 'Morse' keys. If Sw_R is closed and released quickly, the circuit will make one self-latching self-completing dot, just like Sw_L... but if held closed, it will make a dash with the same qualities as the dot. The advantages over the unprocessed key are uniform dot weight, uniform spacing between dots and dashes and dots, and freedom from keying transients.

Deviating from the design-objective use of the circuit, consider its possible use in a tv

continued on page 58

Automatic electronic keyer

You're gonna like this one! It has all the features of the expensive ones except memory. It uses just two cheap chips and one output transistor. The key-up current is only a few microamperes, so no on-off switch is needed. Even used every day, the current drain of a couple hundred microamps, with satisfactory operation down to 5V, the 9-volt radio battery can be expected to last its shelf-life.

Performance features

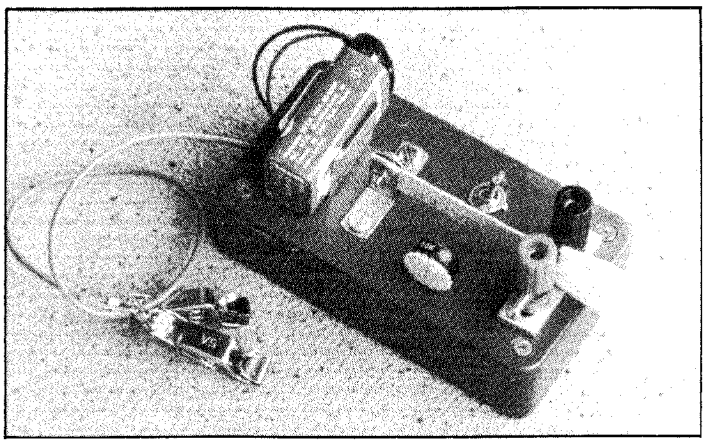
– Self-latching and self-completing dots and dashes,
– 50% duty-cycle for dots, and 75% duty cycle for dashes, with provision for increasing or decreasing weights,
– instant starting with the first dot being no longer than succeeding dots,
– uniform automatic spacing between dots and dashes and dots,
– good immunity to strong r.f. fields from high s.w.rs on transmission lines,
– freedom from key clicks and bounce transients,
– capability of keying both negative-grid-block and positive-cathode keyed transmitters, and
– continuous hold-down for transmitters tune-up.

After assembly, measure the terminal voltage of your 9-volt battery. Then connect the voltmeter from any V_{ss} point to either one of the i.c. terminal 14 points, and snap in the battery. The voltmeter should read about ½volt less than its terminal voltage... this reading will be called 'hi' in the following test procedures. If a reading is near zero, it will be called 'lo'.

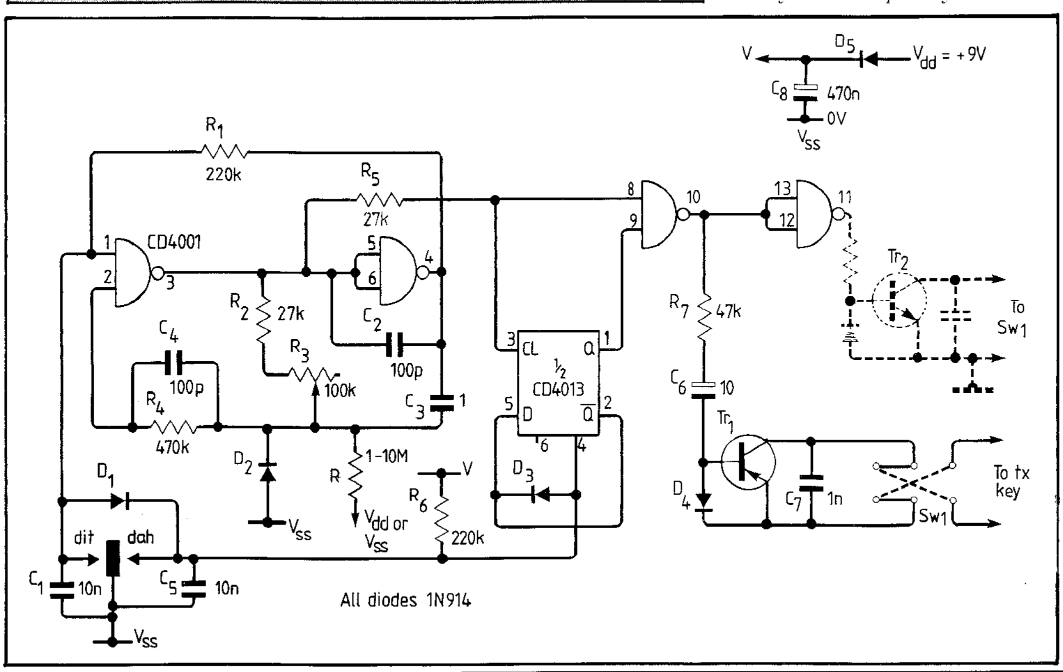
In the unkeyed (key up) position, terminal 3 will be lo, and 4 will be hi. When the paddle is closed for either dots or dashes, with the speed control midway, terminal 3 voltage should rise to one-half of hi, and the meter pointer will quiver. Likewise, the voltage at 4 should drop to one-half hi, and quiver. This shows normal operation, i.e. the C4001 is doing its job and generating dots.

Going to the CD4013, in the key-up condition, hi will be low, and will stay that way when dots are keyed. But when the dash paddle is closed, it will rise to one-half of hi, and rock back and forth. This indicates that the 4013 is making one dash for every two dots, i.e. dividing by two. Going back to the 4001, terminal 10 will be hi in the key-up condition, but when dots are made, it will drop to the half-way point and quiver... when dashes are made, it will drop to ¼ hi and rock back-and-forth.

For the final test, connect the keyer to the transmitter and turn on the a.c. power. If the transmitter 'keys on', simply reverse the position of Sw_1. Operating the paddle will now make the transmitter make dots and dashes. To check the duty-factor, connect your voltmeter to the Tr_1 collector, and read the transmitter keying voltage. Now close the dot paddle and note that the meter drops to half the unkeyed voltage, and quivers. If it is not exactly perfect, you can use R to adjust.



This circuit mounts on ready-made p.c. board, details from the editorial office. Please send s.a.e. and mark your envelope 'Keyer'.



By Frank Ogden

Digital altimeter

An updated liquid crystal display and much improved temperature compensation for the May 1985 electronic altimeter

Fig.1. Calibration of the altimeter depends on setting the reference voltage supplied to the d.v.m. chip via the 100kΩ calibration control. This derives from the voltage applied across the pressure transducer bridge thus ensuring perfect temperature tracking. The original instrument was calibrated against a certified aneroid barometric altimeter taken to 5500ft from airfield level. Readings related better than one per cent at all intermediate levels following calibration.

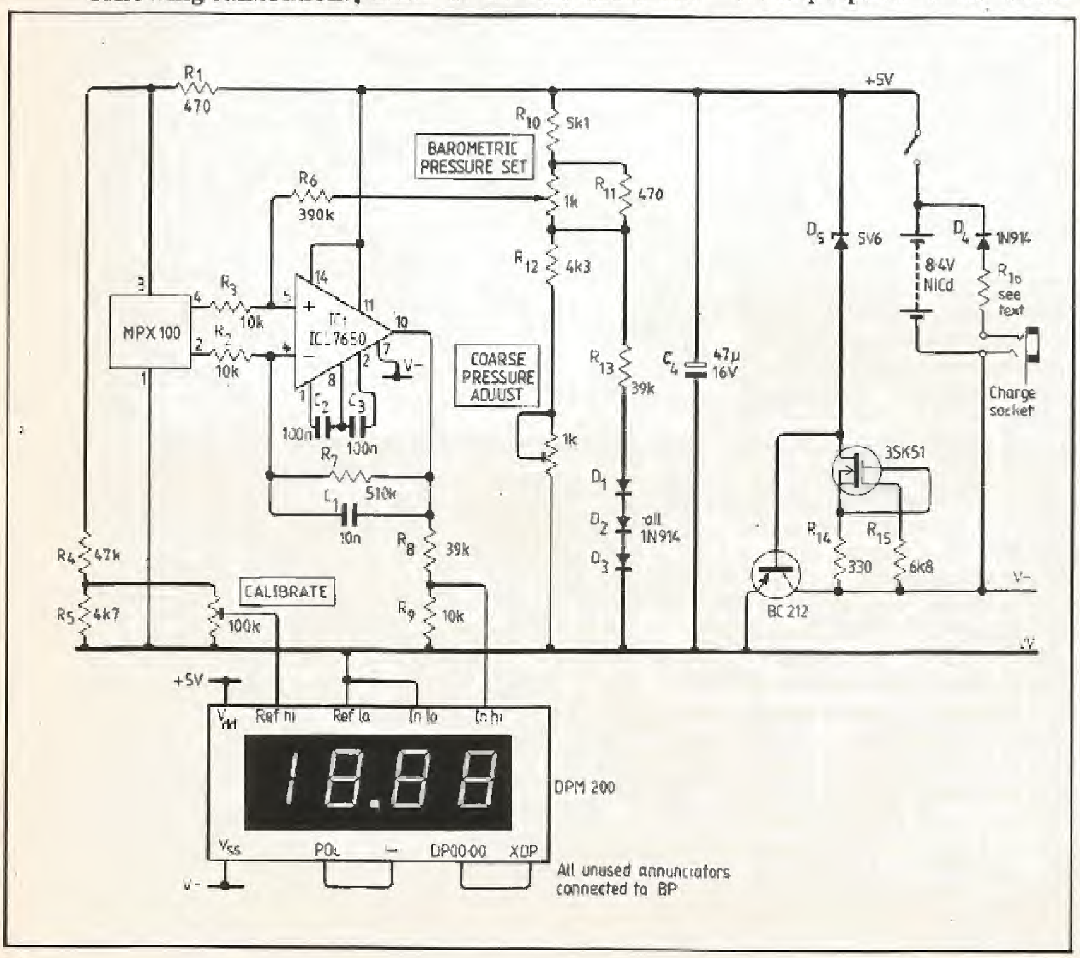
This improved design uses the same type of cheap, automotive pressure transducer and chopper stabilized operational amplifier as the original. The digital model incorporates both first and second-order temperature compensation enabling a readout stability of ±10ft over a 30°C temperature change (equivalent to climbing through 15,000ft in normal conditions). The scaling accuracy is better than one per cent at 20,000ft equivalent pressure. The 3½ digit meter module provides a resolution of 10ft maximum altitude reading is 19,990ft.

The original also incorporated a vario, a differentiator circuit fed directly from the meter drive. This added considerably to the instrument's bulk and current consumption, and reduced the full scale deflection to 3000ft. This has been thrown out. The display l.s.d with its 10ft reading intervals clocks up or down with relatively small rates of climb or sink, largely obviating the need for a separate vario circuit.

Operating principle

Heart of the instrument is an MPX100 pressure transducer manufactured by Motorola. This comprises a thin silicon dice etched on its reverse side to form a hollow cavity when mounted onto the device header. This space under the chip is in a state of high vacuum. Integrated silicon resistors on the chip topside – silicon strain gauges – register flexing of the dice through applied air pressure. The Wheatstone bridge arrangement of these gauges provides a differential output from the transducer, typically around 2.5mV/lb in^2 change in applied pressure. This works out at about 1.2mV/1000ft at the lower altitude levels. A low drift differential d.c. amplifier – stability co-efficient about 0.1μV/°C – raises this to 12mV/1000ft at the d.v.m. input.

The chopper stabilized op-amp, IC_1 in the circuit diagram Fig.1, actually produces around 60mV/1000ft at its output subsequently attenuated down by network R_8, R_9 for the d.v.m. This is to allow for a healthy vario drive signal, obtained by differentiating IC_1 output.



Temperature compensation

The silicon resistors used in the pressure transducer exhibit large positive temperature coefficients. In the intended application, automative fuel injection systems, a couple of percentage points over a 50°C temperature range is neither here nor there. The transducer includes a basic compensation mechanism without which the temperature coefficient would be even greater.

The MPX100 and other transducers like it have two distinct problems associated with altimeter use. The internal bridge is balanced during manufacture at the zero pressure end of the scale. This means that normal air pressure causes a standing voltage of some 40mV across the bridge connection in the circuit shown here. This inbalance is subject to variation with temperature, a first-order correction.

Secondly, a substantial change of altitude also causes a substantial change of temperature; the standard environmental lapse rate is 1.98°C/1000ft. The internal transducer compensation network requires external series resistance, R_1, to make it work. Since the entire bridge resistance changes with temperature, the differential output for a given pressure change also changes with temperature. This requires a second-order correction.

The common-mode voltage at the transducer outputs varies positively with temperature. By unbalancing the differential amplifier – making R_6 at the non-inverting terminal slightly lower in value than R_7 which is connected to the inverting terminal – the reduced common-mode rejection works against the temperature coefficient of the standing voltage on the transducer.

Second-order scaling errors are simply rectified by using the total voltage developed across the top and bottom of the bridge as the voltage reference for the d.v.m. The internal bandgap reference in the module is left out of circuit. More volts across the bridge means more volts for a given pressure change. Since indicated voltage on the d.v.m. is inversely proportional to reference voltage, the correction is absolute.

Only one more correction remains. Reverse c.m.r. provides near perfect compensation for the transducer but resistor R_6 through which the offset current flows also has a temperature coefficient. This is taken care of by resistor R_{13} and silicon diode chain D_1 to D_3. The value for this chain was found empirically and depends on the resistor type used for R_6. Uncorrected, a metal oxide component contributed about a 200ft reading error over a 30°C temperature change.

As a general point the circuitry associated with the transducer requires use of a temperature-stable supply voltage over the life of the battery. The regulator circuitry comprising current source, Zener D_5 and series pass transistor offers far better stability than the standard three-terminal regulator.

Practical considerations

The prototype, built on Veroboard, occupies a black ABS box measuring 3¼ by 2½ by 1½in. It uses a DP200 module available from Lascar Electronics Ltd, of Module House, Whiteparish, Salisbury. SP5 2SJ. Resistors should be of high stability, metal oxide construction.

The design requires good quality trimmers for the variable resistors; I suggest either cermet or, if size is no object, multiturn types. A 240 degree moulded-track component for "calibrate", together with a pointer knob enables a barometric subscale to be calibrated and marked on the instrument. Alternatively, a further d.v.m. display measuring the voltage between the slider and a static resistor chain could provide direct l.c.d. of barometric pressure setting.

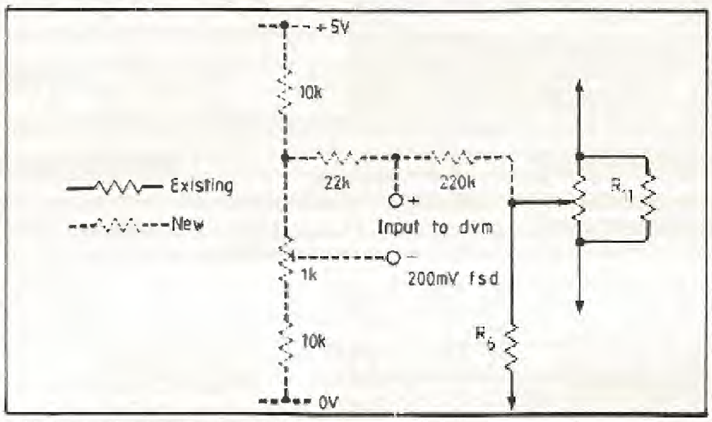
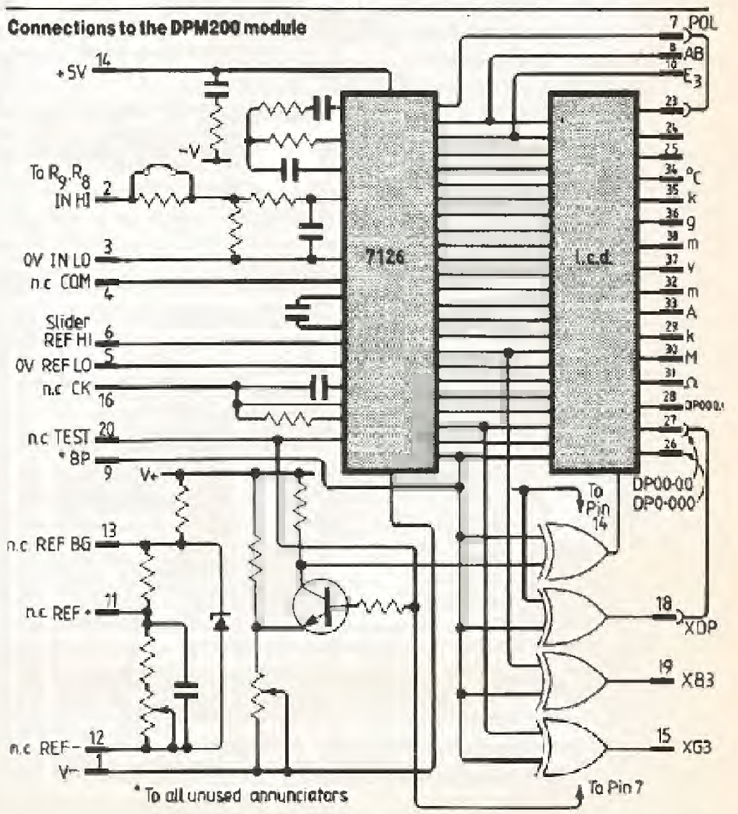


Fig.2. An extra d.v.m. module to read barometric pressure setting may be added with this additional circuitry.

Yet another alternative for the barometric pressure setting would be to use a cmos analogue switch (4016) to put the module in either the barometric pressure set or altitude-read mode. Figure 2 shows the general arrangements for barometric pressure display.

The whole instrument draws 10mA at 6 to 9V. An 8.4V nominal PP3 size NiCd battery, which also fits into the ABS case, provides about 10 hours of continuous use before recharge is necessary.

Hermetic sealing of the instrument in its case is neither necessary or desirable! Tight sealing except for a tiny pinhole will invite internal condensation. The (mostly) low impedance circuitry appears fairly resistent to the odd shower or flying through a bit of cloud. It is a sensible precaution to cover all tracks and components with a liberal smearing of silicone grease. Happy landings.

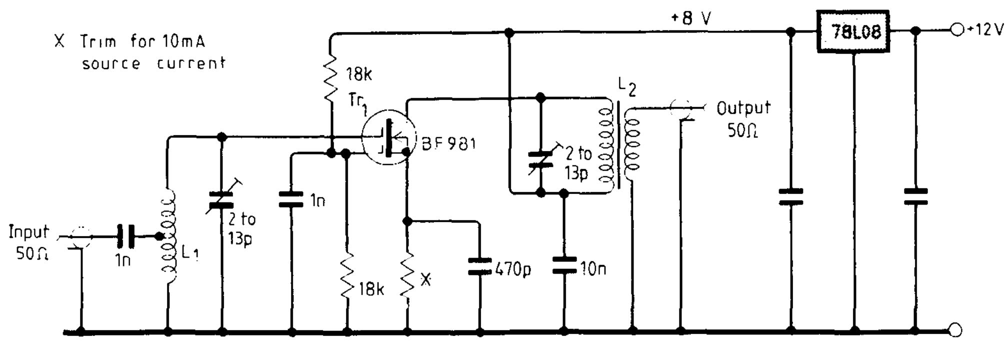


Low-noise v.h.f. pre-amplifier

by R.A. Sansoni

This circuit, designed for Amsat-UK as a 145MHz pre-amp for Oscar-10 working, is very tolerant of modification.

Bob Sansoni is a consultant engineer specializing in satellite tv receiving installations. In his spare time, as G4MWR, he is also interested in amateur and meteorological satellites.



The design requirements for this pre-amplifer were a gain of 15dB or more, a noise figure below 1dB and a simple and reliable construction technique capable of withstanding the weather. I also planned to keep the cost of components below £10.

There is a wide variety of seemingly suitable r.f. transistors, at a wide range of prices. My first choice was the NE41137, which offers a gain of 20dB at 900MHz and a noise figure of 1.3dB. Many 'black box' manufacturers use this device at 432MHz. But its price (£4.50) seemed rather high and it was not very tolerant of mishandling or of high r.f. levels (as I found to my cost). Since the prototype was to be used in conjunction with a 40W transmitter, some elaborate coaxial relays would have been needed to protect it.

After further research I came upon the BF981 dual-gate mosfet, which gives around 18dB gain and 0.7dB noise at 200MHz, all for a price of only 85p. To my delight I found the circuit simple, effective and also very tolerant of modifications.

In addition, the device seemed more durable. I have been using this pre-amp in a sealed die-cast box at the masthead for a year with no measurable deterioration in its performance.

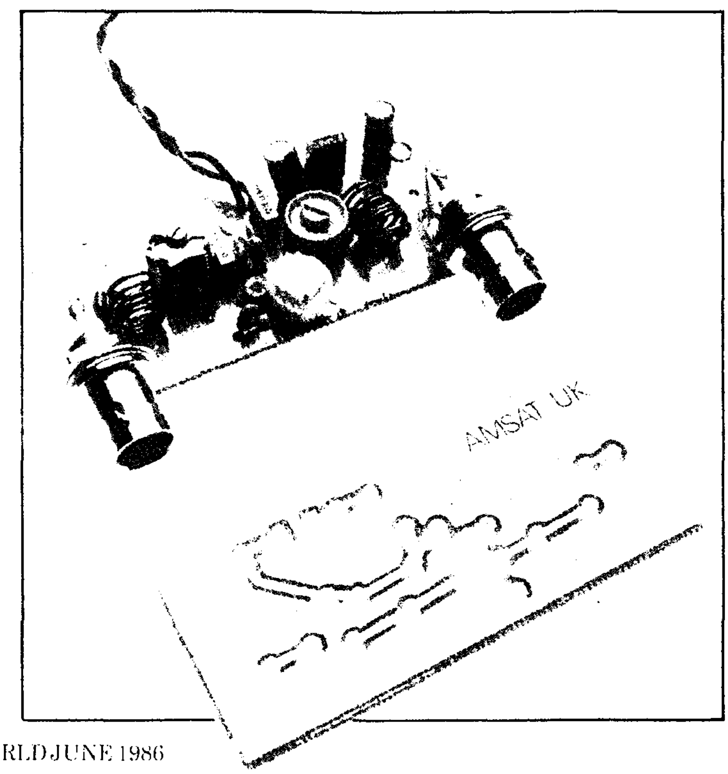
Construction

The preamplifier is built on a double-sided copper-clad board. To provide a ground-plane the component side is left unetched. All leads through the board to earth should be soldered both top and bottom; others should have the drilled hole chamfered to avoid shorting.

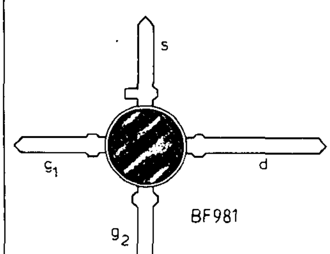
Coils are of 22sw.g. wire wound on a 6mm diameter former: L_1 has six turns, tapped one turn from the cold end; L_2 has six turns; and L_3 three turns.

The last piece to be soldered in should be the BF981. Its leads should be as short as possible.

For best results you should install the unit at the mast-head to overcome losses in the downlead. It is small enough, however, to fit inside most 2m transceivers.



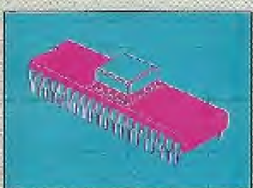
Typical noise figure quoted by the BF981's manufacturer is 0.7dB at 200MHz. The 8V regulator reduces gain to 15dB but helps maintain stability.



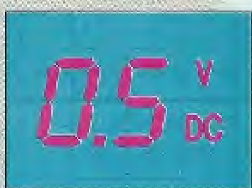
A ready-made p.c.b. for this design is available by post at £2 plus postage from Amsat-UK, 94 Herongate Road, London E12 5EQ. Amsat is a non-profit-making body: please enclose a stamped self-addressed envelope or an international reply coupon with any enquiry.

THE SMART SCOPE

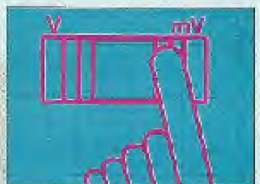
The new face of 50 Mhz 'scope technology



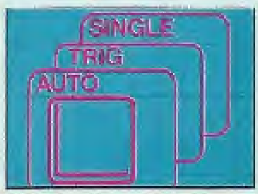
Autoset. PM 3050's green button gives instant, fully automatic setting of all parameters.



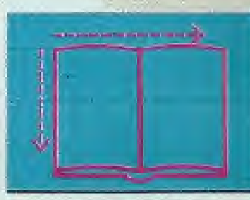
LCD panel. At-a-glance indication of instrument settings, parameter values and selected control key functions.



Up/down. Todays technology for fast input of amplitude and time settings.



Multifunction softkeys. Simple panel layout and menu makes operation quick and easy.



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CIRCLE 38 FOR FURTHER DETAILS

Relativity simplified

by M.H. Butterfield

Whilst aiming to demystify relativity, Prof. Butterfield suggests a basis for explaining many phenomena concerning light and matter

Michael Butterfield works on the system dynamics and control at UKAEA, Winfrith, and is a visiting professor in the School of Electrical Engineering and Applied Physics, City University, London.

This simple and unusual approach requires barely A-level mathematics. Starting from the premise that energy has mass, it rederives Einstein's results for clocks and measuring rods in practical terms without making any assumption about light; it explains the existence of light and the various forms of action at a distance via an 'Impact theory'. This approach leads to the concept of a 'spatially distributed single event' which provides a realistic basis for a theory of matter akin to quantum mechanics.

The early Theory of Relativity has changed remarkably little since its early presentation by Einstein[1]. The theory is widely thought difficult to swallow since the basic assumption that the speed of light 'c' is the same irrespective of relative motion of the source and the observer, goes against common sense; "You cannot add to a velocity and get back the original velocity". The fact that the famous law of addition of velocities that is derived from Einstein's Theory, namely

$$w=\frac{u+v}{1+\frac{uv}{c^2}}, \qquad (1)$$

reduces to the usual $w = u+v$ when u and v are small and yields $w = c$ when $u = c$ for any v, is regarded simply as demonstrating that the algebra is consistent but not as answering the problem.

Basic kinematics – mass and energy

We can take the mystery out of relativity if we start again with traditional Newtonian concepts plus a law stating that 'energy has inertial mass'. This is a much more reasonable proposition to accept than the usual one about the absolute nature of the speed of light. We argue that if something increases its energy by virtue of motion, heat content etc., its mass will also increase and it will require a greater force to accelerate it. The idea of conservation of energy and mass is satisfied if the increase of mass is directly proportional to added energy, that is

$$\begin{pmatrix}\text{mass}\\ \text{increase}\end{pmatrix}=(\text{constant}, \lambda)\times\begin{pmatrix}\text{energy}\\ \text{increase}\end{pmatrix}$$

On the basis that nature is essentially simple we use this very simple relationship.

Suppose we take any object, for example a brick, of mass m_0, place it (at rest) on a long smooth straight table and apply a constant force F to accelerate it along the table. When the brick has moved a distance x the force will have done work Fx on it equal to the increase in kinetic energy. This increase of energy Fx appears as an increase in mass λFx; the brick gets more massive and its acceleration reduces. According to Newton, force is rate of change of momentum, so

$$F=\frac{d}{dt}\left[m\frac{dx}{dt}\right]=\frac{d}{dt}\left[(m_0+F\lambda x)\frac{dx}{dt}\right] \qquad (2)$$

This equation is easily solved for x as a function of time and gives position,

$$x=\frac{-m_0+\sqrt{m_0^2+F^2\lambda t^2}}{F\lambda},$$

and speed,

$$u=\frac{dx}{dt}=\frac{Ft}{\sqrt{m_0^2+F^2\lambda t^2}} \qquad (3)$$

Consider now the two laboratories L_1 and L_2 moving with relative velocity V and both observing the same brick under prolonged acceleration. Even if the accelerating force is different according to L_1 and L_2 we conclude that both will observe the brick to approach the same asymptotic speed $c = 1/\sqrt{\lambda}$. Hence we have the situation that c + v gives c! Notice that the concept of light has not yet been introduced, nor the principle of relativity, except as it is embodied in Newtonian mechanics.

Light and the 'Impact theory'

The previous section explained that as the clock is accelerated relative to L_1 it is observed to go more slowly according to equation 6. Ultimately on approaching the velocity c its mass would become infinite and it would cease to go round. As seen by L_1, any two events (x_1, t_1),(x_2, t_2) on the path of the moving clock at the origin of L_2 are such that

$$x_1-x_2=c(t_1-t_2).$$

But as seen by L_2

$$x_1'=x_2'=0 \text{ and } t_1'-t_2'=0.$$

Both events are at its origin. Hence in the limit according to L_2 spatial separation is zero and time separation zero: they are the same event!

A photon of light is considered to be a particle of zero rest mass moving at speed c, hence the two points on its track corresponding to its creation and absorption are the same event as observed by the photon. Consider for example the photon created as an electron in a lamp filament is slowed. It is seen at a photocell by knocking out another electron. According to our analysis the emission and absorption of the photon are the same event. The energy exchange can therefore be regarded as a "Direct impact" between the electron in the lamp filament and the electron at the sensor. The whole history of the photon is one event!

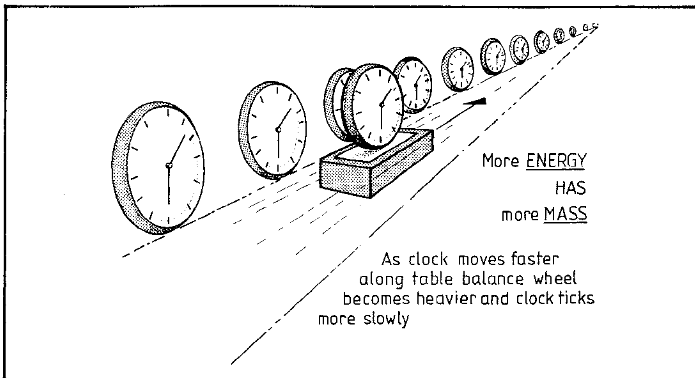
Simultaneity and measuring rods

It is essential to understand that the length of any object must be defined in terms of simultaneous measurements at the ends. It is therefore necessary to be clear what is meant by simultaneity or synchronizing clocks. This is another area of misunderstanding in writings on relativity.

The experiementer in L_1 synchronizes identical clocks at A and B by sending a pulse of light from A to B and reflecting it back to A. Then half time between start and finish at A is attributed to the reading of the clock at B when the reflection took place. In this way any number of stationary clocks can be synchronized in the system fully consistently.

The experimenter in L_2 moving at speed v relative to L_1 would go through similar procedures for clocks fixed in the frame. While the experimenter sends a signal forward from C to D which is reflected back to C in L_2, the position of C in L_1 moves. Hence according to L_1 the length of the first leg from C to D is greater than the return distance from reflection at D back to C. Since (as we have established) the speed of light is constant in L_1, L_1 registers the reflection at D after half time. Measuring the length CD, L_1 will see it to be shorter than L_2 since L_1 registers the simultaneous position of D with half time somewhat earlier than L_2. This foreshortening corresponds to the Fitzgerald contraction (ref.2) which was subsequently explained by relativity theory and this analysis also shows the length ratio to be $(1-v^2/c^2)^{1/2}$.

Notice that this result is consistent with the effects of motion on clocks described earlier. Since L_1 sees a measuring rod in L_2 as shortened, its ends will pass a point in L_1 more quickly than if the rod had its full length. Alternatively, as explained earlier for a series of events at a fixed point in L_1, L_1 will record a shorter time interval than L_2, which is a consistent result. This foreshortening is also consistent with the direct impact experienced by a photon, since at the speed c, the photon sees everything else foreshortened to zero length.



This result has the remarkable property that as t becomes very large the speed tends to $Ft/\sqrt{F^2\lambda t^2} = 1/\sqrt{\lambda}$ but this speed is never actually reached. This limiting speed is independent of the initial mass of the brick or the force applied to it, i.e. no material body can be taken beyond (or even quite up to) the speed $1/\sqrt{\lambda}$. If we call this limiting speed c then $\lambda = 1/c^2$ and therefore

$$\begin{pmatrix}\text{energy}\\ \text{increase}\end{pmatrix} = \begin{pmatrix}\text{mass}\\ \text{increase}\end{pmatrix} \times c^2 \quad (4)$$

Now since (3a) and (3b) give

$$1 - \frac{u^2}{c^2} = \frac{m_0^2}{m_0^2 + F^2\lambda t^2} = \frac{m_0^2}{(m_0 + F\lambda x)^2}$$

and $m = m_0 + F\lambda x$ as in (2), we get Einstein's formula:

$$m = \frac{m_0}{\left(1 - \frac{u^2}{c^2}\right)^{1/2}}. \quad (5)$$

This mass, m, is what an experimenter standing by the side of the long table would measure by displacing the brick sideways, for example.

Time and relative motion

Suppose now the experimenter made a batch of identical clocks with balance wheels of rest mass m_0 and subjected one of them to the accelerating force F. The balance wheel of the moving clock would become more massive as the speed along the table increased and this would alter its observed timing. In practical terms we arrange for the moving clock to spark and burn a hole in the table every time the balance wheel goes through the central position. These 'events' are then timed using the stationary clocks synchronized by conventional means, for example by sending signals or projectiles back and forth.

To quantify the motion of a spring and balance wheel requires relativistic knowledge which we do not have at this stage of the argument. But we can use a simpler mechanism since, by Newton's Laws of Motion, the time spacing must be consistent with a simple disc rotating about an axis parallel to its motion on a frictionless bearing. The mass and hence the moment of inertia of the disc both increase with speed according to equation 5. To maintain constant angular momentum the rate of rotation must therefore reduce as the speed u along the table increases. If the disc made a mark on the bench every time it completed a revolution, the time interval between rotations would increase as the disc moved faster along the table. Hence as seen by the experimenter

$$\begin{pmatrix}\text{time}\\ \text{interval}\end{pmatrix} = \frac{\begin{pmatrix}\text{time}\\ \text{interval}\end{pmatrix}_{u=0}}{\left(1 - \frac{u^2}{c^2}\right)^{1/2}} \quad (6)$$

If the force F is removed on reaching speed u the subsequent motion will be uniform and the speed u of the brick or clock could have been reached via any appropriate history.

Consider now the situation as observed by a second laboratory L_2 moving with constant speed u relative to the first laboratory L_1. The disc was initially travelling backwards at speed u relative to L_2; as seen by L_2 it has been brought to rest by a deceleration force, given up its translational kinetic energy and now has rest mass m_0. Again we can consider the rotating disc marking both tables as it completes each revolution. Initially when the disc is at rest in L_1 it will give spark time intervals T_0 and $T_0(1-u^2/c^2)^{1/2}$ observed by L_1 and L_2 respectively, but when at rest in L_2 the situation is reversed. Hence a clock which is stationary in L_1 appears slow to L_2 and a clock fixed in L_2 appears slow to L_1. These are two different series of events, there is no inconsistency as often presented to provide a *reductio ad absurdum* argument against Einstein's theory of relativity. Both observers see time behaving the same way. It is not the case that clocks are going both faster and slower.

Conclusions to be drawn

1. The existence of light and the absolute nature of its velocity c and the time and space properties of the Lorentz transformation follow directly using Newtonian mechanics from the simple proposition that energy had inertial mass.
2. Along a path covered at the speed c all events are the same and the two ends constitute an 'impact' in that frame of reference. This provides an explanation for electromagnetic radiation and other actions at a distance at the speed of light.
3. Frames of reference with velocity c provide a mechanism whereby every particle in the universe can interact directly with every other particle. While this may seem far-fetched we know that it occurs in universal gravitation. An explanation for gravitational attraction may lie in the notion that the further apart the interacting particles are the more energy is expected to be in transit as we view it; and if the energy of a system increases as particles are separated this shows as an attraction.
4. Since energy is conserved, this continual exchange between all particles may be the mechanism that makes universal constants universal.
5. The idea that the space-time track of a photon is one event yields the concept of a 'spatially distributed single event'. It is not reasonable to consider a fundamental particle such as an electron as a point. The concept evolved here enables an interaction with another particle to occur throughout both as one event. The concept therefore promotes a theory of matter akin to quantum mechanics.
6. The concept of a spatially distributed single event rationalizes interference phenomena. If, as it seems it must, the photon goes through both parallel slits then it is not obviously a single quantum! We can follow the ideas presented by Feynman in ref.3 and consider all the conceptually possible paths collectively as constituting one distributed event. We say that the passages through both slits in the interference experiment are parts of one event and any experiment that we perform to look at this will participate in the event.
7. While the 'Impact theory' describes light as 'corpuscular', it also offers a possible explanation for light to have a wave nature at the same time. According to quantum mechanics particles are subject to a quantization of angular momentum or spin reversal of $h/2\pi$. If we can establish that absorption of light entails spin reversal then the 'Impact' or photon of light as we observe it will have angular momentum $h/2\pi$. If we attribute moment of inertia I and angular velocity $\omega = 2\pi\upsilon$ to the photon then it has rotational energy:

$$\tfrac{1}{2}I\omega^2 = \tfrac{1}{2}(I\omega)\omega = \tfrac{1}{2}.\frac{h}{2\pi}.\,2\pi\upsilon = \tfrac{1}{2}h\upsilon.$$

The fore-shortening phenomenon and a single-entity concept for the photon leave open the argument that the photon has only two degrees of freedom (rotation about and translation along its line of motion). If the total energy is equally partitioned we explain the required factor of two to deduce $E = h\upsilon$.

8. A different type of 'Impact' or photon (for example with different or zero angular momentum) would not be absorbed by intervening matter in the same way as in point 7. This could explain the difference in character between electromagnetic radiation and gravitation which is not influenced by intervening matter.

References

1. The Meaning of Relativity, by A. Einstein. Methuen, 1922.
2. Spare Time and Gravitation, by A.S. Eddington. CUP, 1923.
3. Quantum Mechanics and Path Integrals, by R.P. Feynman and A.R. Hibbs. McGraw-Hill, 1965.

Events

May 23
Use of personal computers in control systems, IEE Colloquium at the Institution of Electrical Engineers. Details from IEE, Savoy Place, London WC2R 0BL. Tel: 01-240 1871 Ext. 269.

May 27
Mass storage devices for computers. IEE Colloquium. Details from IEE as above.
UK Skynet IV satellite. IEE Lecture. Details from IEE as above.

May 28
Test equipment for optical communications systems. IEE Colloquium. Details from IEE as above.

May 29
Opitcal modulators. IEE Colloquium. As above
Automated NDT data reduction. IEE Colloquium. As above Hertz and Randall – pioneers of radiation. IEE Lecture.

May 30
Solid State microwave power generation. IEE Colloquium. Details from IEE as above.

June 3 to 5
Advanced infrared detectors and systems. Third International Conference at Savoy Place. Details from IEE as above.

June 10 to 12
Networks 86. International computer communications conference and exhibition. Wembley Conference Centre, London. Details from Online International. Tel: 01-868 4466.

June 24 to 26
Image processing and its applications. IEE and others International conference at Imperial College, London. Details from IEE, as above.
Broadcast 86. International trade fair for film, radio and tv. Messe Frankfurt. Tel: (069) 7575 458.

July 1 to 3
KBS 86; International conference and exhibition on knowledge based systems. Wembley Conference Centre. Details from Online as June 10. Voice processing. Conference at Wembley Conference Centre. Online, as above.

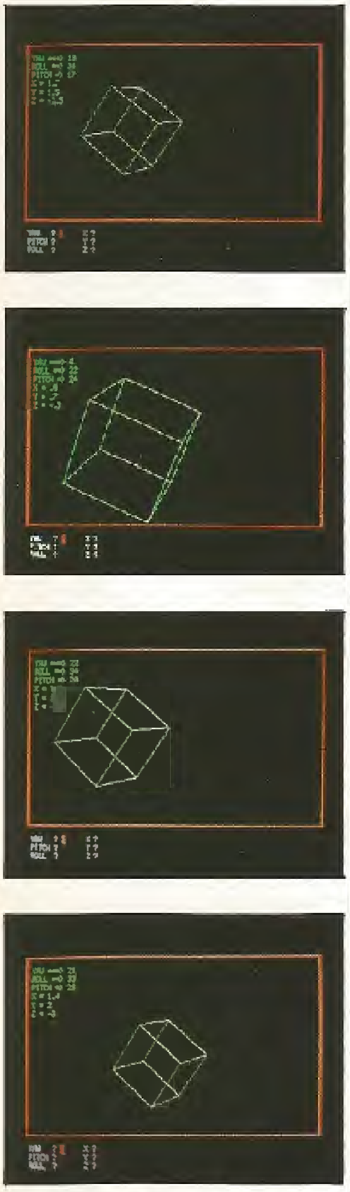
July 1 to 4
Radio receivers and associated systems. IERE/IEE Conference at University of N. Wales, Bangor. Details from IERE. Tel: 01-388 3071.

July 8 to 10
Cable 86. Brighton Metropole Hotel. Details from Online.

by Hugh Gleaves

An introduction to 3D graphics

Software for producing wire-frame objects in perspective using the QL microcomputer



Wire-frame cube constructed and manipulated using the 3D graphics program.

Last month's article discussed the theory of producing three-dimensional images using a microcomputer. This software is an example of how that theory is implemented in Super Basic on the QL microcomputer.

Using the program

The entire program is constructed from three major Superbasic procedures, ERASE, SETUP, and VIEW.

ERASE. Once you have loaded the program into the QL, you should enter ERASE to invoke the ERASE procedure. The procedure dimensions all arrays used to hold the 3D a.e. This effectively deletes any previous environment arrays.

SETUP. Whenever the command SETUP is entered, it invokes the SETUP procedure which examines the present 3D a.e. and makes arrangements to insert any new data in its logical place. It then presents a series of screens to the user, requesting various forms of environment data.

The first screen asks you how many bodies you are going to add to the 3D a.e. The second screen then tells you the position in the 3D a.e. of the next body you are going to define and asks for the number of polygons in this body. It then asks you for the polygon number for each of these polygons. The third screen then asks for details concerning each of the new polygons in the new body, i.e. number of vertices and vertex number for each vertex of this polygon.

When this is finished, screen four will ask for x, y and z coordinates for each undefined vertex in each polygon. Once this task is complete the procedure tells you so and ends automatically.

VIEW. This procedure is the heart of the graphics program and is responsible for drawing the perspective image on the screen and obtaining camera commands. Once you have used SETUP to define a body, you should enter VIEW. This places the camera at position $x=0$, $y=0$ and $z = -10$, while setting YAW, PITCH and ROLL, all to zero. The view from this position will then be drawn together with a table of your position.

The bottom of the screen is used to enter various camera commands for changing position and/or orientation. If you do not want to change a particular parameter then simply press enter to skip to the next.

When you have been through all six parameters, the program calculates the changed parameters and draws the new view. You can break into the program and update the 3D a.e. at any time and then reenter VIEW. You should avoid using a break while you are in SETUP though, as if SETUP is not allowed to finish its job, corruption to the 3D a.e. may occur.

Software notes

The task being performed can be performed by any microcomputer with a line drawing facility. I have endeavoured to make the software modular and structured, with each module clearly annotated.

Superbasic is an enhanced version of BBC Basic, and the two have many features in common. Procedures, i.e. subroutines, are invoked merely by the appearance of their name.

For example the identifier APPLY-YAW when encountered during execution causes a call to the yaw application procedure which on completion causes a return to the statement following APPLY-YAW. BBC Basic is similar, except that procedure names must be prefixed by 'PROC' both in their definition and invocation.

Keyword LINE, is a built in procedure that allows a line to be drawn on the screen from point x_1, y_1 to x_2, y_2 as follows

LINE x_1, y_1 to x_2, y_2

Here, x and y are the numeric identifiers.

Keyword AT is an improved version of TAB, and the PRINT or INPUT cursor can be positioned anywhere on the screen using AT line, column. This allows full control over displaying and entering data.

In my opinion, SuperBasic facilities are far more sensible and less idiosyncratic than those of the BBC microcomputer. Drawing a line on the BBC computer involves extra parameters and codes and the SuperBasic version of the graphics software is far more readable to the novice than would be an equivalent implementation on the BBC computer.

Further reading

Real time 3D graphics for microcomputers, Marcus Newman, *Byte*, Sep. 1984, p251.

Computer images, Joseph Deken, Thames and Hudson, contains many photographs of state-of-the-art 3D graphics.

The universal encyclopedia of mathematics, Pan, contains a useful treatment of coordinate transformations.

Principles of interactive computer graphics, W.M. Newman and R.F. Sproull, ISBN 0 07 066455 2.

Software in QL Basic for producing and manipulating 3D wire-frame objects.

This program, and a more advanced one including features such as colouring and hidden-face removal – subjects of Hugh's next article – can be obtained by sending £3 and a blank QL tape or £5 to Hugh Gleaves, PO Box 594, Muswell Hill, London N10 3PF.

```
220 REMark ************************************************************
230 REMark * THIS IS THE MAIN PROCEDURE 'SETUP'. IT IS INVOKED WHEN THE  *
240 REMark * USER WISHES TO ADD ONE OR MORE BODIES TO THE PRESENT 3DAE.  *
250 REMark * WHEN INVOKED THE PROCEDURE WILL LOCATE THE NEXT FREE ENTRY  *
260 REMark * IN THE 3DAE , AND INSERT THE DATA FOR THE NEW BODY/BODIES.  *
270 REMark ************************************************************
280 :
290 DEFine PROCedure SETUP
300  DEFINE_DATA_BASE
310  FOR BODY_NO = START_BODY TO END_BODY
320       DEFINE_BODY(BODY_NO)
330       LIMIT = BODY%(BODY_NO,0)
340       FOR I = 1 TO LIMIT
350            DEFINE_POLYGON(BODY%(BODY_NO,I))
360       END FOR I
370       FOR I = 1 TO LIMIT
380            VERTEX_LIMIT = POLY%(BODY%(BODY_NO,I),1)
390            FOR J = 1 TO VERTEX_LIMIT
400                 DEFINE_VERTEX(POLY%(BODY%(BODY_NO,I),J+1))
410            END FOR J
420       END FOR I
430  END FOR BODY_NO
440  LAST_SCREEN
450 END DEFine
460 :
470 REMark ************************************************************
480 REMark * THIS PROCEDURE IS INVOKED IN ORDER TO RE-CREATE THE ARRAYS  *
490 REMark * USED TO STORE THE DATA-BASE, ITS INVOCATION WILL RESULT IN  *
500 REMark * THE COMPLETE DELETION OF THE PRESENT 3DAE.                  *
510 REMark * THE PRESENT ARRAY BOUNDS ARE NOT CRITICAL.                  *
520 REMark ************************************************************
530 :
540 DEFine PROCedure ERASE
550  DIM BODY%(10,20)
560  DIM POLY%(100,10)
570  DIM VERTEX(1000,2)
580  DIM DEFINED(1000)
590 END DEFine
600 :
610 REMark ************************************************************
620 REMark * THIS PROCEDURE QUERIES THE USER FOR THE NUMBER OF BODIES HE *
630 REMark * WISHES TO ADD TO THE EXISTING 3DAE, AND ALSO DETERMINES THE *
640 REMark * START AND END BODY NUMBERS , FOR THESE BODIES IN THE 3DAE.  *
650 REMark ************************************************************
660 :
670 DEFine PROCedure DEFINE_DATA_BASE
680  MODE 8 : PAPER 1 : INK 7 : CLS : BORDER 3,2 : PAUSE 40
690  AT 1,1 : PRINT 'YOU ARE DEFINING THE 3DAE.'
700  AT 3,6 : PRINT 'HOW MANY BODIES'
710  AT 4,6 : INPUT 'DO YOU WISH TO ADD ? ';ADD_NUMBER
720  START_BODY = BODY%(0,0) + 1
730  END_BODY   = START_BODY + (ADD_NUMBER - 1)
740  BODY%(0,0) = END_BODY
750 END DEFine
760 :
770 REMark ************************************************************
780 REMark * THIS PROCEDURE ALLOWS THE USER TO DESCRIBE A BODY IN TERMS  *
790 REMark * OF ITS FACES, WHICH ARE REFFERED TO AS POLYGONS.            *
800 REMark ************************************************************
810 :
820 DEFine PROCedure DEFINE_BODY(No)
830  LOCal I : LOCal POLY_No : CLS : PAUSE 40
840  AT 1,1 : PRINT 'YOU ARE DEFINING BODY NUMBER '&No
850  AT 2,6 : INPUT 'HOW MANY POLYGONS ? '; POLY_No
860  BODY%(No,0) = POLY_No
870  AT 3,6 : PRINT 'THESE ARE :-'
880  FOR I = 1 TO POLY_No
890       AT 4,6 : PRINT 'POLYGON No
900       AT 4,17 : INPUT BODY%(No,I)
910  END FOR I
920 END DEFine
930 :
940 REMark ************************************************************
950 REMark * THIS PROCEDURE ALLOWS THE USER TO DESCRIBE THE STRUCTURE OF *
960 REMark * EACH POLYGON IN A GIVEN BODY, IN TERMS OF ITS VERTEX No's.  *
970 REMark ************************************************************
980 :
990 DEFine PROCedure DEFINE_POLYGON(No)
1000  LOCal I :  LOCal VERT_NO : CLS : PAUSE 40
1010  AT 1,1 : PRINT 'YOU ARE DEFINING POLYGON '&No
1020  AT 2,6 : INPUT 'HOW MANY VERTICES ? ';VERT_NO
1030  POLY%(No,1) = VERT_NO .
1040  AT 3,6 : PRINT 'THE VERTEX Nos ARE :-'
1050  FOR I = 1 TO VERT_NO
1060       AT 4,6 : PRINT 'VERTEX NUMBER
1070       AT 4,20 : INPUT POLY%(No,I+1)
1080  END FOR I
1090 END DEFine
1100 :
1110 REMark ************************************************************
1120 REMark * THIS PROCEDURE ALLOWS THE USER TO DEFINE EACH VERTEX IN     *
1130 REMark * THE BODY.  THE USER IS ASKED TO SUPPLY THE 3 DIMENSIONAL   *
1140 REMark * CARTESIAN CO-ORDINATES OF THE POINT IN THE 3DAE SPACE.      *
1150 REMark ************************************************************
1160 :
1170 DEFine PROCedure DEFINE_VERTEX(No)
1180  IF DEFINED(No) THEN RETurn
1190  CLS : PAUSE 40
1200  AT 1,1 : PRINT 'VERTEX DEFINITION'
1210  AT 3,6 : PRINT 'YOU ARE DEFINING VERTEX No '&No
1220  AT 4,6 : PRINT "ENTER IT's CO-ORDINATES"
1230  AT 5,8 : INPUT 'X = ';VERTEX(No,0)
1240  AT 6,8 : INPUT 'Y = ';VERTEX(No,1)
1250  AT 7,8 : INPUT 'Z = ';VERTEX(No,2)
1260  DEFINED(No) = 1
1270 END DEFine
1280 :
1290 REMark ************************************************************
1300 REMark * THIS PROCEDURE SIMPLY INFORMS THE USER THAT THE TASK OF    *
1310 REMark * SETTING UP THE 3DAE IS COMPLETED.                           *
1320 REMark ************************************************************
1330 :
1340 DEFine PROCedure LAST_SCREEN
1350  CLS : PAUSE 40
1360  AT 1,1 : PRINT 'YOU HAVE FINISHED DEFINING '
1370  AT 2,1 : PRINT 'ALL THE BODIES.
1380 END DEFine
1390 :
1400 REMark ************************************************************
1410 REMark * THIS PROCEDURE ALLOWS THE USER TO VIEW THE ENTIRE 3DAE IN  *
1420 REMark * PERSPECTIVE. THE 3DAE SHOULD PREVIOUSLY HAVE BEEN BUILT BY *
1430 REMark * USING THE PROCEDURE 'SETUP'.                                *
1440 REMark * THIS PROCEDURE PROMPTS THE USER FOR CAMERA COMMANDS, SEE    *
1450 REMark * THE FULL ARTICLE FOR DETAILS.                               *
1460 REMark ************************************************************
1470 :
1480 DEFine PROCedure VIEW
1490  REMark ************************************************************
1500  REMark * FIRST SET THE DEFAULT POSITION & ORIENTATION, FOR THE      *
1510  REMark * VIEWER. AND THEN DISPLAY (IN PERSPECTIVE) ALL THE BODIES. *
1520  REMark ************************************************************
1530  :
1540  YAW = 0 : PITCH = 0 : ROLL = 0
1550  COS_YAW = 1 : COS_PITCH = 1 : COS_ROLL = 1
1560  SIN_YAW = 0 : SIN_PITCH = 0 : SIN_ROLL = 0
1570  Cx  = 0 :  Cy  = 0 :  Cz  =  -10 : D = 5
1580  MODE 4 : PAPER 0 : INK 4 : BORDER 2,2 : SCALE 2,-1.6,-1
1590  REPeat VIEWING_LOOP
1600   CLS
1610   TOTAL_BODIES = BODY%(0,0)
1620   FOR B = 1 TO TOTAL_BODIES
1630        DISPLAY_BODY (B)
1640   END FOR B
1650   GET_USER_COMMAND
1660  END REPeat VIEWING_LOOP
1670 END DEFine
1680 :
1690 REMark ************************************************************
1700 REMark * THIS PROCEDURE TAKES A BODY NUMBER, AND THEN PERFORMS THE  *
1710 REMark * REQUIRED PROCESSING TO DISPLAY THE BODY IN PERSPECTIVE.    *
1720 REMark ************************************************************
1730 :
1740 DEFine PROCedure DISPLAY_BODY(No)
1750  TOTAL_POLYS = BODY%(No,0)
1760  FOR P = 1 TO TOTAL_POLYS
1770       DISPLAY_POLY (BODY%(No,P))
1780  END FOR P
1790 END DEFine
1800 :
1810 REMark ************************************************************
1820 REMark * THIS PROCEDURE TAKES A POLYGON NUMBER, AND THEN DRAWS THE  *
1830 REMark * POLYGON IN PERSPECTIVE .                                    *
1840 REMark ************************************************************
1850 :
1860 DEFine PROCedure DISPLAY_POLY(No)
1870  TOTAL_VERTICES = POLY%(No,1)
1880  FOR V = 1 TO (TOTAL_VERTICES - 1)
1890       PROCESS_VERTEX  POLY%(No,(V + 1)),I,J
1900       PROCESS_VERTEX  POLY%(No,(V + 2)),M,N
1910       LINE I,J TO M,N
1920  END FOR V
1930  PROCESS_VERTEX POLY%(No,2),I,J
1940  LINE I,J TO M,N
1950 END DEFine
1960 :
1970 REMark ************************************************************
1980 REMark * THIS MODULE, IS USED TO PERFORMS ALL THE MATHEMATICAL      *
1990 REMark * TRANSFORMATIONS NEEDED TO PRODUCE THE PERSPECTIVE IMAGE OF *
2000 REMark * A GIVEN VERTEX.                                             *
2010 REMark ************************************************************
2020 :
2030 DEFine PROCedure PROCESS_VERTEX(No,Sx,Sy)
2040  LOCal X : LOCal Y : LOCal Z
2050  TRANSLATE (No)
2060  APPLY_YAW
2070  APPLY_PITCH
2080  APPLY_ROLL
2090  Sx = PERSPECTIVE(X)
2100  Sy = PERSPECTIVE(Y)
2110 END DEFine
2120 :
2130 REMark ************************************************************
2140 REMark * THE FOLLOWING FIVE PROCEDURES PERFORM THE FIVE SEPERATE     *
2150 REMark * OPERATIONS REQUIRED FOR 3-D IMAGE PROCESSING.               *
2160 REMark ************************************************************
2170 :
2180 DEFine PROCedure TRANSLATE(No)
2190  X = VERTEX(No,0) - Cx
2200  Y = VERTEX(No,1) - Cy
2210  Z = VERTEX(No,2) - Cz
2220 END DEFine
2230 DEFine PROCedure APPLY_YAW
2240  LOCal TX
2250  TX = X * COS_YAW  +  Z * SIN_YAW
2260  Z  = Z * COS_YAW  -  X * SIN_YAW
2270  X  = TX
2280 END DEFine
2290 DEFine PROCedure APPLY_PITCH
2300  LOCal TY
2310  TY = Y * COS_PITCH  +  Z * SIN_PITCH
2320  Z  = Z * COS_PITCH  -  Y * SIN_PITCH
2330  Y  = TY
2340 END DEFine
2350 DEFine PROCedure APPLY_ROLL
2360  LOCal TX
2370  TX = X * COS_ROLL  +  Y * SIN_ROLL
2380  Y  = Y * COS_ROLL  -  X * SIN_ROLL
2390  X  = TX
2400 END DEFine
2410 DEFine FuNction PERSPECTIVE(VALUE)
2420  RETurn (VALUE/(1 + (Z/D)))
2430 END DEFine
2440 :
2450 REMark ************************************************************
2460 REMark * THIS PROCEDURE IS USED TO OBTAIN THE CAMERA CONTROL DATA   *
2470 REMark * FROM THE USER. A NULL ENTRY IS INTERPRETED AS NO CHANGE.   *
2480 REMark ************************************************************
2490 :
2500 DEFine PROCedure GET_USER_COMMAND
2510  CLS #0
2520  AT 1,1 : PRINT 'YAW ===> '&YAW
2530  AT 2,1 : PRINT 'ROLL ==> '&ROLL
2540  AT 3,1 : PRINT 'PITCH => '&PITCH
2550  AT 4,1 : PRINT 'X = '&Cx
2560  AT 5,1 : PRINT 'Y = '&Cy
2570  AT 6,1 : PRINT 'Z = '&Cz
2580  AT #0,1,1 : PRINT #0,'YAW   ? '
2590  AT #0,2,1 : PRINT #0,'PITCH ? '
2600  AT #0,3,1 : PRINT #0,'ROLL  ? '
2610  AT #0,1,15 : PRINT #0,'X ? '
2620  AT #0,2,15 : PRINT #0,'Y ? '
2630  AT #0,3,15 : PRINT #0,'Z ? '
2640  AT #0,1,9 : INPUT #0,YAW$
2650  AT #0,2,9 : INPUT #0,PITCH$
2660  AT #0,3,9 : INPUT #0,ROLL$
2670  AT #0,1,19 : INPUT #0,X$
2680  AT #0,2,19 : INPUT #0,Y$
2690  AT #0,3,19 : INPUT #0,Z$
2700  :
2710  REMark ********************************************
2720  REMark * TEST EACH INPUT FIELD, AND UPDATE ONLY    *
2730  REMark * THOSE ITEMS ENTERED BY THE USER.          *
2740  REMark ********************************************
2750  :
2760  IF YAW$ <> '' THEN
2770     YAW = YAW + YAW$
2780     COS_YAW = COS(RAD(YAW))
2790     SIN_YAW = SIN(RAD(YAW))
2800  END IF
2810  IF ROLL$ <> '' THEN
2820     ROLL = ROLL + ROLL$
2830     COS_ROLL = COS(RAD(ROLL))
2840     SIN_ROLL = SIN(RAD(ROLL))
2850  END IF
2860  IF PITCH$ <> '' THEN
2870     PITCH = PITCH + PITCH$
2880     COS_PITCH = COS(RAD(PITCH))
2890     SIN_PITCH = SIN(RAD(PITCH))
2900  END IF
2910  IF X$ <> '' THEN Cx = Cx + X$
2920  IF Y$ <> '' THEN Cy = Cy + Y$
2930  IF Z$ <> '' THEN Cz = Cz + Z$
2940 END DEFine
```

Using SmartWatch

How to improve your computer's timekeeping with our current special offer

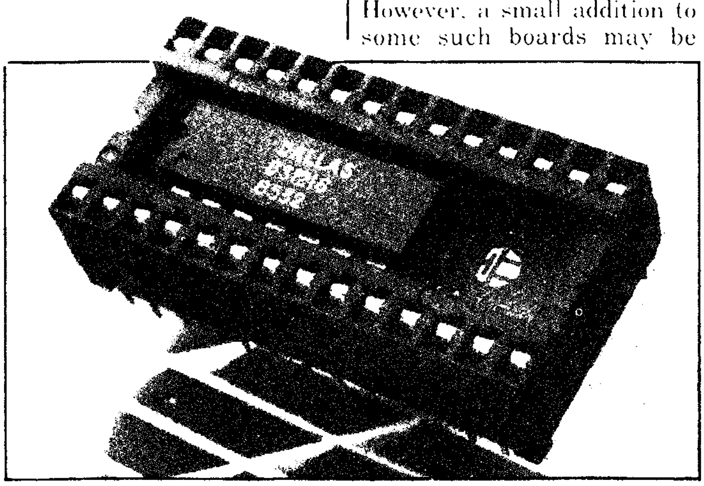
A coupon for ordering SmartWatch at our special price appears on page 67.

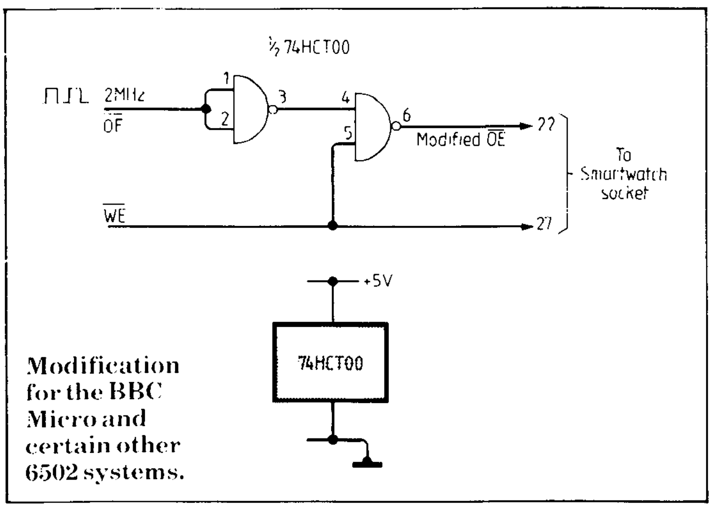
The SmartSocket-SmartWatch application note published by Dallas Semiconductor includes an alternative software listing in 8086 assembly language.

Adding a real-time clock to a microcomputer system equips it for a wide variety of uses in equipment control. And with Dallas Semiconductor's SmartWatch, clock and calendar features can be added to most types of micro with little or no modification of the hardware.

As an example, we show here how to fit SmartWatch to a BBC Micro. For further information about the facilities SmartWatch offers, see page 27 of last month's issue.

The i.c. and its built-in lithium battery are mounted in a 28-pin Jedec socket which also carries an 8K-byte low-power static ram. The module will fit any of the sideways ram/rom expansion boards sold for the BBC machine. However, a small addition to some such boards may be needed to enable the computer to write to SmartWatch.





Modification for the BBC Micro and certain other 6502 systems.

Details of the modification, which may be found necessary in certain other computers, are shown in Fig. 1. Its purpose is to stop the ram's output-enable line (pin 22 of the 28-pin memory socket) going low during write operations – a condition which with ram is illogical. The 74HCT00 may be soldered piggy-back fashion on top of some other small dil device, its unused input pins connected to 0V or 5V. Do not be tempted to substitute a 74C00 or a standard 4000 series c-mos device – these are unlikely to have sufficient drive capability.

Software

The first listing, in BBC Basic and assembler is for setting the clock. To gain access to the clock it is necessary to write an unbroken sequence of 64 initialization bits to the D_0 line of its socket. The sequence is held in the program in packed form as a set of eight bytes which are rotated one at a time and written until every bit has been sent. The same procedure is then used to write eight bytes of time data to the clock, in binary-coded decimal format.

The address we have chosen for write operations is &8008. In the Acorn rom format this location holds a version number which can be disturbed without ill effect.

For reading the clock the initialization sequence is followed by 64 read operations. A suitable arrangement is shown in our second program example, which produces an interrupt-driven date and 24-hour time display in Mode 7.

The program makes use of the vertical sync event of the BBC Micro, a pre-packaged interrupt which occurs every 20ms at the start of each field scan. To keep the interrupt service routine as short as possible the code is split into two parts: a section which reads the clock and stores the b.c.d. time data at eight locations in page zero, and a display routine which formats it and writes it direct to screen memory.

A counter ('flag') is decremented every 20ms by the event handler. When it reaches zero the code branches to the read routine. On the next event, the counter reaches −1 (&FF) and the display routine is called. This routine ends by setting the counter and so fixing the number of events which must occur before the next read operation begins. Since the sync event occurs every 20ms, a value of eight gives five read/display cycles per second.

When the computer is in a display mode other than Mode 7, flag is set to a high value which will ensure that the clock is not accessed. It is certainly possible to use SmartWatch in other screen modes, but the display routine will be slower.

The machine code fills just less than a page and a half of memory: we have put it into the upper half of the soft key buffer and the storage area for characters 224-255 (page &C). But by deleting those parts which form the date display (lines 310-370, 400, 410, 440-460, 1120-1390 and 1760-1950) you can reduce it to under a page; or you can remove the display routine entirely and have your program extract the data direct from page zero.

Starting SmartWatch

SmartWatch is delivered with its oscillator turned off. It can be switched on by writing to one of the device registers. Full details, including logic levels and read/write timing, are given in the data sheet supplied with SmartWatch.

In this application, the reset pin is not used. The pin can be disabled by writing to one of the SmartWatch registers.

```
10 REM     ** Program "WATCHSET.BAS" to set SmartWatch **
20 REM     by Martin Eccles and Richard Lambley
30 REM     Electronics and Wireless World, June 1986
40 DIM unit(8)
50 osrdrm=&FFB9:REM Read byte, add. in F6/F7, romno in Y, data ret. in A
60 socket%=&D :REM number of sideways socket containing Smartwatch
70 SmartWatch=&8008
80 PROCsetwatch:PROCassemble:CALL main:END
90 :
100 DEF PROCsetwatch
110 FORtime%=7 TO 1 STEP -1
120 READ unit$:PRINT"Enter the ";unit$;
130 INPUT""unit(time%):REM Now convert it to b.c.d. format
140 unit(time%)=unit(time%) MOD 10+16*(unit(time%) DIV 10)
150 NEXT
160 INPUT"24-hour or 12-hour clock (12/24) ";hour$
170 IF INSTR(hour$,"12") THENunit(3)=unit(3)+&80
180 PRINT'"Press spacebar to start the clock...."
190 IF GET
200 ENDPROC
210 DEF PROCassemble
220 DIM code% 100
230 FORpass% = 0 TO 2 STEP 2
240 P%=code%
250 [ OPT pass%
260 .data          EQUD     &5CA33AC5 \SmartWatch
270                EQUD     &5CA33AC5 \initialization bytes
280 .time          EQUB     0          \Centiseconds
290                EQUB     unit(1)    \Seconds
300                EQUB     unit(2)    \Minutes
310                EQUB     unit(3)    \Hour
320                EQUB     unit(4)    \Day (bit 4 low=reset, bit 5 low=osc. on)
330                EQUB     unit(5)    \Date
340                EQUB     unit(6)    \Month
350                EQUB     unit(7)    \Year
360 .xtemp         EQUB     0          \Temporary store for X register
370 .ytemp         EQUB     0          \Temporary store for Y register
380                \Write 64 init. bytes, then 64 time bytes; X points to data
390  .main         SEI              \disable interrupts to avoid trouble with Beeb
400                JSR      romrd      \Read byte first to reset SmartWatch
410                LDX      #0         \Point to 1st init. byte
420 .write         LDA      data,X     \Get data byte
430                LDY      #8         \Set bit counter to bits+1
440 .write1        STA      SmartWatch    \Write byte to s.w. rom area
450                DEY                 \Decrement bit counter
460                BEQ      write2     \End of next byte test if zero
470                LSR      A          \Rotate bits right, 0 in bit 7
480                JMP      write1     \Send next bit
490 \Bump pointer, test for last byte, if not last, loop back
500 .write2        INX                  \Bump data pointer
510                CPX      #&10        \Last data byte+1?
520                BNE      write       \Loop back if not last data byte
530 .wrend         CLI                  \Restore interrupts
540                RTS                  \Back to Basic
550 \Read a byte from sideways ram area
560 .romrd         STX      xtemp       \Save X register
570                STY      ytemp       \Save Y register
580                LDA      #SmartWatch AND &FF  \Rom read address low byte
590                STA      &F6         \Put it in F6
600                LDA      #SmartWatch DIV &100  \Rom read address high byte
610                STA      &F7         \Put it in F7
620                LDY      #socket%
630                JSR      osrdrm      \Read byte from rom, result in A
640                LDX      xtemp       \Restore X
650                LDY      ytemp       \Restore Y
660                RTS                  \Return to calling routine, data in A
670 ]
680 NEXTpass%
690 ENDPROC
700 DATAyear: 19,month (1-12),date of the month,day of the week (1-7),hour:
,minutes: ,seconds: .
```

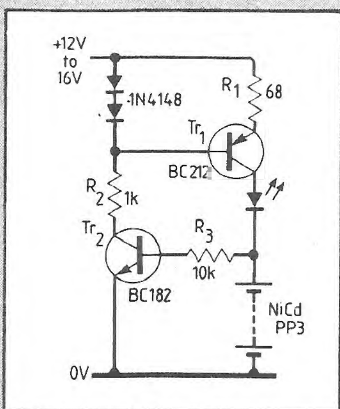
```
 10 REM    *** Program WATCH.BAS to read SmartWatch ***
 20 REM    by Martin Eccles and Richard Lambley
 30 REM    Electronics and Wireless World, June 1986
 40 REM    Reads SmartWatch and pokes Mode 7 screen
 50 REM    with date and time (24-hour clock display)
 60 socket%=&D :REM number of socket holding SmartWatch
 70 osrdrm=&FFB9:oswrch=&FFEE:osbyte=&FFF4:eventv=&220
 80 flag=&85:screen=&86:screenhi=&87:data=&88:daymo=&F8
 90 REM Locations above are safe in Basic, Comal and OS1.2
100 SmartWatch=&8008:code=&B80:REM Move if necessary
110 FOR pass% = 0 TO 3 STEP 3
120 P%=code
130 [ OPT pass%
140 .setup        LDA      eventv
150               STA      oldev             \Save contents of
160               LDA      eventv+1          \event vector and
170               STA      oldev+1           \redirect it to
180               LDA      #eventh AND &FF   \point at
190               SEI                        \new code
200               STA      eventv
210               LDA      #eventh DIV &100
220               STA      eventv+1
230               CLI
240               LDA      #14         \Enable vertical sync event
250               LDX      #4          \(=*FX14,4). To kill display
260               JSR      osbyte      \use *FX13,4 or Break
270               RTS                  \Exit to calling program
280
290 .init         EQUD     &5CA33AC5   \SmartWatch init. data:
300               EQUD     &5CA33AC5   \64 bits packed into 8 bytes
310 .banner       EQUB     &84         \Alpha blue
320               EQUB     &9D         \New background
330               EQUB     &85         \Alpha magenta
340               EQUS     "SmartWatch"
350               EQUB     130         \Alpha green
360               EQUS     "19"        \Year display
370               EQUB     0           \End of string
380 .xtemp        EQUB     0           \Temporary parking
390 .ytemp        EQUB     0
400               \Don't separate the next four lines
410 .month
420 .sep          EQUB     131         \to display time in yellow
430               EQUS     "::/"       \seperators for time display
440               EQUS     "JanFebMarAprMayJunJulAugSepOctNovDec"
450               \Don't separate the next four lines
460 .dweek
470 .oldev        EQUW     0           \Return address to go here
480               EQUB     0           \Spare, but don't remove!
490               EQUS     "SunMonTueWedThuFriSat"
500               \Next routine calls the clock and reads it
510 .readck       LDA      #SmartWatch AND &FF    \Set up pointer for
520               STA      &F6         \osrdrm to look at address
530               LDA      #SmartWatch DIV &100   \within SmartWatch
540               STA      &F7
550               JSR      romrd  \Read byte first to reset SmartWatch
560                               \then write 64 bytes to activate it
570               LDX      #0          \Point to 1st init. byte
580 .wake_up      LDA      init,X      \Get initialization byte
590               LDY      #8          \Set bit counter to bits+1
600 .wake_up1     STA      SmartWatch  \Write byte to sideways ram area
610               DEY                  \Decrement bit counter
620               BEQ      wake_up2    \End or next byte test if zero
630               LSR      A           \Rotate bits right, 0 in bit 7
640               BPL      wake_up1    \Loop until all eight sent
650 .wake_up2     INX                  \Bump ident pointer
660               CPX      #8          \Last init. byte+1?
670               BNE      wake_up     \End if last init. byte
680           \Read 64 bytes, assemble result as 8 bytes in zero page
690 .read         LDY      #8          \Set bit counter to bits+1
700               DEX                  \bump data pointer
710               BMI      eventex1    \End if last data byte
720 .read1        JSR      romrd       \Get rom byte in A
730               LSR      A           \Put data bit 0 in carry, then
740               ROR      data,X \put carry in data bit 7; store
750               DEY                  \Decrement bit counter
760               BNE      read1       \Loop if counter is not zero
770               BEQ      read        \Next byte
780 .eventh       PHP              \This routine called at every event
790               CMP      #4          \Is it a vertical sync event?
800               BNE      eventex2    \Exit if not
810               PHA
820               TXA
830               PHA                  \Save registers
840               TYA
850               PHA
860               DEC      flag        \Bump event counter
870               BEQ      readck      \When flag=0, read SmartWatch
880               BMI      display     \When flag=-1, display results
890               LDA      #160        \When neither,
900               LDX      #&55        \read screen mode
910               JSR      osbyte
920               CPX      #7          \exit if mode 7; otherwise
930               BEQ      eventex1    \set flag to a value which
940               LDA      #&7F        \will ensure that the clock is
950               STA      flag        \neither read nor displayed
960 .eventex1
970               PLA
980               TAY
990               PLA                  \Restore registers
1000              TAX
1010              PLA
1020 .eventex2    PLP
1030              JMP (oldev)          \Exit gracefully
1040                     \This routine prints the clock display
1050 .display     LDA      #160        \Read address of top l.h.
1060              LDX      #&50        \corner of screen,
1070              JSR      osbyte      \then
1080              STY      screen+1    \save high byte
1090              STX      screen      \save low byte
1091
1100              LDY      #&FF        \Set loop counter
1110 .pbanner     INY
1120              LDA      banner,Y    \Prepare blue bar
1130              STA      (screen),Y  \for clock display
1140              BNE      pbanner
1150              LDA      data        \Get low byte of year
1160              JSR      bcd         \and display it
1170              LDA      #dweek AND &FF  \Set string pointer
1180              SEC
1190              SBC      #3          \offset to allow for day
1200              STA      daymo       \position in display
1210              LDA      #dweek DIV &100
1220              SBC      #0
1230              STA      daymo+1
1240              LDA      data+3      \Day of the week
1250              JSR      showchars   \Print day string
1260              LDA      #135        \Alpha white
1270              STA      (screen),Y  \Poke to screen
1280              INY                  \Bump display pointer
1290              LDA      data+2      \Day of the month
1300              JSR      bcd         \Print it
1310              LDA      #month AND &FF \Set string pointer
1320              SEC                   \to give months
1330              SBC      #25          \offset for display position
1340              STA      daymo
1350              LDA      #month DIV &100
1360              SBC      #0
1370              STA      daymo+1
1380              LDA      data+1      \Month
1390              JSR      showchars   \Print month string
1400              LDX      #0          \Loop counter
1410 .time        LDA      sep,X       \Get spacer character
1420              STA      (screen),Y  \Poke to screen
1430              INY                  \Bump display pointer
1440              LDA      data+4,X    \Get hh/mm/ss from page 0
1450              JSR      bcd         \and print
1460              INX                  \Centiseconds count is
1470              CPX      #3          \held in data+7, but we
1480              BNE      time        \haven't used it
1490 .setflag     LDA      #8          \Set event counter for a
1500              STA      flag        \suitable update rate.
1510              JMP      eventex1    \Leave
1520 \ subroutines
1530 .romrd       STX      xtemp       \Read byte from rom
1540              STY      ytemp       \Save X and Y registers
1550              LDY      #socket%    \Socket containing SmartWatch
1560              JSR      osrdrm      \Read byte, result in A
1570              LDX      xtemp       \Restore X reg.
1580              LDY      ytemp       \Restore Y reg.
1590              RTS                  \Return, data in A
1600 .bcd                  \convert b.c.d. to Ascii and display
1610              PHA                  \Save byte
1620              LSR A                \Get top four bits
1630              LSR A                \and divide by 16
1640              LSR A
1650              LSR A
1660              ORA #&30             \Convert to Ascii
1670              STA (screen),Y       \and poke to screen
1680              INY                  \Bump display pointer
1690              PLA                  \Retrieve byte
1700              AND #&F              \Mask off bits 0-3
1710              ORA #&30             \Convert to Ascii
1720              STA (screen),Y       \Write to screen
1730              INY                  \Bump display pointer
1740              RTS                  \and exit
1750 \
1760 .showchars         \Displays text strings for day and month
1770              STA xtemp            \High bit of A will be clear
1780              ASL A                \so this clears carry.
1790              ADC xtemp            \Multiply Y by 3 to point at
1800              CLC                  \at correct part of string
1810              ADC daymo      \ add result to basic string pointer
1820              STA daymo      \ so that Y index can be used both
1830              LDA daymo+1 \to load characters and to poke them
1840              ADC #0
1850              STA daymo+1
1860              LDA #134             \Alpha cyan
1870              STA (screen),Y       \Write to screen
1880              INY                  \Bump display pointer
1890              LDX #2               \Ready to display day/month
1900 .pdaymo      LDA (daymo),Y        \Read from day/month string
1910              STA (screen),Y       \Write to screen
1920              INY                  \Bump screen pointer
1930              DEX                  \Bump loop counter
1940              BPL pdaymo           \Done all three chars yet?
1950              RTS
1960 ]
1970 NEXTpass%
1980 OSCLI("SAVE SMARTWAT.COM "+STR$~code+" "+STR$~P%)
1990 CALL setup:MODE 7:PRINT
```

CIRCUIT IDEAS

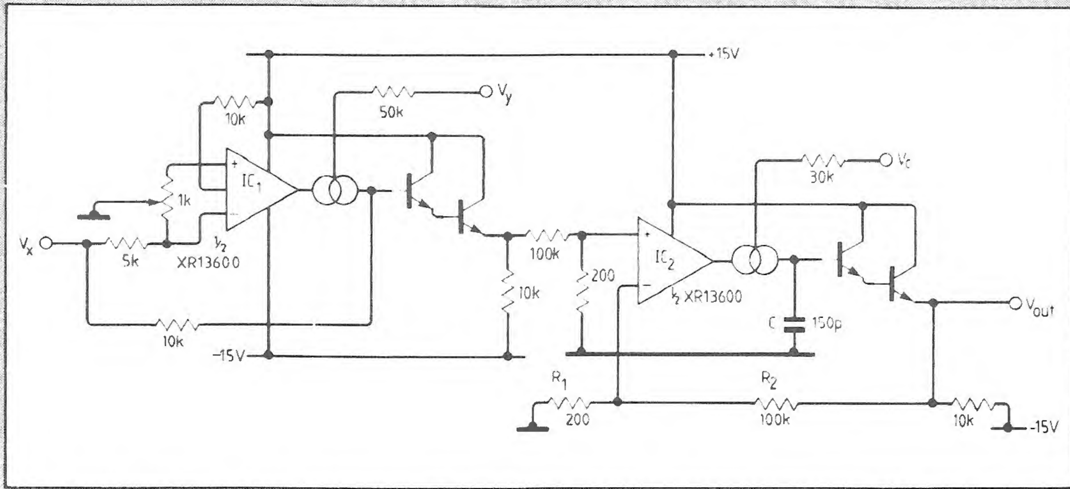
Charger with reverse shut-down

Simple NiCd battery chargers have no inbuilt reverse connection safeguards. They simply discharge the battery at the set charge rate. This circuit cuts out automatically when the battery is reverse connected.

Two diodes, $R_{1,2}$ and Tr_1 form the charger and the second transistor and R_3 are the protection circuit. If an NiCd battery of more than 0.6V is connected, Tr_2 switches on and the circuit works as normal.



Reverse-connected batteries or ones giving less than 0.6V cause Tr_2 to turn off and shut down the circuit. Values shown are for PP3-type batteries.
John Wyrill
Huddersfield



One-chip phase detector

A phase detector can be built using one XR13600 dual transconductance op-amp.

Cut-off frequency depends on control voltage V_c, which can be varied over a wide range.

The phase detector consists of a multiplier and voltage controlled low-pass filter. Given two input signals of $\sin\omega t$ and $\sin(\omega t+\phi)$, a signal of

$$\sin\omega t.\ \sin(\omega t+\phi)$$

$$=\tfrac{1}{2}\cos\phi-\tfrac{1}{2}\cos(2\omega t+\kappa)$$

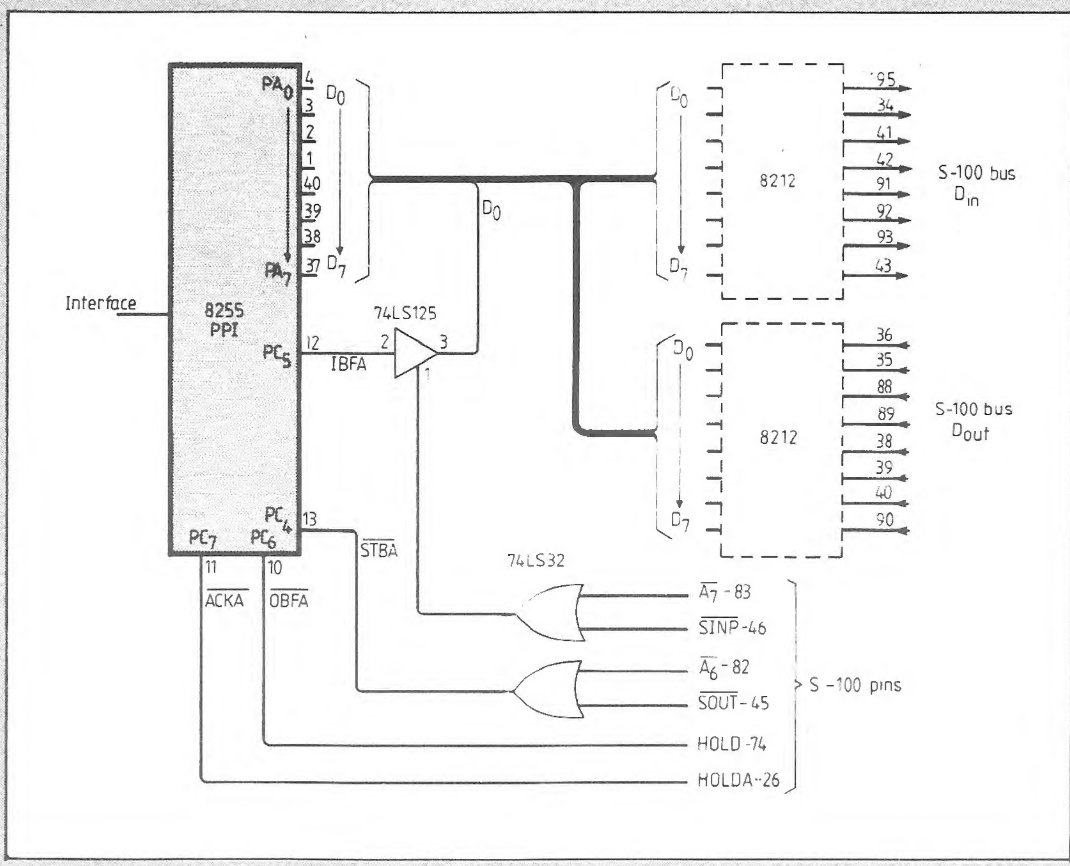
appears at the multiplexer output.

Having low-pass filter cut-off frequency ω_c at far less than 2ω gives $\tfrac{1}{2}\cos\phi$ at the output, i.e. output of the low-pass filter is proportional to phase of the incoming signal.
Kamil Kraus
Rokycany
Czechoslovakia

S100 bus interfacing

Two 8212 i/o latches are used here to transfer data between an 8255 parallel i/o device and the S100 bus.

From the S100 side, port A of the 8255 is address byte BF_{16} and port C is byte $7F_{16}$. Buffer-full information is on data line zero.
Hakikur Rahman
Dhaka
Bangladesh



16bit Z80 direct memory access

This circuit allows 16bit direct memory access (d.m.a.) to and from 16bit i/o and Z80 memory.

Memory of the Z80 is logically split into two – a low-order block accessed when A_0 is low and a high-order block accessed when A_0 is high. In this way the c.p.u. sees a single 128Kbyte memory.

The 245 buffers and write multiplexer prevent bus conflict during normal c.p.u. operation. During refresh, Z80 address line A_0 is multiplexed with Z80 line A_7 to ensure a full refresh cycle.

Memory-management unit m.m.u. maps the 128Kbyte data ram and program rom/ram into the 64Kbyte logical c.p.u. address range. Data ram is mapped as four 32Kbyte blocks in the upper half of the Z80 address range, selected by writing the block number to the m.m.u. latch.

An inverted $\overline{RD}$ signal is used by the write-multiplexer to produce an early-write cycle which allows input/output pins on the d-rams to be connected together.

During c.p.u. accesses, Z80 line A_0 switches the write-enable signal between high and low-order rams. When d.m.a. access is granted this function is disabled, allowing writing to both high and low-order rams.

Connection of the d.m.a. controller to the c.p.u. control bus is as usual, $\overline{IORQ}$, $\overline{MREQ}$, $\overline{RD}$, $\overline{WR}$, $\overline{BUSRQ}$, $\overline{BUSAK}$, etc, but its address bus is shifted up by one so that the d.m.a. controller A_0 is the Z80 A_1, etc. In this way, the controller sees only 64K of 16bit wide ram.

Direct connection is used for linking the low-order data bus and controller. High-order data lines connect to an 8bit three-state latch controlled by the d.m.a. controller (the high-order data latch).

During a d.m.a. operation, the controller first reads the data bus, either memory or i/o, and stobes it into an internal latch. Using a write operation, the controller switches this latched data onto the data bus (HODL) and strobes it into the memory or i/o.

Assume that $\overline{BUSRQ}$ has been asserted, bus-release granted and that $\overline{BUSAK}$ is active. The controller starts a memory-read cycle, output of IC_1 goes low ($\overline{DMARD}$), bistable device IC_{2a} reset is released and on the first rising edge of clock ϕ, bistable device IC_{2a} $\overline{Q}$ output goes low.

One T-state later, which is 250ns at 4MHz, the rising clock edge raises IC_{2a} $\overline{Q}$ output and strobes data into the high-order data latch.

When the controller runs an i/o-read cycle it inserts an extra T state – a wait state – which causes the cycle to start on the rising clock edge. To prevent this first edge toggling IC_{2a}, $\overline{DMARD}$ is delayed by about 40ns by three LS07 buffers.

Controller write cycles $\overline{DMAWR}$ are detected when $\overline{IORQ}$ or $\overline{MREQ}$ is low, indicating data request (DRQ), and $\overline{RD}$ is high. Signal $\overline{DMAWR}$ goes low, resetting IC_{2b} $\overline{Q}$ output which puts high-order data from its latch onto the data bus.

At the end of the write cycle, $\overline{DMAWR}$ goes high, removing the set condition from IC_{2b}. Output $\overline{Q}$ of IC_{2b} remains low until the rising clock edge sets it high. This ensures stable data at the rising edge of the $\overline{WR}$ signal.

Address decoding, not shown, should be straightforward; decoding Z80 A_{15} provides program rom/ram and data ram selects by controlling the $\overline{CAS}$ signal.

Port decoding need not decode Z80 A_{8-15} although see note on software. Lines A_{0-7} on the Z80 are decoded to produce m.m.u. $\overline{RD}/\overline{WR}$, low and high-port $\overline{RD}/\overline{WR}$ and d.m.a. chip-enable.

Since the address lines are shifted, the internal registers occupy two Z80 i/o ports each. A multiplexer ensures that the controller has simultaneous access to high and low-order i/o ports when d.m.a. access is granted.

Software is simplified if the program is constrained to the program area only and data is passed by d.m.a. To maintain the low/high-order convention, low-order bytes should be loaded to even addresses and high-order bytes to odd addresses. Both may be loaded into and from register pairs if the pair is given even addresses, e.g. LD HL, (8000H), #LD (0FFFEH).

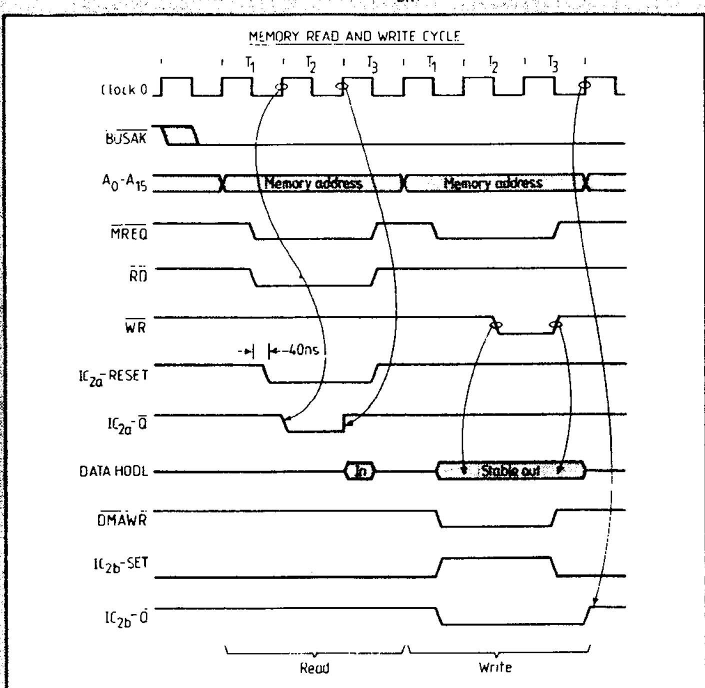
During access to i/o ports and controller registers, Z80 A_{15} must be high. This is done using IN r,(C) and OUT (C),r instructions. The C register is loaded with the port address and the B register with 80_{16}. On execution of these instructions, the B register is placed on Z80 lines A_{8-15}.

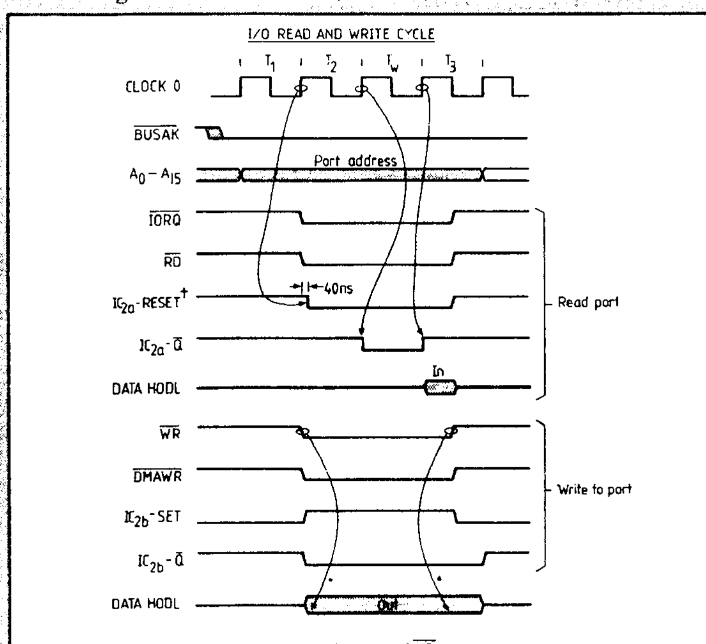
Internal registers of the controller each appear twice since the controller address lines are shifted. Apart from this, memory, i/o source/destination and length registers can be loaded normally, although as one d.m.a. word is two bytes, the length and addresses should be carefully calculated.

Using the d.m.a. controller as an interrupt could cause problems since the IN intruction cannot supply an interrupt vector or sense an RETI return-from-interrupt instruction.

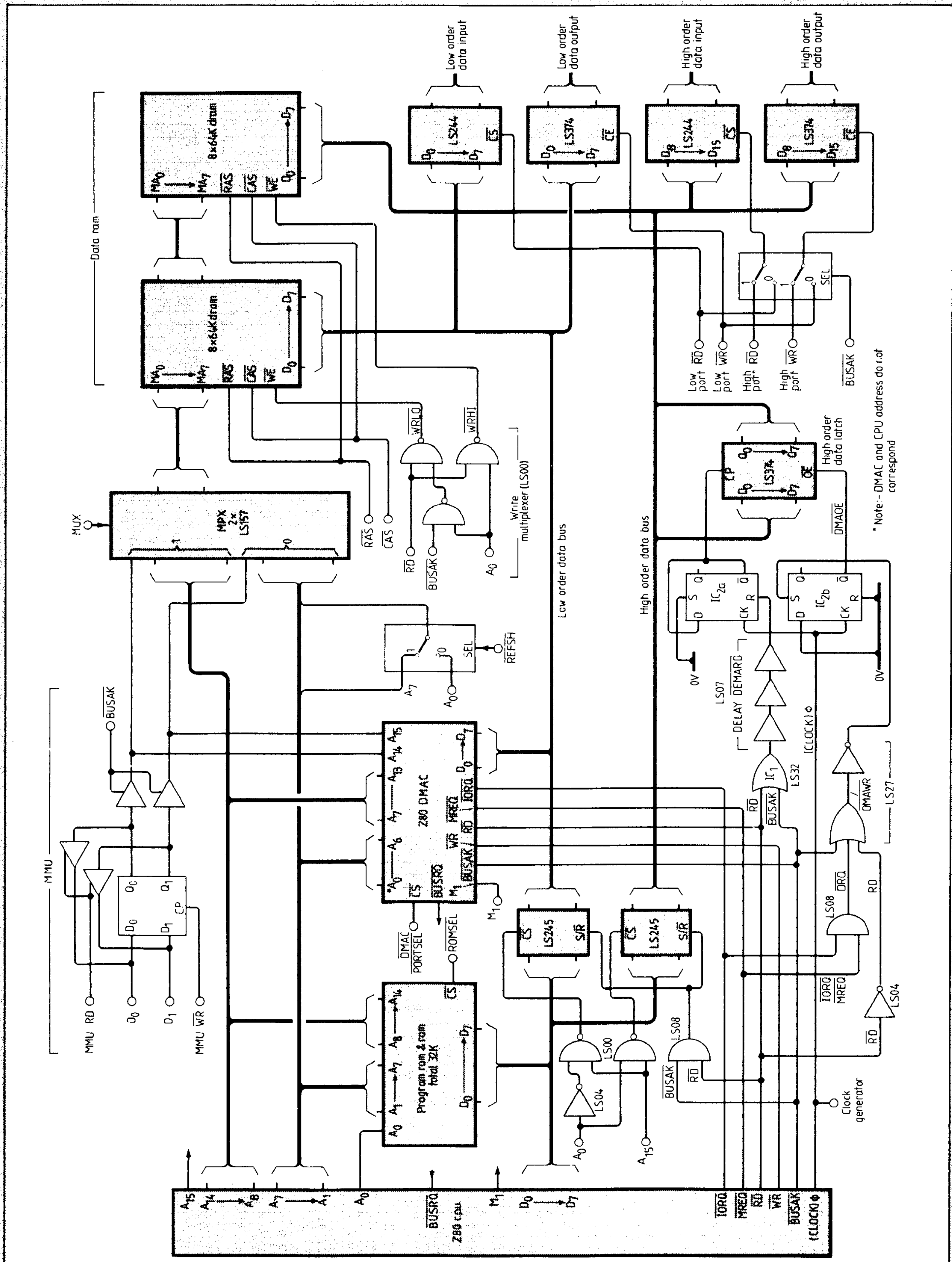
To produce $\overline{RAS}$, MPX and $\overline{CAS}$, I recommend reading John Adams' first SC84 computer article in the May 1984 issue of *E&WW*.

W.K. Todd
Colchester
Essex



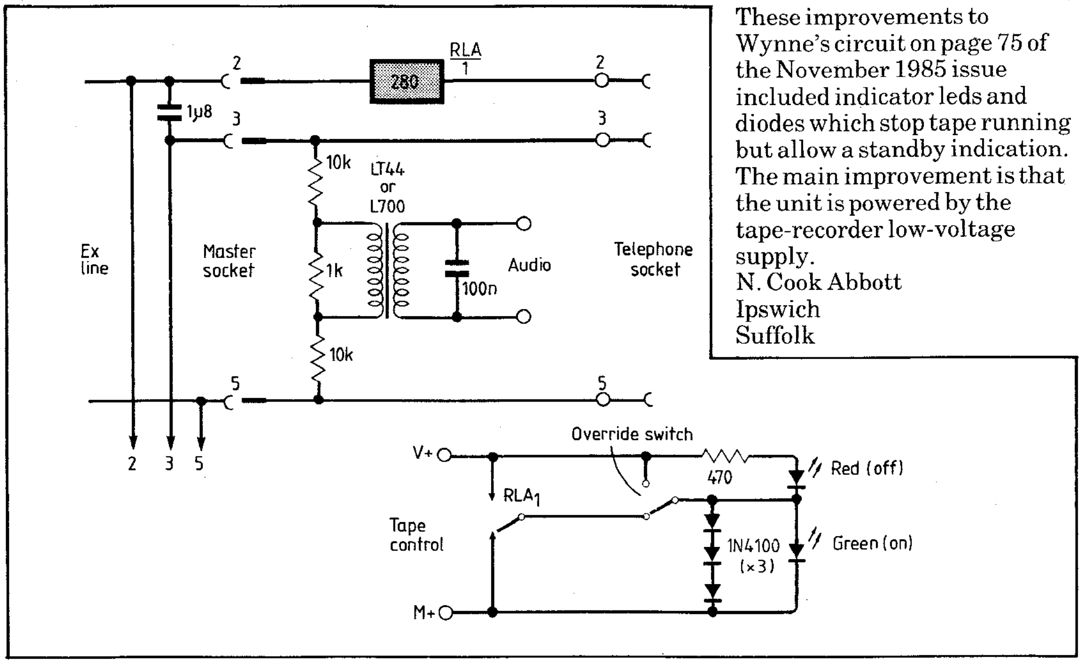


* Data only stable on rising edge of $\overline{WR}$
† Delayed $\overline{DMARD}$



Data ram
8×64K dram
8×64K dram
MPX 2× LS157
MUX
Low order data input
Low order data output
High order data input
High order data output
LS244
LS374
LS244
LS374
SEL
Low port RD
Low port WR
High port RD
High port WR
BUSAK
High order data latch
LS374
DMAOE
* Note:- DMAC and CPU address do not correspond
Write multiplexer (LS00)
WRLO
WRHI
RAS
CAS
Low order data bus
High order data bus
REFSH
MMU
MMU RD
MMU WR
Z80 DMAC
DMAC/PORTSEL
ROMSEL
Program rom & ram total 32K
LS245
LS245
LS00
LS04
LS08
LS32
LS07
DELAY DEMARD
(CLOCK) Φ
LS27
DMAWR
DRQ
IORQ
MREQ
Clock generator
Z80 cpu
BUSRQ
M1
0V

Automatic telephone recording on cassette

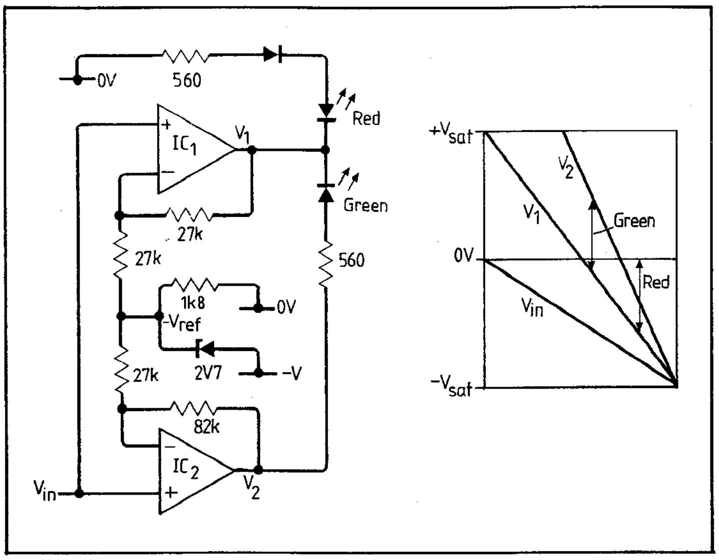


These improvements to Wynne's circuit on page 75 of the November 1985 issue included indicator leds and diodes which stop tape running but allow a standby indication. The main improvement is that the unit is powered by the tape-recorder low-voltage supply.
N. Cook Abbott
Ipswich
Suffolk

Linear led voltage indicator

The range of colours produced by the three-colour led in this arrangement gives a fair indication of input-voltage level.

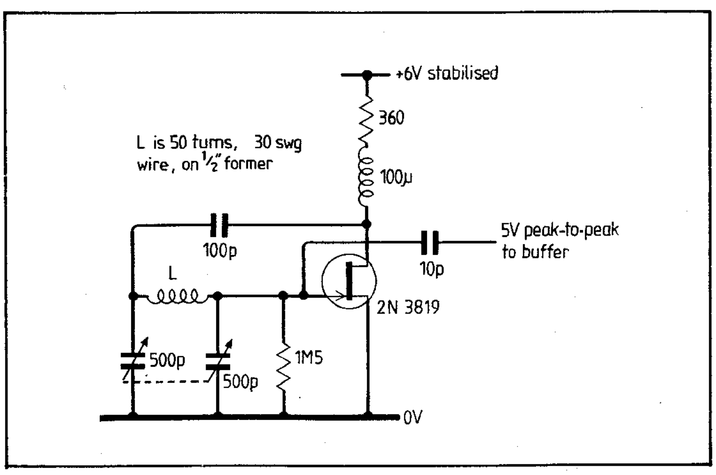
This version indicates from 0 to −12V as a smooth progression from off through green and yellow to red and it can easily be modified for other input ranges and polarities.
H.R. Banton
Manchester



Reliable LC oscillator

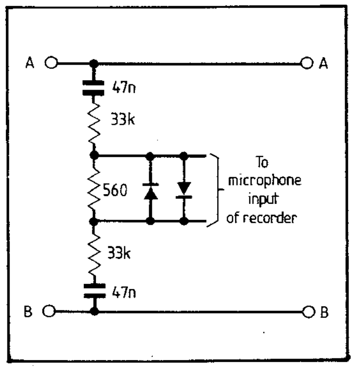
LC oscillators can be temperamental. Either they require experimentation with circuit values to make them oscillate or they are complicated.

This one is guaranteed to work, tunes from 2-10MHz, is stable and has low harmonic output. It would be ideal as the v.f.o. for a transmitter or receiver.
P. Hall
London



Telephone-line microphone output

This is a very simple passive audio take-off for recording from a telephone line. It can be shunted across the line at any point and left in place if desired. Normal working of the telephone is unaffected. Ringing current and line surges are suppressed and it is unlikely that the recorder will be damaged; I use the circuit without the limiting diodes.



Good quality components are essential and the capacitors should have a 250V direct rating. A 600Ω 1:1 ratio isolating transformer can be inserted between the output of the device and recorder input if required.
D. Brooks
London

Telephone circuits

Please remember that in the UK, all equipment for connection to the public-switched network must have BABT approval. BABT does not consider circuit diagrams for approval, only complete apparatus, and the approval process is expensive and time consuming.

The approval system is intended to ensure that signals passed down the telephone line are within certain limits so that they do not cause interference on other lines, and to ensure that lethal voltages can never appear on the telephone line.

British standards relating to connection of apparatus are given in the December 1985 issue, page 77.

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(a)

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MODEMS

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The world standard BT approved modem covering all standard CCITT and BELL (outside UK only) standards upto 1200 baud. Allows communication with virtually any computer system in the world. Expandability to Auto Dial and Auto Answer with full software control enhance the considerable features already provided on the modem. Mains powered. WS 2000 **£102 (b)**, Data Cable **£7(d)**,

NEW WS-3000 RANGE — the new professional series. All are intelligent and 'Hayes' compatible, allowing simply 'English' commands to control its many features. All models feature Auto-Dial with 10 number memory, Auto-Answer, Speed buffering, printer port, data security option etc. All models are factory upgradeable.

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The WS3000 range all have BT approval.

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This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II....**£195.00 (b)**
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Solder	60	85	125	170
IDC	175	275	325	—
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Solder	90	130	195	290
IDC	195	325	375	—
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18 pin	**60p**	—
20 pin	**75p**	—
24 pin	**100p**	**150p**
28 pin	**160p**	**200p**
40 pin	**200p**	**225p**

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All prices in this double page advertisment are subject to change without notice.
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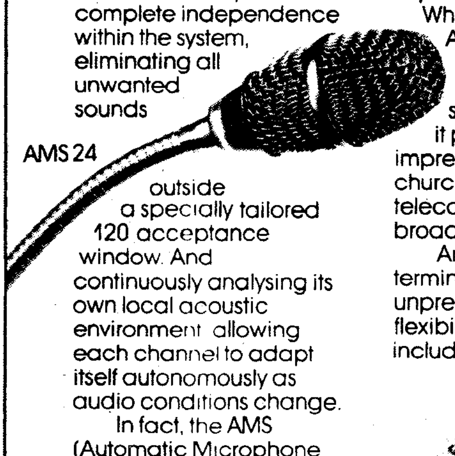
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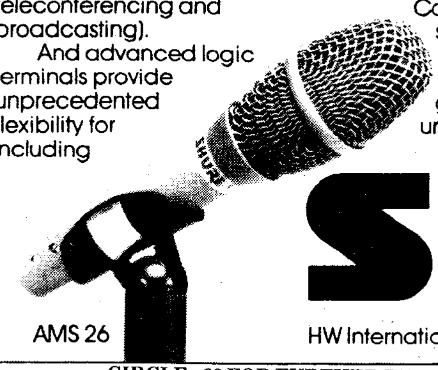
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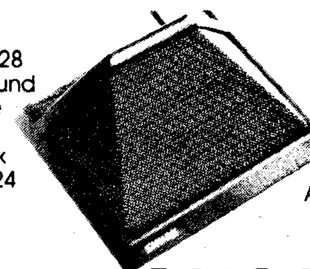
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CIRCLE 68 FOR FURTHER DETAILS

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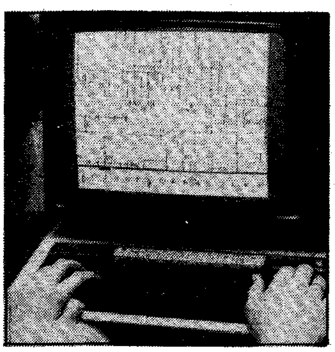

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H.P. TEST OSCILLATOR 651A 10Hz-10MHz	£100
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CIRCLE 72 FOR FURTHER DETAILS

Coin recognition in vending machines

by Bob Deane,
B.Sc., M.I.E.E.
Mars Electronics Ltd

Inductive sensors and custom l.s.i. combine to reject dud coins

Social trends are making it increasingly impractical to employ people in routine point-of-sale tasks; vending machines are rapidly becoming the norm rather than the exception here. Some advances in vending machine technology have been obvious – the ability to accept a variety of coin values, give change, and even to synthesize verbal prompts – but the less obvious developments which underwrite the more extensive use of vending machines lie in the improved accuracy of coin-recognition mechanisms. It is the application of the latest l.s.i. and transducer technology which has permitted this enhanced performance.

The vending and amusement machine industry is constantly on the look out for ways of combating the ingenuity of would-be fraudulent users who continue to devise new kinds of coin counterfeits, known colloquially as 'slugs'. To frustrate these efforts, more discriminating coin-recognition mechanisms became essential. Yet, with the average life of a coin stretching to ten years, sufficient tolerances to cope with the subsequent change in characteristics of valid coins must be accommodated.

Mars Electronics achieved the first reliable solution to these two conflicting requirements. The design described here can accept up to six different "valid" coins.

Inductive sensors

The combined results of three independent tests, matched against a "template" held in prom, determine whether a coin is accepted. The sensors measure the thickness, material composition and diameter using inductive principles. The location of these successive transducers is shown in Fig 1, which also indicates the physical passage of the coin; the ceramic snubber serves to absorb excessive kinetic energy and ensure smooth passage of the coin through the mechanism. There are subsequent monitor devices (not shown) which check that the mechanism has not been tampered with. Economical use of the electrical power is achieved by implementing a standby mode, where only the first sensor and the c-mos detection circuits are active until a coin is inserted.

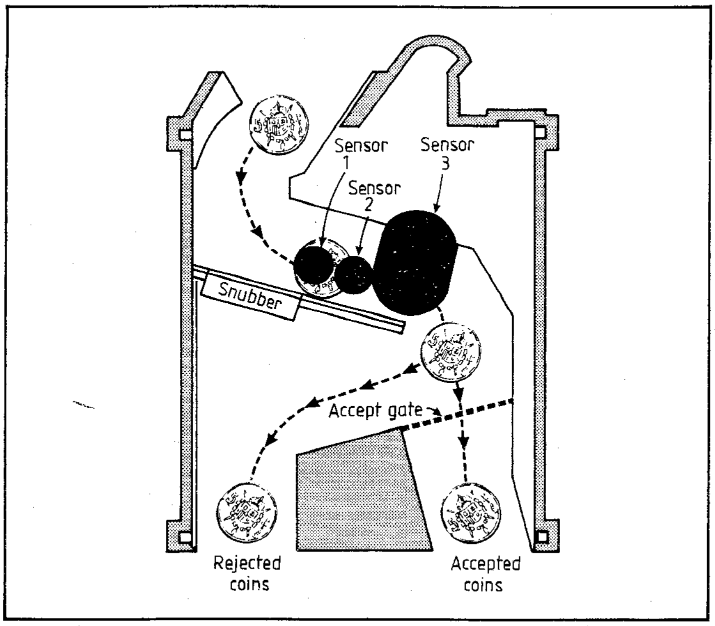
Each sensor is made up of one or two ferrite-core coils, which are arranged symmetrically to face the path of the coin. The inductors are components in resonant circuits; the physical size of the coils and the fundamental frequency are different for each sensor, being carefully chosen to give the optimum sensitivity for the desired characteristics being measured. As the coin passes the coils, the oscillator frequency is increased and the amplitude of the oscillation is reduced through energy absorption by the coin.

In the case of the first sensor (thickness), the fundamental frequency is 1MHz. This is sufficiently high to ensure that the electromagnetic energy does not penetrate significantly into the bulk of the coin (because of skin-effect), and the frequency shift can be almost totally ascribed to the distance of the coin surfaces from the coils (i.e. the thickness of the coin).

Further information can be gathered by this transducer. The circuit is sensitive enough to accurately read the depth of the stamping on the faces of the coin and to some extent the pattern. This information is most valuable for differentiating between coins of otherwise similar characteristics: for example, the 5p piece and the German 1DM.

In the case of the second (composition) sensor, the aim is to evaluate the conductivity of the material, so a lower fun-

Fig. 1. Physical path of the coin through mechanism, indicating the position, relative size and sequence of the three sensors.



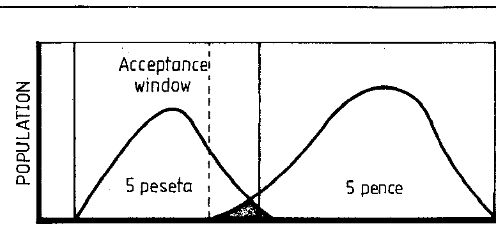


Fig. 2 shows how the acceptance window is modified to individual machine manufacturers requirements by adjusting the acceptance rate for valid (but worn) coins and the rejection rate for counterfeit or foreign money. 5p coin is accepted 90% of the time, with a worse-case 10% acceptance of the 5 peseta coin. Broken line shows 5p coin accepted 98% of the time, with a worst-case 30% acceptance of the 5 peseta coin.

damental frequency of oscillation is used (100kHz) to achieve a higher depth of penetration. The effect of energy absorption in the material of the coin is to reduce the amplitude of the oscillations, the extent of the voltage change being a function of the composition.

The final sensor (diameter) is similar to the thickness sensor in that it relies on high frequency skin-effect to minimize energy absorption (using an f_0 of 650kHz). However, in contrast to the small size of the thickness sensor, this last sensor has a coil diameter exceeding the diameter of the largest valid coin. The electromagnetic field effects are therefore dependent on the coin's diameter.

Custom integrated circuit

While a commercial prom provides a convenient storage medium for the predetermined characteristics of the required range of valid coins, all the remaining logic circuitry (some 3000 transistors) is contained in a custom i.c. This chip is essential to prevent the complete circuit board being unacceptably large and complex, with consequent reliability problems. The i.c. must run continuously in "standby" mode, so c-mos was chosen as the most appropriate technology to employ.

In operation, the custom l.s.i. chip establishes the ratio and the difference between the maximum measured value and the normal (without coin) levels from the resonant circuits. The results from each sensor are then compared with the pre-programmed values held in prom, the coin type is identified (up to six denominations can be handled) and an "accept/reject" decision made, which can be modified to suit the requirements of an individual vending machine manufacturer.

There is inevitably some compromise involved between the acceptance rate for valid (but worn) coins and the rejection rate for counterfeit or foreign money. An example of this is given in Fig. 2. The "acceptance window" can be adjusted to suit the priorities which are considered most appropriate for the job.

Improving 4000 series oscillators

continued from page 35

receiver as a synchronized horizontal or vertical oscillator. Inasmuch as there is no 'long first pulse' to react against the sync pulse, it will be instant starting, dependably. Then consider adding a three-five-eight crystal into the circuit to interrupt the pulse, and it becomes a combination horizontal oscillator and colour burst generator in one chip... actually in half a chip, as the other half could be the synchronized vertical oscillator. But this is outside of the scope of this article.

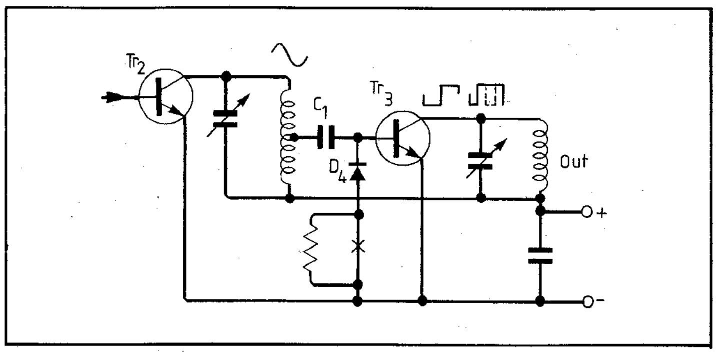


Fig. 2 shows an output circuit for coupling the negative-going signal on IC_2 pin 4 to the base of Tr_1, which keys a negative-grid-block transmitter. Resister R_4 is for decoupling, capacitor C_1 is for d.c. blocking, and D_3 is used to turn the transmitter on continuously for 'tune-up'. Turn-on is accomplished when Sw_2 is reversed from the position shown. Then the negative voltage at the transmitter key jack will go through D_3 to the base of Tr_1 and then through the base-collector diode of Tr_1 in forward direction to ground, thus keying the transmitter on continuously. Study of the circuit will show that in the reversed switch position, the keyer will key a positive-cathode keyed transmitter... and in that case, returning the switch back to the position shown, it will turn on the transmitter continuously. In other words, the circuit will key both negative and positive keyed transmitters.

An interesting factor, not generally known, is that the pulse at IC_1, pin 3 may be too fast to trigger a flip-flop. There are several ways to overcome the problem, but the simplest and most effective one turned out to be the addition of a small capacitor between IC_1, pin 3 and IC_2 pin 4. It serves to slow down the transfer-time at pin 3 by some inverse feedback from pin 4. It is an important part of the circuit shown in the panel.

Figs 1 and 2 turn out to be a practical and operable keying instrument. The only other modification would be the addition of r.f. by-pass capacitors (1nF) from IC_1 1 and 2 to ground, and from Tr_1 collector to ground.

An alternative to the Fig.2 circuit would be the use of an n-p-n transistor in place of the p-n-p transistor. In that case, the input would be taken from Ig pin 3, and C_1 would be eliminated. It would still key both plus and minus keyed transmitters, but the common ground would be better for cathode-keyed transmitters.

In Fig.2, D_3 prevents a positive cutoff charge from building up on the base of Tr_1. It may also increase the actual drive, but these effects may not be prominent due to the high resistance of R_4 and any leakage in C_1 and in Tr_1. The Fig.3 r.f. amplifier circuit shows the effect more predictably. Notice that D_4 replaces the usual base-return resistor, thus eliminating the circuit loading which would occur on both the positive and negative halves of the driving cycle. On the negative half, it puts a positive charge on C_1 so that on the positive half the driving voltage is double. Transistor Tr_3 collector current becomes a square wave that is rich in odd harmonics. If a resistor is connected in series with D_4, some negative bias will be allowed to build up, so the Tr_3 collector current will become a pulse wave, rich in even-order harmonics. Either way, circuit efficiency will be higher, whether it is an amplifier or frequency multiplier.

Wallchart of frequency allocations

Since the mid-1970s, when our last wallchart of frequency allocations appeared, there have been many changes in the radio spectrum. Some have been minor points of detail; others, like those that flowed from the World Administration Radio Conference in 1979, have been more far-reaching.

Following the recommendations of the Merriman committee, the UK administration recently released much information not previously available about its frequency assignments. Within the civilian allocations, our chart therefore carries more detail than its predecessor. However, information about bands occupied by the government is still in short supply.

Allocations in the United Kingdom follow closely the general pattern for Region 1, which includes Europe, Africa and Soviet Asia. However, like other national telecommunications administrations, the DTI enjoys the freedom to depart from the basic plan where the risk of creating undue interference in neighbouring countries is small. Some information on the chart therefore does not hold good for other European countries.

The aim of the chart is to give a picture of the uses to which the various parts of the radio spectrum are put. Detailed information has been included where space allows but much has had to be left out. Several categories of radio user have been merged in the interests of readability: for instance under the heading Aeronautical we have bracketed the aeronautical fixed, mobile and satellite services.

'Primary' and 'permitted' services are the principal users; 'secondary' users may not cause interference with either of them, but can claim protection against interference from other secondary users assigned later.

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Software from £1,400 to £9,800
Demo System £70.00

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- ☆ Easy to use menu system

Software £895.00 inc MOUSE
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Note: All prices exclude VAT & Delivery

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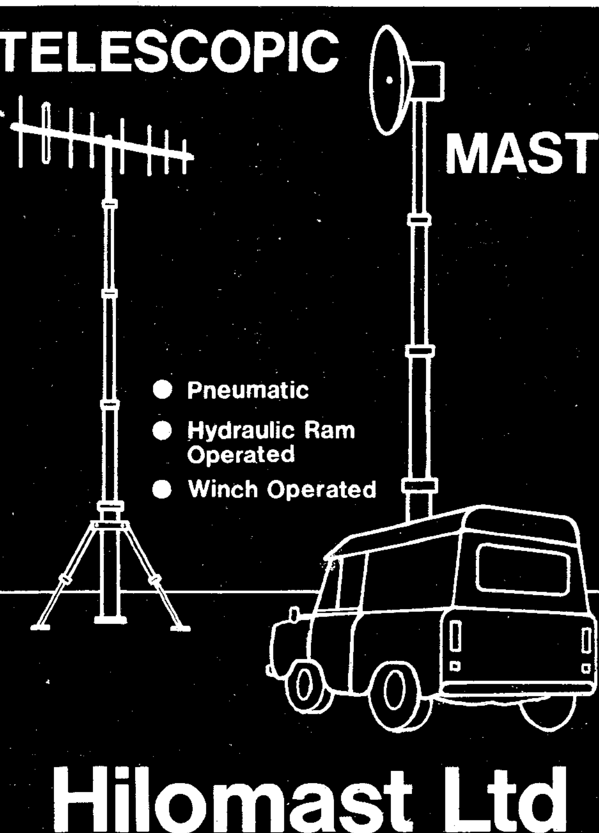
CIRCLE 67 FOR FURTHER DETAILS

TELESCOPIC MASTS



- Pneumatic
- Hydraulic Ram Operated
- Winch Operated

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CIRCLE 29 FOR FURTHER DETAILS

APPLICATIONS SUMMARY

Most manufacturers in the electronics industry spend large amounts of time and money on developing and describing applications for their products. To keep you informed, we will be publishing extracts from these notes from time to time. Readers wanting more information about particular notes need only circle the appropriate Reader Enquiry Service number.

Low power f.m. transmitter system

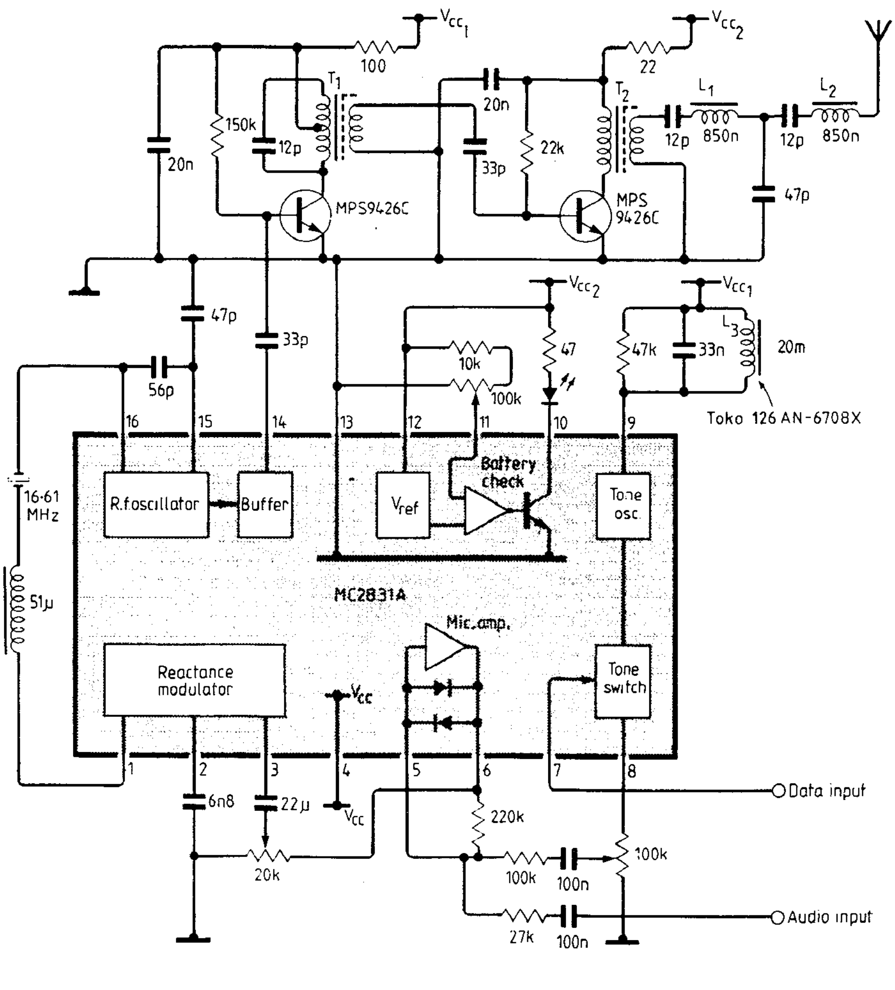
This is one application of a chip designed for f.m. communication equipment transceivers, cordless telephones, remote control and data links.

In the circuit shown, tone oscillator and microphone output can be summed at the audio amplifier input or at the modulator input through resistors.

Motorola application note ANHK02 for the MC2831A i.c. describes further applications including a single-channel cordless telephone and base set, and 10 channel versions. A brief functional description of the i.c. and wiring for tone burst or dual-tone f.s.k. are also given.

The MC2831A includes an audio amplifier with limiter, r.f. oscillator for up to 30 MHz, tone oscillator for pilot/data signalling and a variable reactance frequency modulator. Designed for battery operation, the 2831 has a supply voltage monitor and runs from 3-8V.

EWW300



Application notes received

Analog Devices

AD670 8-bit ad converter applications.

Low-cost two-chips voltage-controlled amplifier and video switch.

Brooktree

Comparison of NTSC, PAL and SECAM video levels, AN3.

Ditigal-to-analogue converter definitions, AN4.

Differential gain and phase characterization of Videodac AN5.

Motorola

Interfacing the MC145418 and MC145419, AN945.

MC68HC805C4 8-bit eeprom MCU programming module, AN966.

Floppy-diskdrive design using FDDP control processor and MC2870 read-write amplifier, ANHK04.

New mosfets revise power transistor performance specifica tions, AR146S.

MC68020 32-bit mpu: opening new application doors, AR232.

Rockwell

R6511Q-based terminal.

Low-power c-mos terminal design, Application Note 2185.

Apple IIe to LCE download program, Application Note 2194.

Quality of received data for signal processor-based modems, Application Note 671.

8088 microprocessor to R1212/2424 modem interface, Application Note 672.

Interfacing Rockwell signal processor-based modems to an Apple IIe computer, Application Note 673.

R96FAX modem tone-detector filter tuning, Application Note 668.

R2424 and R1212 modems auto dial and tone detection, Application Note 676.

Analog Devices Ltd, Central Avenue, Eastd Molesey, East Molesey, Surrey KT8 0SN.

Brooktree: Thame Components, Thame Park Road, Thame, Oxon OX9 3XD.

Motoroloa: Hawke Electronics Ltd, 45 Hanworth Road, Sunbury-on-Thames, Middlx TW16 5DA.

Rockwell International Ltd, Central House, Lampton Road, Hounslow, Middx TW3 1HA.

Using video d-to-a converters

In video d-to-a conversion, proper component selection, hardware and p.c.b. layout are essential for stable, low-noise operation.

Because the video converter is part analogue and part digital, the analogue output signal is subject to degradation from power-supply noise, ground loops, radiated pickup and magnetic coupling.

Brooktree application note AN1 provides guidelines to help both the design engineer and p.c.b. designer get the best from a video d-to-a converter.
EWW301

12 bit analogue i/o port

Details of an i/o port for measuring and producing analogue signals are given in Analog Devices note "12 bit Analog I/O Port Uses AD7549 and 8051 Microcomputer".

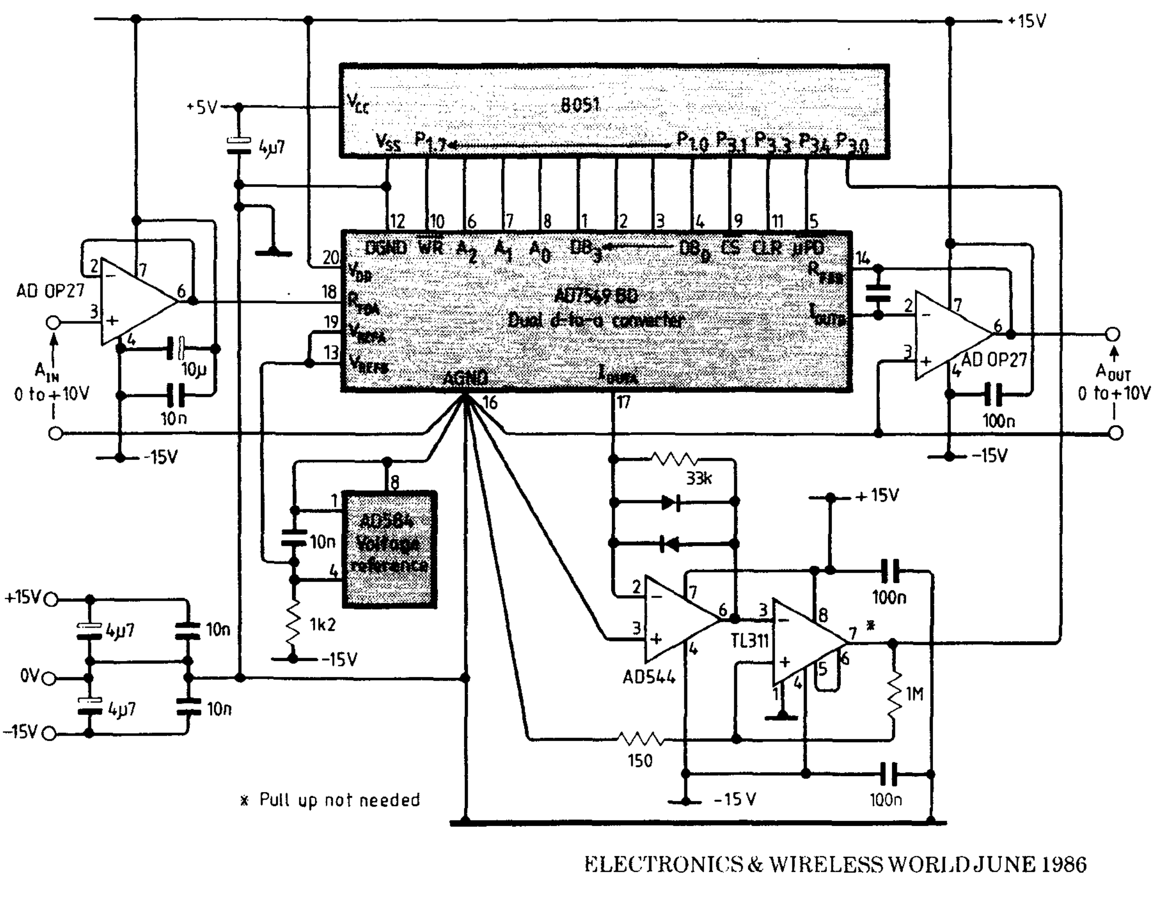
The 7549 consists of two 12bit multiplying digital-to-analogue converters, each with its own data register. Output current settling time of each converter is 1.5μs.

Data is loaded into the 7549 from the 8051 microprocessor through a 4bit data bus in three parts. One of the two d-to-a converters is used with comparators and software successive approximation for analogue-to-digital conversion.

Software described consists of two main routines, one for each conversion direction. Output software for d-to-a conversion uses 55 program bytes to transfer the 12 bit digital word from 8051 memory to the 7549 register. This routine takes about 74μs.

Execution time of the 145 byte analogue-input routine varies between 140 and 180 μs depending on the input signal value. This variation is caused by the successive approximation.

For increased bandwidth, the input buffer can be replaced by a sample-and-hold circuit to allow sampling of signals up to 2.7kHz. Details of the s/h circuit are not given in the note.
EWW302

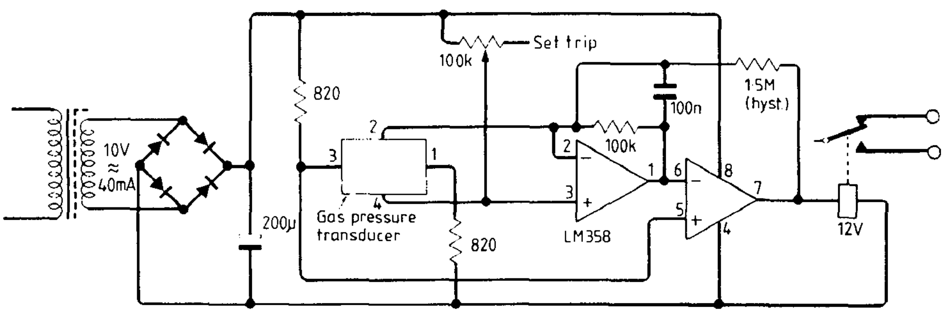


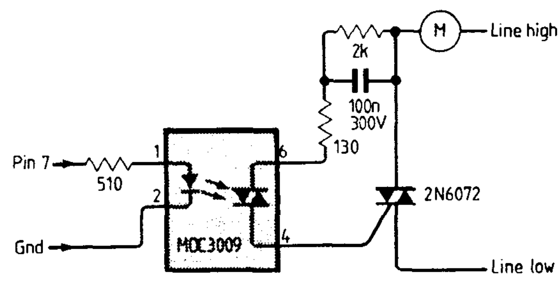
Solid state pressure switch

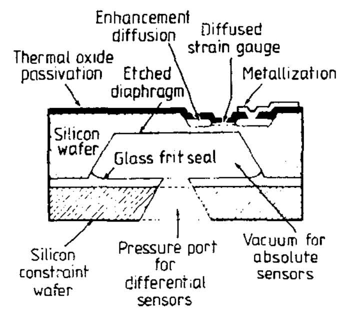
Output from MPX piezoelectric pressure sensors is a millivolt-level analogue signal. By adding two op-amps and a relay, as in Motorola application note AN962, these sensors become simple and economical pressure limit switches.

Construction of the sensor is detailed in the note and there's a table of operating characteristics for comparing various sensors in the MPX range. There are devices for four pressure ranges between 0-10 and 0-200kN/m² (0-1.5 and 0-30lb/in²).

The circuit – with p.c.b. layout – is well described and the note includes suggestions improving circuit performance. Applications of the circuit include compressor motor control, liquid level control and clean-room pressure maintenance.
EWW303







NEW PRODUCTS

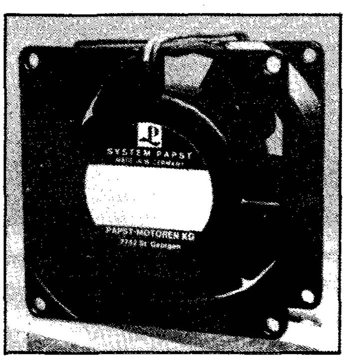
Colour palette on a chip

A resolution of 1024 by 1024 pixels and a virtually unlimited (16 million) range of colours are available through the Am8051 graphics colour palette. The device is a 200MHz d-to-a converter with look-up table ram and video sync mixing. It has inputs for horizontal and vertical syncs and for blanking. Another input enables the overlaying of text or graphics. For high-speed applications, greater than 60MHz, the chip will accept e.c.l. signal levels, otherwise t.t.l. levels are accepted.

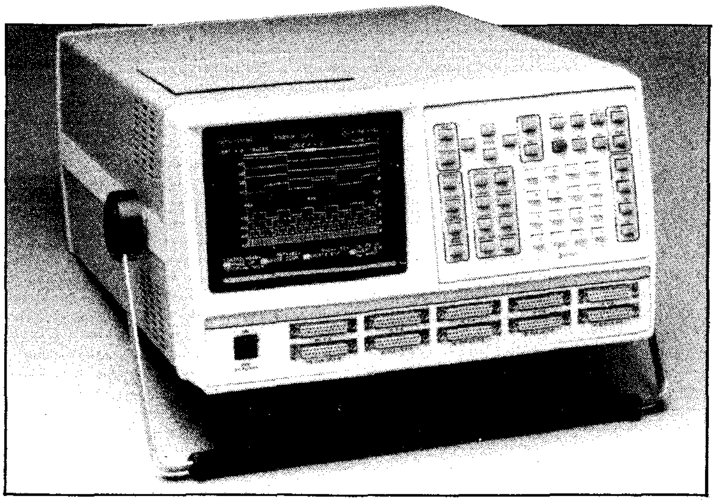
Three of the devices, one each for red, green and blue would be required in a colour graphics system. In monochrome applications, the 8151 can be used as a gamma corrector or as contrast enhancer for image processing. Advanced Micro Devices (UK) Ltd, Goldsworth Road, Woking, Surrey GU21 1JT.
EWW 215 on reply card.

Quiet fan

Suitable for use in office computers or other electronic devices, the Papst 8112GL fan operates from a nominal 12V direct supply. Its noise level is claimed to be 24dBA, quieter than the background noise in a quiet office, it is fitted in a 79mm square frame with a depth of 39mm. Speed, airflow and noise can be adjusted by varying the power voltage between 8 and 16V. Available



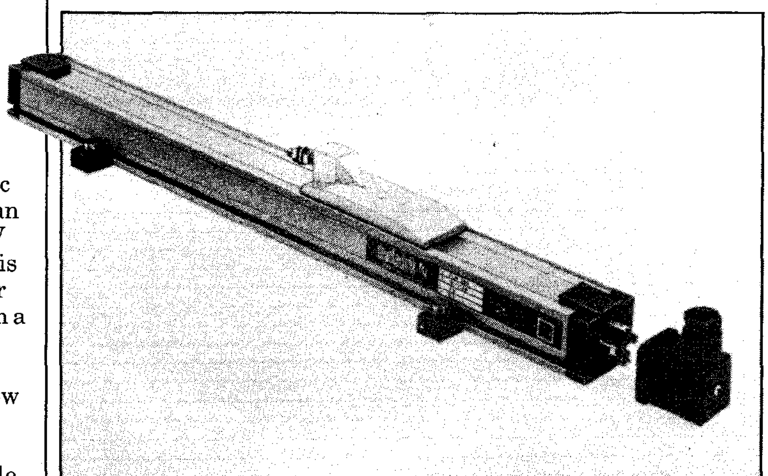
through Dialogue Distribution Ltd, Watchmoor Road, Camberley, Surrey GU15 3AQ.
EWW 218 on reply card.



Logic analyser for microprocessors

New from Gould Electronics is the K115 logic analyser which is specifically designed for use in designing, debugging and testing microprocessor application circuits. It has 32 or 64 channels at 20MHz for logic level and timing in 8, 16 and 32-bit applications and a direct link to either four or eight channels at 5ns, or 8 or 16 channels at 10ns. A major feature is the ability to switch between state and timing modes by push button, without the need to reconfigure the hardware. Gould Electronics Ltd, Instrument System, Roebuck Road, Hainault, Ilford, Essex IG6 3UE.

EWW 229 on reply card.



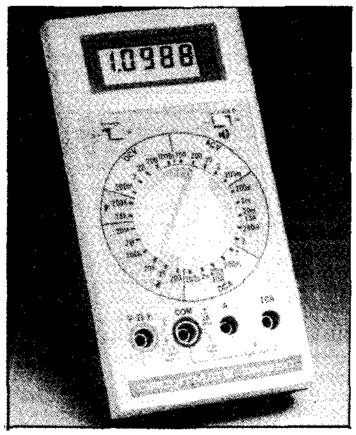
Long-life slide potentiometer

A new wiper design, patented in Germany by Novotechnik, incorporates two wiper arms mounted in line with each other. Their pivot points are on opposite sides of the wiper carrier. Both units act as a single pick-up, providing an average output which lies between the values picked up by each arm. Mechanically the arms operate in opposition and cancel out errors which can be caused under extremes of acceleration and wear. The general result is: more tolerance of spacing between the rack and the wiper; capability of high linear acceleration and a fourfold increase in wiper reliability. The TLH series of potentiometers are available with linearites down to 0.01% and in lengths up to two metres. The rodless design also saves on space. Available through Variohm Components, Cattle Market, Watling Street, Towcester, Northants NN2 7HN.
EWW 219 on reply card.

Frequency-counting multimeters

Built-in frequency counters have been added to two Beckman digital multimeters. DM800 (£135) has average readings for alternating current and voltage, while the DM850 (£175) offers true r.m.s . D.c accuracy for both meters is 0.05%

The frequency counter facility allows measurement up to 200kHz and may be used, for example, on modem tone testing. There is a 'data hold' switch which retains the



current reading on the display. Each meter has five voltage ranges, five current and six resistance ranges. Beckman Industrial Ltd, Queensway, Glenrothes, Fife KY7 5PU.
EWW 211 on reply card.

Compact stepper motors

High torque and performance characteristics are claimed for these compact, lightweight Vextra stepper motors. The PX series of two-phase motors have step angles of 0.9, 1.8 and 3.6°, with versions suitable for bipolar and unipolar drives. Working over a wide temperature range and with high insulation resistance ,the motors are thought to be best used in computer applications such as floppy or rigid disc drives, small printers and x/y plotters. Leeway Data Products Ltd, Central Way, North Feltham Trading Estate, Feltham, Middlesex TW14 0RX.
EWW 225 on reply card.

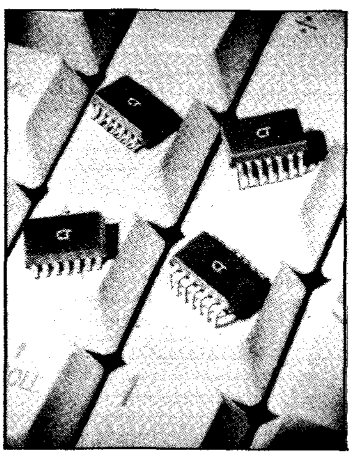
Oscilloscopes from Hitachi

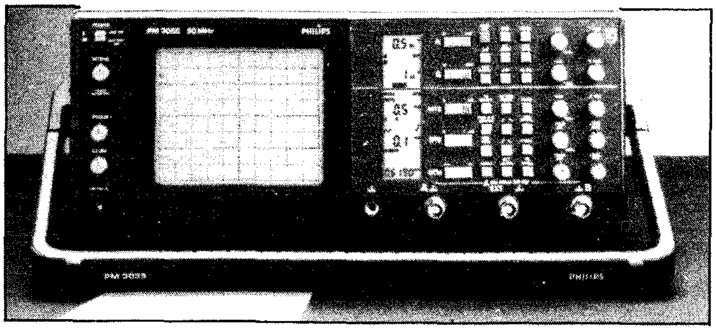
VC6020 costing £1395 is a 1000MHz dual-trace digital storage oscilloscope. It features a maximum sampling frequency of 1MHz, a vertical resolution of eight bits and a storage capacity of 1Kbyte/channel. It has a pre-triggering function. Storage modes are Normal, Hold, Single and Roll, the latter is used for monitoring at very low speeds. The instrument is provided with an output to a chart recorder and a GPIB interface to controllers or to computers for data storage. Hitachi Denshi (UK) Ltd, 13 Garrick Industrial Estate, Garrick Road, Hendon, London NW9 9AP.
EWW 223 on reply card.

Surface mount resistor networks

Resistor networks in miniature packages for surface and through-hole mounting offer considerable space saving on p.c.bs. They can be used in pull-up/pull-down applications and for 7-segment l.e.d. current limiting, d-to-a conversion ladders etc.

These from CorinTech come in two configurations; as seven separate resistors or 13 resistors with a common connection. Standard values are from 10Ω to 1MΩ in the E6 series, with a tolerance of 2%. Other configurations and values are available to order within four weeks. CorinTech Ltd, Ashford Mill, Station Road, Fordingham, Hants SP6 1DG.
EWW 212 on reply card.





Low-cost 50MHz oscilloscope

Two particular features make the Philips PM3055 different. The first is that it has a green button on the front marked 'Auto set'. This automatically adjusts the settings on the oscilloscope to find the trace, scale the amplitude and select the correct timebase and triggering to display the incoming waveform correctly. The second new feature is the large L.c.d. panel which gives a direct readout of all the setting in use. The settings can be easily altered by the use of the rocker switches next to the l.c.d. panel and the series of push buttons to select functions such as timebase and trigger settings. It is possible to have an add-on GPIB interface. The dual trace oscilloscope has the additional ability to display the trigger waveform.

Philips have taken a leaf from the Japanese manufacturers' book to automate the production of the PM3055. It has a one-shot moulded case and all the internal electronics are plugged in easily and quickly. This leads to easy servicing, and a quick-test program through the GPIB interface is used to diagnose any faults. It also leads to the low cost of £850 for a dual timebase unit and £800 for the single timebase. Pye Unicam Ltd, York Street, Cambridge CB1 2PX.

EWW 228 on reply card.

Telecomm i.cs

Several new integrated circuits aimed at the telecommunications, applications specific and modem markets are produced by Exar. One product is the V22/Bell modem chip set which includes switched capacitor filters, a modulator, demodulator, data buffer and V22 filter for full-duplex operation up to 1200bit/s. Another i.c. is a low-power p.c.m. line driver. The bi-directional T1C repeater chip-set provides data transmission at up to 3.152Mbit/s. Other telecomms i.cs are an interface circuit for operation at 2 or 8Mbits/s; and speaker phone chips for use in intercoms, mobile telephone, etc. Exar are also promoting their standard cell approach to application-specific analogue and digital integrated circuits and claim that analogue i.cs can be designed as easily as digital circuits using a building-block approach. Available through Microcall Ltd, Thame Park Road, Thame, Oxon OX9 3RS.

EWW 230 on reply card.

Immersible switches

A series of d.i.l. switches are available which have internal rubber sealing and can be immersed for cleaning. They do not need to be taped up and thus save much time and trouble. The A6D range comes in 'top' or 'side' actuated types and with 4, 6 and 8 ways. The switches can cope with 100mA d.c. at 50V and have a life expectancy of 5000 mechanical switchings. They also save space by being smaller than comparable d.i.l. switches. IMO Precision Controls Ltd, 1000 North Circular Road, Staples Corner, London NW2 7JP.
EWW 213 on reply card.

Extruded enclosures

The traditional die-cast box may have reached the end of the line with the launch of an ingenious range of extruded aluminium boxes by Lincoln Binns Ltd. The Linc-Ace system is based on three standard extrusions, the largest of which is big enough to house a disc drive or medium-sized power supply.

On the outside are dovetails which interlock with those on other units in the range, or can accept fixing brackets or rubber feet. Inside, as well as the usual mounting slots for p.c.bs, is a slide-way into which can go a clever heat-sinking bracket for power transistors up to TO-3 size. On its bracket a transistor may be soldered direct to the board. Yet the user can slide the whole assembly in and out freely without the need to dismantle anything.

The metal panels at front and back can be weatherproof with sealing gaskets. No drilling is required.

All units are obtainable black anodized or with natural finish. In one-off quantities, the natural finish version costs no more than an ordinary die-cast box of the same size. Lincoln Binns Ltd, P.O. Box 110, Haywards Heath, West Sussex RH17 5YU.
EWW 227 on reply card.

Pulsed probe

This digital pulser injects a signal into a circuit node to determine if the device at that node is working correctly. This avoids the need to isolate the device from the circuit. It can inject a 2μs single pulse, or a repeated pulse at 0.5Hz or 500Hz. It can drive a node that is not powered by the host circuit or sense the state and voltage of the node and provide the power to force the node into the opposite logic state. The instrument has a high imput impedance, while output impedance is low to avoid loading the circuit under test. OK Industries UK Ltd, Dutton Lane, Eastleigh, Hants SO5 4SL.
EWW 214 on reply card.

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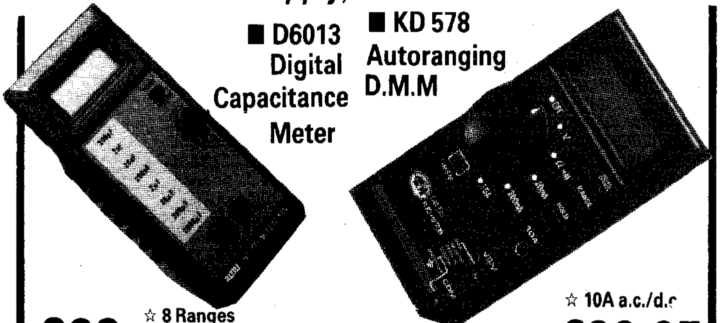

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MicroProcessor Engineering Ltd
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BARCLAYCARD

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SmartWatch

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This real-time clock/calendar from Dallas Semiconductor includes a battery-backed c-mos ram capable of holding data for 10 years.

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Looking like a 28-pin socket, SmartWatch fits into a computer's 8K-by-8bit memory socket* — without any hardware modifications on most computers.

For memory read/write operations, no software modifications are required either.

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

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

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

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

Because of their extremely low power consumption, the 6264-type static memory i.c. and clock/calendar remain powered for 10 years using the same battery.

**JEDEC pinout*

Send to:— E&WW SmartWatch Offer.
M.S. Components, Zephyr House, Waring St., West Norwood London, S.E.27 9LH.
Offer applies to U.K. only. Please allow 28 days for delivery. Price includes data sheet.

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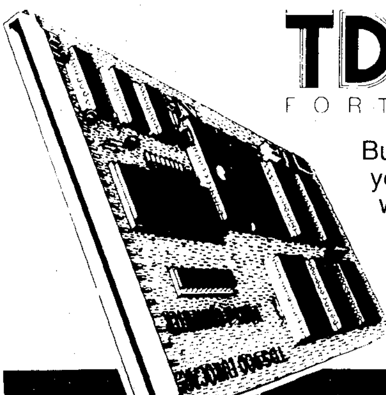

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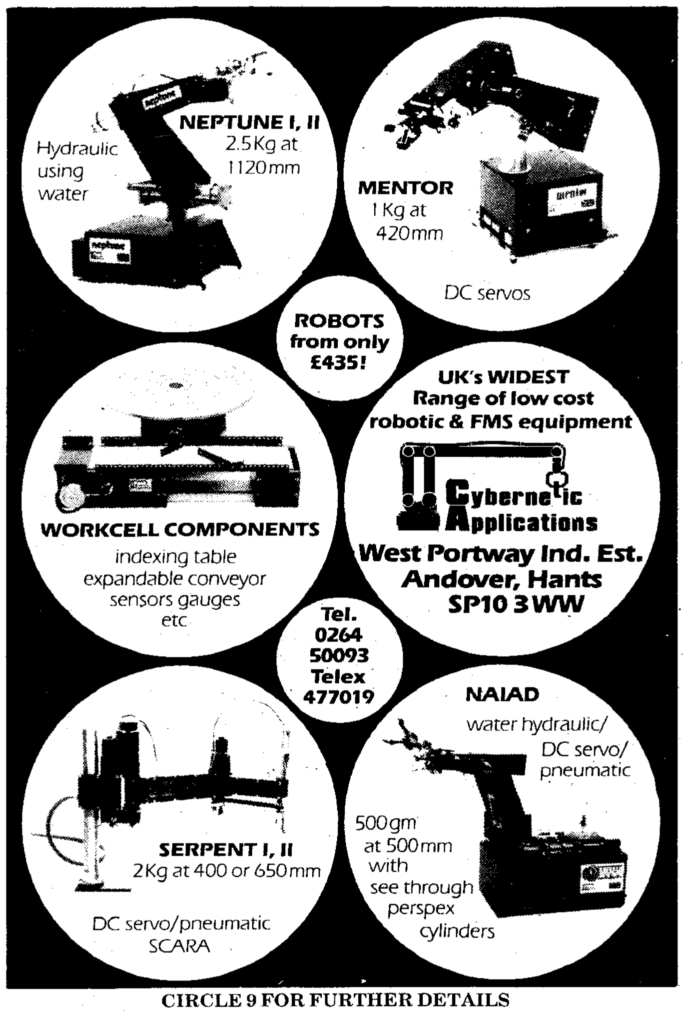
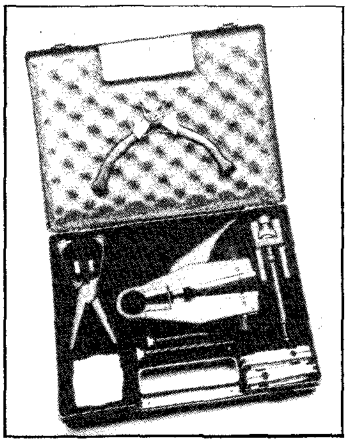


CIRCLE 9 FOR FURTHER DETAILS



Optical fibre tool kit

A tool kit is available that enables all types of optical fibres to be managed easily. Included is Kevlar stripper which can remove Kevlar reinforced protective sleeving up to 6.5mm diameter. A silicon stripper is used for the removal of silicon coatings from the fibres. The Delrin stripping blades are angled so that no damage can be caused to the light guide even if excess pressure is applied. Opti-strip is designed to remove the secondary coating from optical fibres and small cables, less than 2.5mm diameter. Damage to the core is prevented by the insertion of guide bushes which ensure the precise location of the fibre in relation to the stripping blades. Depth of cut is infinitely adjustable. These tools, along with precision screwdrivers, cable cutters, and a complete set of spare cutter blades for each tool are housed in a toughened plastic carrying case. K-Tech Micro Precision, 18 Barton Road, Bletchley, Milton Keynes, MK2 3JH.
EWW 220 on reply card.

Gender changers

A solution to the problem of how to connect a male connector to another male connector is to give one of them a sex change! A range of adaptors and gender changes for subminature D-type connectors is available from Ceep, Unit 7, Haslemere Industrial Estate, Weydown Road, Haslemere, Surrey GU27 1DW.
EWW 217 on reply card.

68000 second processor for BBC

A second processor for the BBC features the full 68000 16/32 bit processor. Intended for the professional and educational markets the system enables the study of 68000 software and hardware. The system monitor included on the board enables the user to load and execute programs, examine and dump the memory, alter 68000 registers, load the BBC memory to the 68000, or from the 68000 to the BBC and execute all BBC osbyte calls. It is possible to step through a program with a register dump following each step. The board has a Eurocard connector to enable expansion of the data, address and control lines. All the usual BBC peripherals; printers, disc drives, analogue i/o etc. can be driven from the 68000.

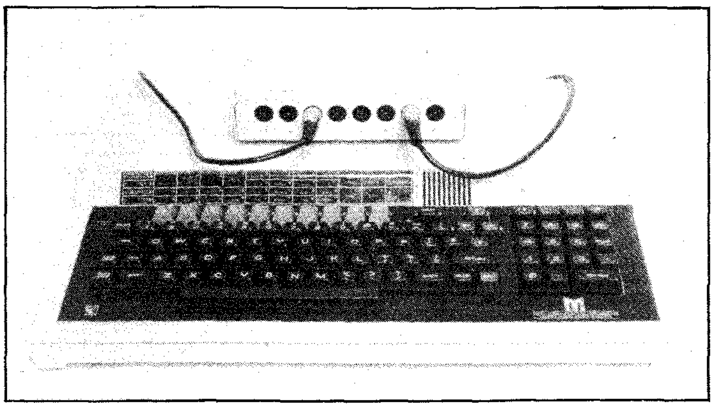
The board comes with 128K ram, assembler, monitor and BBC link in eprom, two systems discs, connecting cables and fixings, and three manuals. All for £299. Delcomm Microcomputer Systems Ltd, 46 Nasmyth Road, Glenrothes, Fife KY6 2SD.
EWW 208 on reply card.

...and a user port extender

When a user wishes to add serial printers, modems, touch screens or such special input devices as mice or tracker balls, the BBC is somewhat limited by the serial interface provision. The need to use a touch screen within an interactive video workstation led the National Physical Laboratory to develop the Soft Switch. This uses the software of the BBC's operating system to select one of eight devices which can be permanently connected to the computer through 5-pin DIN connectors on the Soft Switch. The switch itself connects to the computer through the user port. By controlling the handshaking of the eight peripherals it is possible to ensure accurate data transfer in complex configurations.

The Compton Soft Switch is manufactured under licence from the NPL and marketed (£165) by Soft Option Ltd, Imperial House, Lower Teddington Road, Kingston, Surrey KT1 4EP.

EWW 209 on reply card



Z80000 cpu uses 32 bits

Where high speed and/or large system tasks need to be performed, the Zilog Z80000 is ready for the job; says Hi-Tek. The chip is provided with 16 registers which can handle 8, 16 or 32-bit words. It can also use 16 or 32 bit addresses and has a 256Kbyte on-chip cache which can store the most recently used logical addresses and instructions. This is coupled with an instruction pipeline and a memory management unit. There is also a clever error-trapping mechanism. The Z80000 series uses Zilog's Z-bus and can be used with the full range of Z8000 support chips. Hi-Tek Electronics Ltd, Beadle Trading Estate, Ditton Walk, Cambridge CB5 8QD.
EWW 210 on reply card.

Mosfet power amplifiers

Modular 60W power amplifiers can be fitted in parallel to provide outputs of 120, 180, or 240W r.m.s. Powerblocs, developed by Audix, are incorporated into the Wenden range of integrated mixer/amplifiers. The mosfet modules are inherently protected against short and open-circuit, and their modularity enables the use of multi-channel outputs within a single rack unit. Audix managing director, John Billet, said that they had achieved a method of providing a wide range of outputs in mixer and power amplifiers using as few building blocks as possible. Audex Ltd, Wenden, Saffron Walden, Essex CB11 4LG.
EWW 221 on reply card.

TV tuner on a chip

Push-button synthesized selection of up to 39 tv stations is provided by the SAA1293 integrated circuit from ITT. The device uses voltage synthesis rather than frequency synthesis thus reducing the number of components required and the cost. Tuning voltage is generated by a 12-bit d-to-a converter. Three outputs for uses such as volume, colour intensity and contrast control are also provided. As well as direct station selection the device offers sequential selection, automatically scanning through the stations at intervals. The control program, held in the chip's onboard rom, contains a number of alternative program paths. A companion non-volatile memory chip provides storage of station tuning and analogue settings. Simple setting of flags within the memory permits the addition of extra features, such as picture fade when changing stations. The 1293 offers a direct interface to a standard teletext chip set and is operated from 32-key pad. ITT Semiconductors, 145 Ewell Road, Surbiton, Surrey KT6 6AW.
EWW 222 on reply card.

Appointments

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Department of Biochemistry

RESEARCH ASSISTANT GRADE 1B

(Ref: BC/151)

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The salary will be on the scale £7055 – £10,865 depending upon age, qualifications and experience.

Applications should be sent with the names of two referees to:

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South Parks Road
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not later than 31st May, 1986

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Appointments

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Home Office

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BROADCAST ENGINEER

Swansea Sound, one of Independent Radio's longest established and most successful stations, invites applications for the post of Broadcast Engineer. The successful applicant should be qualified to a minimum of HNC/HND or equivalent; and experience in all aspects of sound broadcasting engineering, or an ability to quickly adapt to this field, is desirable.
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Applications in confidence to:
Mike Winson, Chief Engineer, Swansea Sound, Victoria Road, Gowerton, Swansea SA4 3AB.
Or telephone (0792) 893751 for further information.

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LANCASHIRE POLYTECHNIC AT PRESTON

Faculty of Arts

Applications are invited for the following posts:

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Applicants should be experienced in audio/visual production techniques and should have sufficient technical expertise to undertake routine maintenance of workshop equipment.
Ref: NT/86/87/8.

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Ref: NT/86/87/9.

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36¼ hour 5 day week: posts superannuable.

Application form and further details obtainable from the Personnel Office, Lancashire Polytechnic, Preston PR1 2TQ, quoting appropriate reference.
Closing date: 30 June, 1986.

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THE SERVICES SOUND & VISION CORPORATION

ENGINEERING MANAGER (COMPUTERS)

Ref: 4/59

We currently have a vacancy at our Buckinghamshire headquarters for an Engineering Manager to initiate and eventually lead a computer engineering section within our Engineering Support Department.

Applicants will be expected to hold a relevant degree, H.N.D. or equivalent and have had detailed experience of business computers and computer systems in general (I.B.M. and Apricot in particular). Some experience of interactive video systems would be an advantage.

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Mrs Diane Trigg, Personnel Manager,
The Services Sound & Vision Corporation,
Chalfont Grove, Gerrards Cross,
Bucks SL9 8TN.

Closing date: 3rd June, 1986.

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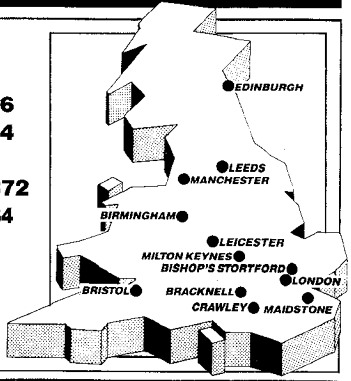

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Further details of the post are available from the Chief Engineer's Office at the Television Centre (622 9966).

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Applicants should have relevant training and experience in servicing the requirements of film and video cameras together with the associated location lighting equipment, in television or documentary film environment.

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Application form and full job descriptions for all the above posts from Personnel Services Department, PS4/a, Room 366, The County Hall, London SE1 7PB. Please enclose S.A.E.
Closing date for completed application forms is 27 June 1986.
These posts are suitable for job share.
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Appointments

THE UNIVERSITY OF LIVERPOOL
Department of Geological Sciences

Technician Grade 5 (Electronics)

The appointee will be required to assist in the development and construction of geophysical research equipment and will be responsible for the maintenance, repair and testing of electronics equipment used for both geophysical research and teaching.

Applicants should hold an H.N.C. or appropriate equivalent qualification and have a minimum of seven years electronics experience. Experience in analogue and digital electronics would be an advantage.

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Application forms may be obtained from The Registrar (NAS), The University, P.O. Box 147, Liverpool L69 3BX. Quote ref: PER/956/WW 241

"THE VOICE OF PEACE" radio station, situated in international waters off Tel Aviv, urgently requires a broadcast transmitter engineer to maintain the transmitters on board. Must be fully experienced in this field. Please write for further information, giving full details of experience to "The Voice of Peace", PO Box 4399, 13 Frug Street, Tel Aviv, Israel. (Please include your telephone number and code.) (253)

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Further details and application forms (returnable as soon as possible) may be obtained from the ***Assistant Registrar, UWIST, PO Box 68, Cardiff CF1 3XA.*** 226

Appointments

Appointments

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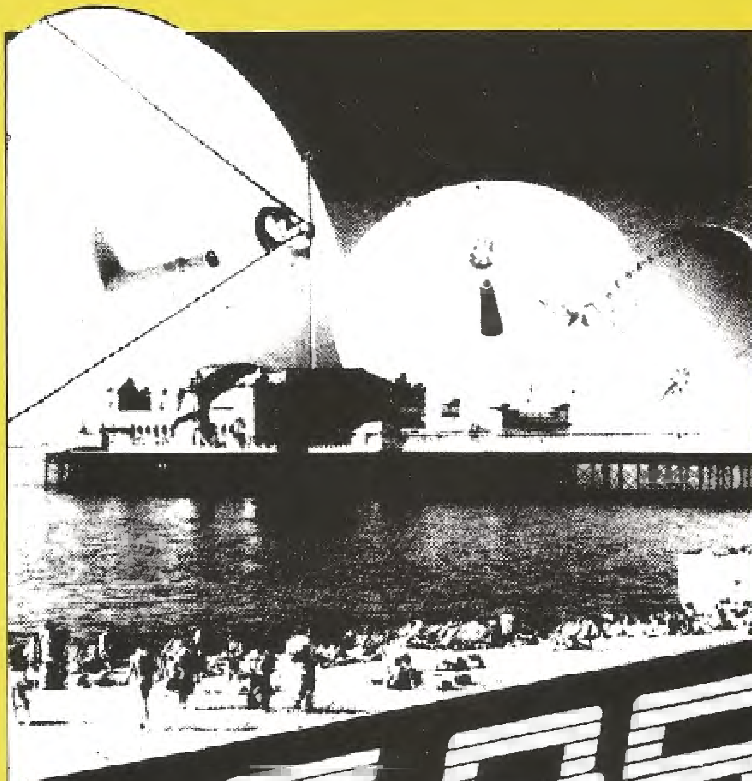

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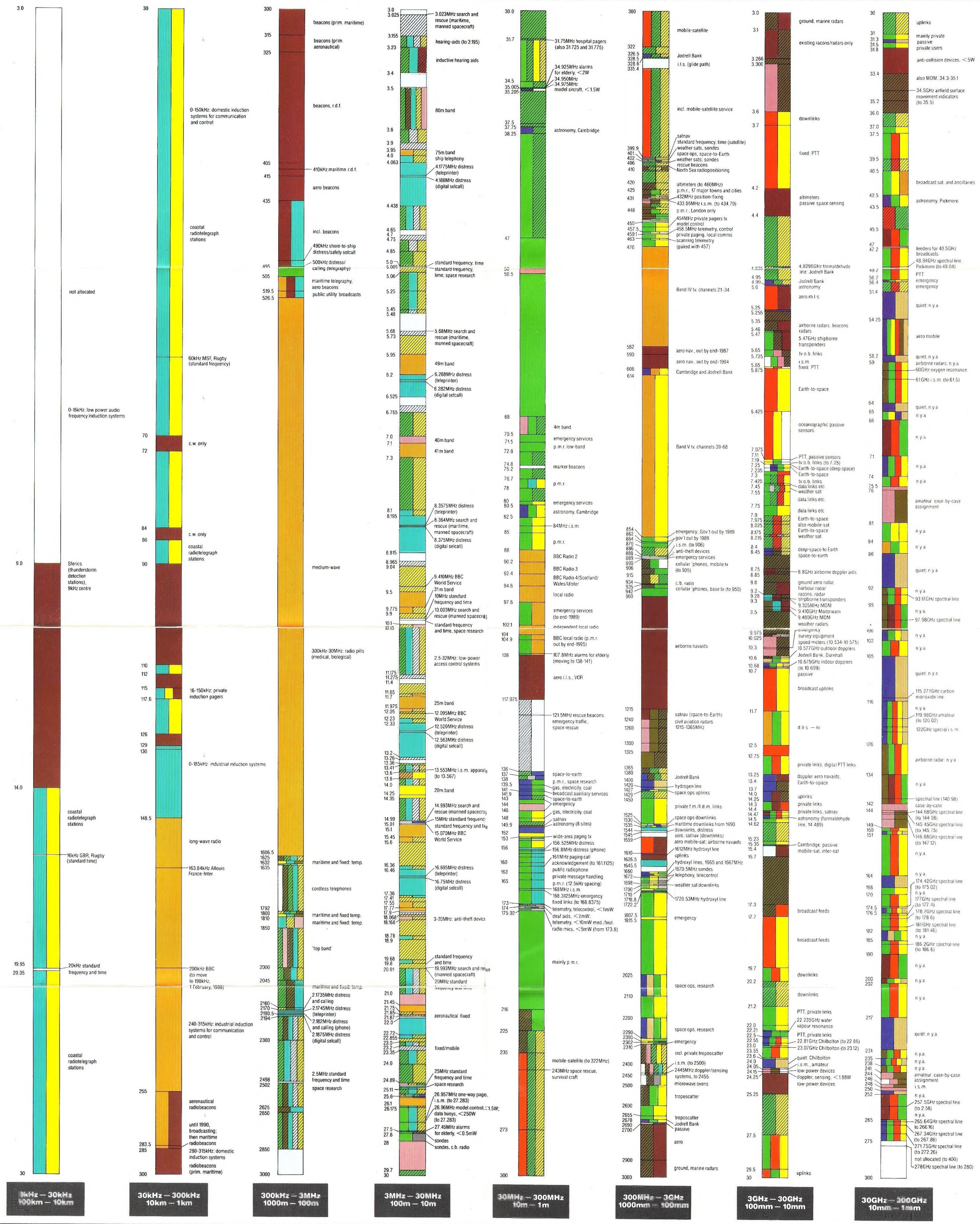
Wallchart of frequency allocations



This chart summarizes frequency allocations in the United Kingdom as they stood at the beginning of 1986. Assignments in Britain are based upon the Radio Regulations of the International Telecommunications Convention, to which the UK is a party. On the world radio map, Britain forms part of Region 1, which also includes Europe, Africa and Soviet Asia.

For more information about individual bands, consult the United Kingdom Table of Radio Frequency Allocations, published by Her Majesty's Stationery Office; or contact the Radio Regulatory Division of the Department of Trade and Industry at Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Some abbreviations used in the chart

- c.b. citizen's band radio
- c.w. continuous wave transmission
- i.l.s. instrument landing system
- i.s.m. industrial, scientific, medical
- m.l.s. microwave landing system
- n.y.a. not yet allocated in the UK
- p.m.r. private mobile radio
- r.d.f. radio direction-finding
- temp. temporary assignment

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