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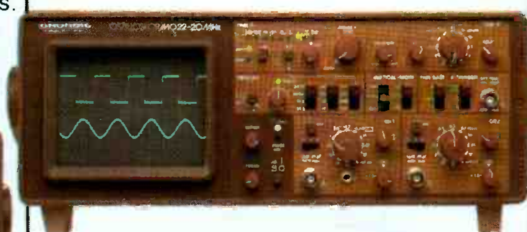

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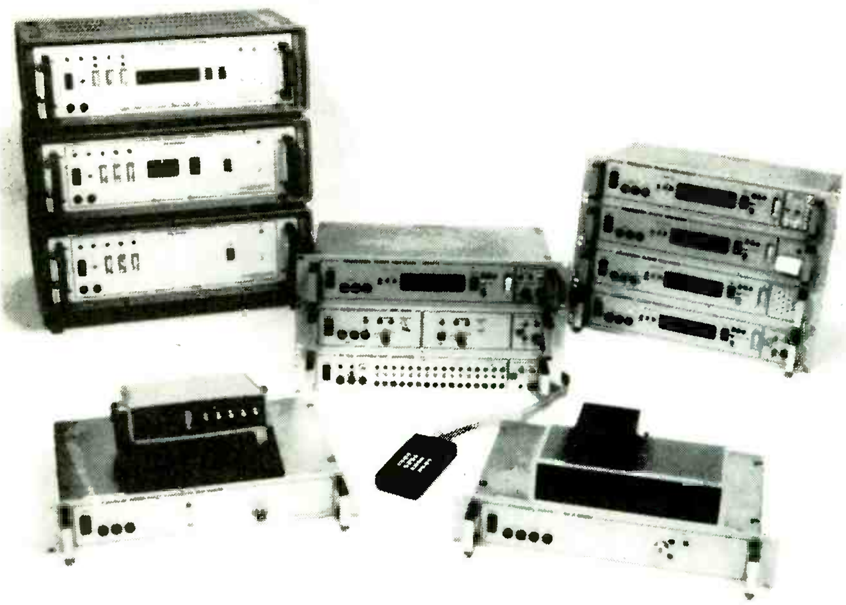

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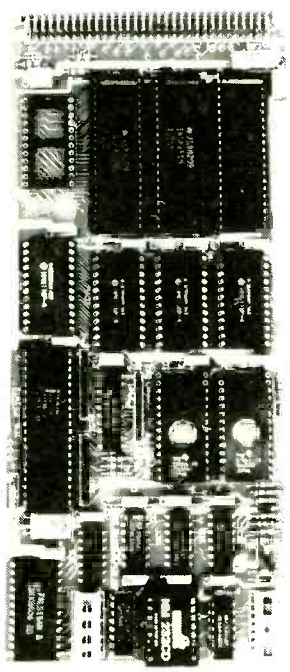

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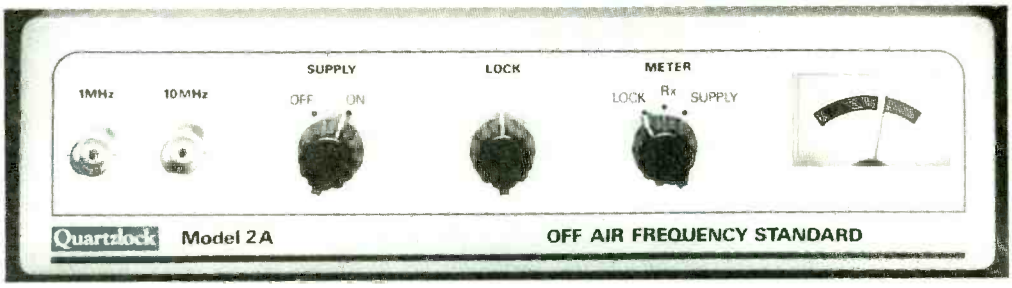

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This real-time clock/calendar from Dallas Semiconductor includes a battery-backed c-mos ram capable of holding data for 10 years.

SmartWatch keeps track of:

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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*

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Offer applies to U.K. only. Please allow 28 days for delivery. Price includes data sheet.

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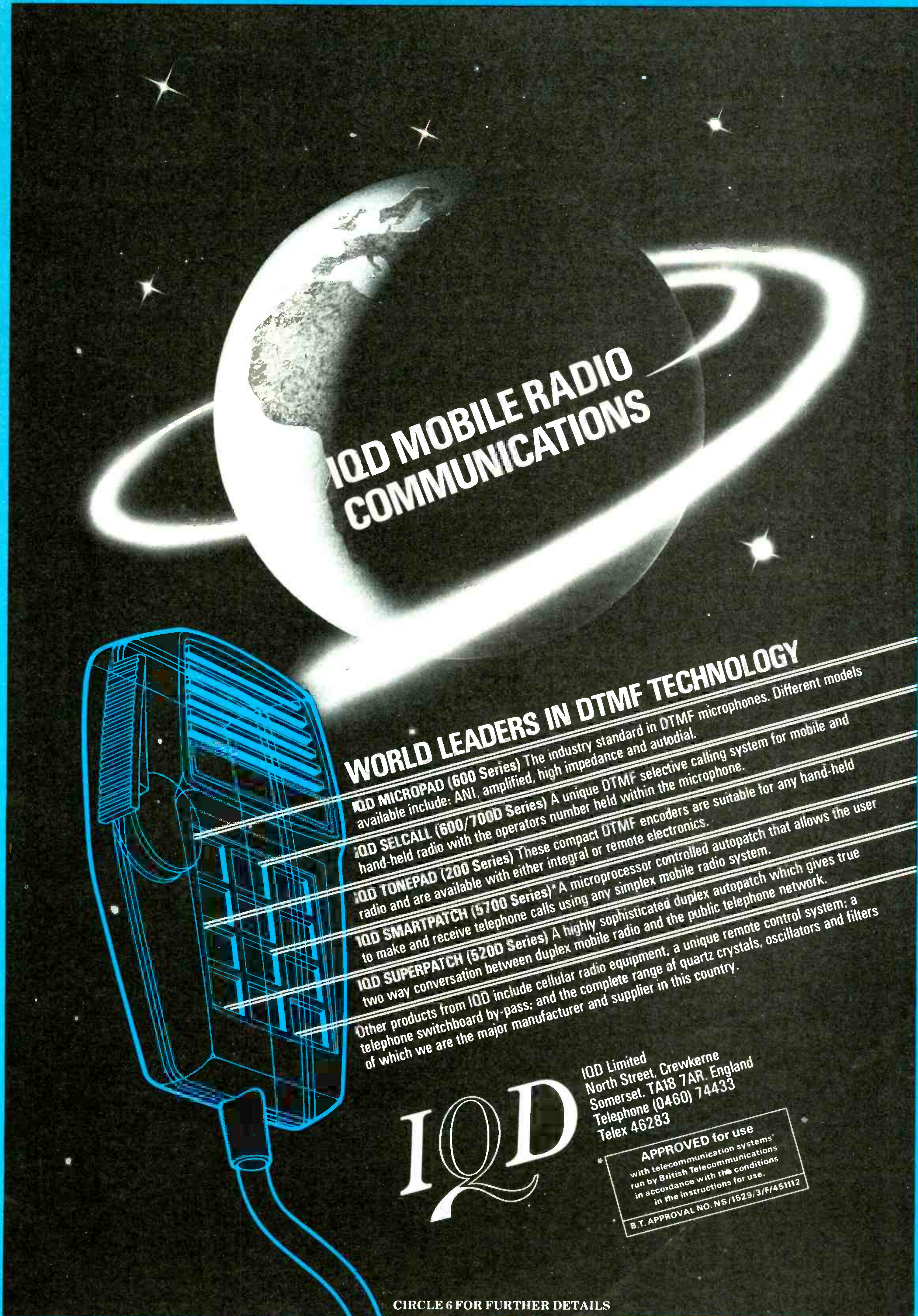

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NEWS COMMENTARY

Dull start for new broadcast exhibition

"Broadcast 86" was held at Frankfurt's Trade Fair centre June 24-27. Europe already has a major international broadcast show each year (IBC in Brighton and the Montreux TV symposium in Switzerland are held in alternate years). "Broadcast" is a newcomer to the European professional broadcast exhibition calendar and Frankfurt Trade Fair say they want it to become the number one show in Europe, on a par with NAB in the US.

However, the first "Broadcast" was more like a local German show than a major international event. Many major broadcast manufacturers were conspicuous by their absence. Ampex, Bosch, Philips, Rohde and Schwarz and Thomson were all absent as exhibitors.

The show's organisers put the poor turn-out down to the short notice at which the show was launched.

The low-level international support for "Broadcast" can also be accounted for by the view held by many major broadcast equipment manufacturers that Europe already has enough broadcast exhibitions with IBC and Montreux.

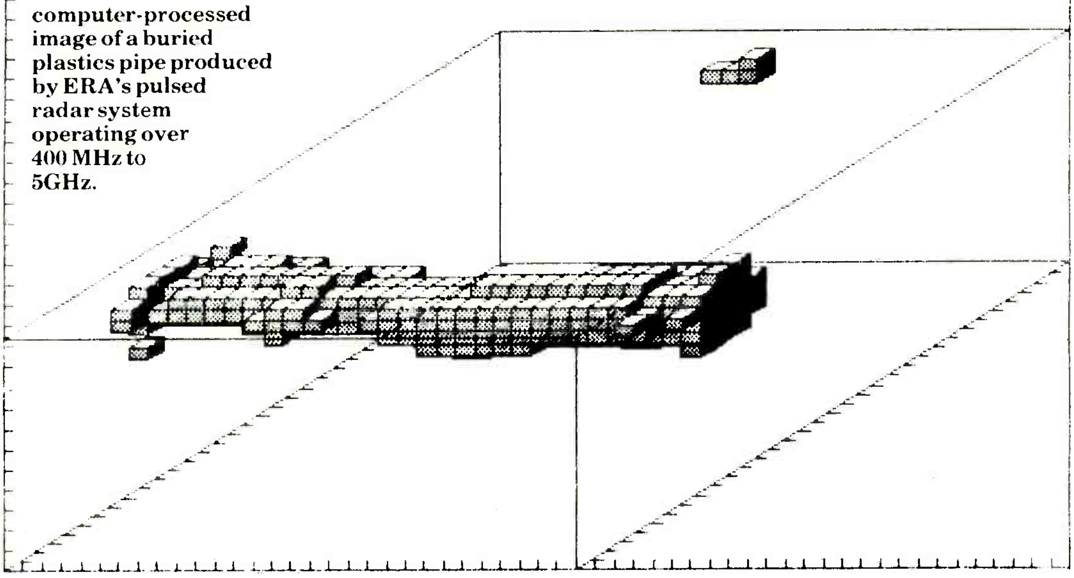
There are also an increasing number of smaller national broadcast exhibitions. France now has 'Antenne' in October, Italy has a new broadcast and telecommunications show in Milan this September.

"Broadcast 86" on its first showing was a dull show for the international visitor, but the excellent exhibition facilities available at Frankfurt may attract larger international support if the planned "Broadcast 88" ever goes ahead.

Radar probes ground

Hidden plastics objects can now be located underground through radar technology developed by ERA Technology. The new system uses a pulsed radar to 'illuminate' the ground through dispersionless antenna elements. A sampling receiver has been designed to detect the signals. Digitizing the return signals enables advanced signal processing algorithms to produce accurate pictures of the buried objects. A detection map can be produced, showing the position in a searched area both in plan view and in cross section if depth information is needed. Developed for and funded by the MoD, the technology can be applied to a variety of civil and military tasks. Civil applications include structural inspection of reinforced concrete or other building applications and detection of pipes, including plastics pipes.

Three-dimensional computer-processed image of a buried plastics pipe produced by ERA's pulsed radar system operating over 400 MHz to 5GHz.



Memory telephone dialler

Number storgae and dialler i.c. UM91610 from UMC used in T. Segaran's March article, is available through Manhattan Skyline, Katakana Ltd, Manhattan House, Bridge Road, Maidenhead, Berkshire SL6 7DB at £1.85.

We are told that the 91610 is pin compatible with the obsolescent MM53143/44 and the AM125610. The AMI chip has no confidence-tone output.

Satcom 87

A new Satellite Communications exhibition is to be included in the British Eelctronics Week 1987, the continuously expanding successor to the All-Electronics Show organised by Evan Steadman. The exhibition will be held alongside the other events at 'The Week' in London's Olympia from 28 to 30 April 1987, now comprising seven concurrent exhibitions: All-Electronics/ECIF Show, Circuit Technology, Fibre Optics, Electronic Product Design, Automatic Test Equipment, Power Sources and Supplies and now Satellite Communications.

At a presentation to potential exhibitors and the press at The Cafe Royal in July, Evan Steadman said that Satellite Communications was 'a natural' to add to the list. "We've done our homework and it's quite apparent that what the satellite industry needs is a professional show" said Steadman "right here in the middle of London." Situated on the top floor served directly by lift, the 75-stand show will cover professional satellite equipment, including receiving dishes and associated technology, up and down-link communication equipment and signal processors, as well as domestic receivers, programme services, marketing problems, and commercial exploitation of data communication and video conference services. A conference is planned for 1988 when Olympia will have its own conference facility. Next year's show is expected to attract European exhibitors as well as visitors, and the event will be supported by the journal that carried that pioneering article...

● Wearing two hats enabled one editor present to complain bitterly of the timing. Claiming to be chairman-designate of a newly formed 14-member European Satellite TV Association he revealed that 'Cable & Satellite 87 would be held a month earlier, also in London. As space runs out we have no room to tell you of the mud that was thrown...

Design award

A tape-slide programme, with a booklet and teaching notes, to enable students to produce a simple microcomputer has been granted a design award from the Design Council. The award for £16,000 to Selwyn Houghton, Lecturer in Engineering at Wakefield District College is sufficient to complete the project.

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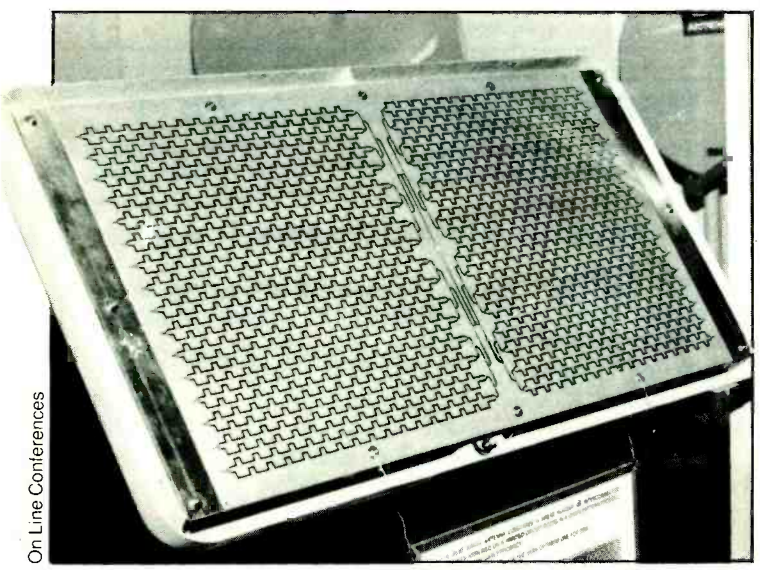
Digital tv standard now...

A universal standard has been recommended by the CCIR (International Radio Consultative Committee) for digital video interfaces and for recording digital tv signals onto tape. The standard is based on that selected by the CCIR for video encoding which stipulates the use of digital component signals, sampled at a rate of 13.5MHz for luminance and 6.75MHz for the two colour difference signals. Digital coding of the component signals, rather than conventional composite signals, offer great benefits to broadcasters and programme producers, says the report of the committee, since it allows almost unimpaired post-processing capability; special effects, electronic tricks and picture manipulation can be performed on recorded signals with the same level of quality that would be achieved if they were performed 'live' on the studio output signal.

...h.d. tv standard later

The CCIR also decided at their recent meeting in Dubrovnik to tackle the standardization of h.d. tv. But this is unlikely to follow such a smooth path as the digital standards; there are a number of national factions, each rooting for its own system. Main contenders are the Japanese system which is concentrating on the studio production standard; the Europeans would like to see an integrated production, transmission and receiver standard based on the MAC family developed by the IBA. The CCIR does however recognise the need for a single international set of parameters and a working party is planning to offer recommendations to a meeting of a study group in 1988. Those recommendations should be adopted by the plenary assembly of CCIR in 1990.

This flat antenna array comprising 64 interconnected elements on an etched circuit board is claimed to have extremely high gain. No performance figures were available for this 'optimum' d.b.s. antenna, shown at Cable '86 by DX Antennas of Japan. Report on page 30.



On Line Conferences

New transmitters for IBA television

As part of a £40M scheme to replace its u.h.f. transmitters, the IBA has signed a contract with Marconi worth £7.5M for the first 14 of them. The transmitters have powers of 15, 25 and 40kW and use pulse operation for the external-cavity klystrons to give peak sync efficiencies of about 70%. This means that they use about half the electricity of the transmitters being replaced and can pay for themselves in terms of saved electricity bills.

Using the same transmitters at all the IBA sites will also save on maintenance costs as the number of different spare parts needed will be greatly reduced.

The transmitters have the capability of sending two sound channels. Although there is no short-term plan for the IBA to introduced stereo tv services, the possibility is available and future competition from cable, satellite or other services might precipitate stereo sound.

Despite the future advent of d.b.s. services, John Whitney, IBA director-general, believes that there will be a continuing need for terrestial tv, particularly in the regional services which could not be offered by satellite for a long time to come. Meanwhile the existing terrestrial u.h.f. transmitters, at 20 years old are reaching the end of their useful life and need to be replaced anyway. The new transmitters are expected to have a similar lifespan.

Automation for social security computers

Five hundred local security offices are to be computerized and linked through a network to each other and to the central offices in Newcastle-upon-Tyne and North Fylde. This will eventually enable any claimant to discuss and obtain benefits and entitlements from any DHSS local office or unemployment benefit office in Britain.

The contract to provide the complete, integrated terminal system has gone to British Telecom, and will include the supply up to 1000 minicomputers and 28 000 terminals. It will also involve development, implementation and maintenance of software to last well into the next century. The first installation, at the Newcastle main office, will be used for accessing the retirement pension records. It is due to be brought into regular use by the end of the year.

Three main subcontractors are Information Technology Ltd, who supply 32-bit minicomputers adapted to BT's design from its Momentum 9000 family, Newbury data, who supply displays to BT design and three designs of printer, and Real Time Developments whose flexible lan will be used to link terminal and computers within a site. BT themselves plan a full OSI network to link all the offices together and to various mainframe computer centres which process benefit claims and enquiries.

In Brief

Amateur, CB radio, and tv licence fees are unaffected by the new scale of fees announced by the DTI. Most other fees have been increased by an average of about 18%, varying depending on the service. The full list is published by the DTI. Wireless Telegraphy (Licence Charges) Regulations 19865 (SI 1986/1039, HMSO £1.90).

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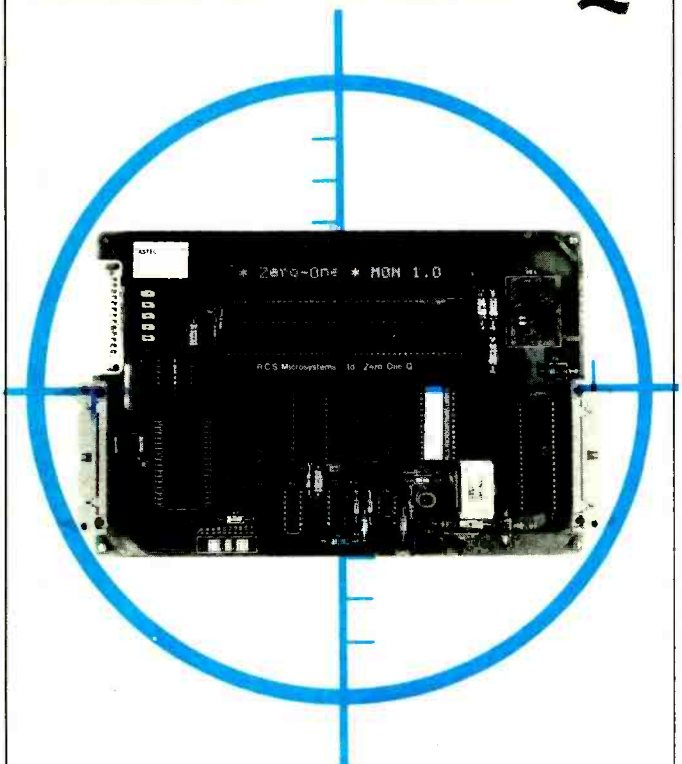
Get in control with the Zero-One-Q



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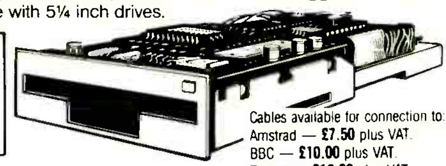

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COMMUNICATIONS COMMENTARY

Two conferences, held within days of each other in July, provided a good opportunity to catch up on current trends in radio communications research and development in commercial applications, military communications, university and Rutherford Appleton Laboratory projects, broadcasting and the world of amateur radio. The IERE Radio Receivers conference at Bangor, with 130-plus delegates, allotted some 25-35 minutes to each of over 30 papers. The URSI National Colloquium at Birmingham with about 65 delegates skipped through 26 papers at a rate of three or four an hour in a range that varied from far-out fundamental physics to the workaday world of measuring h.f. radio noise levels in ships (worryingly high!).

VLF errors

An excellent example of how a project that starts out primarily to confirm other people's work can develop into a discovery of considerable practical significance was the account at the URSI colloquium by Dr R Barr (New Zealand DSIR, currently at Kings College, London) of his investigation of v.l.f radio propagation over the Antarctica icescape. Initially his object was to confirm earlier work in Greenland and North America of the greatly increased attentuation of Omega navigational signals when they pass over thick layers of ice. However by making a synthetic aperture directional analysis of signals received during some routine flights to the New Zealand base in Antarctica he has shown that not only are the Omega signals greatly attenuated but they are in effect diffracted around the ice with the result that any signals with paths crossing or skirting large ice layers are "bent" out of their great circle paths, the arrival angle changed and resulting in false Omega readings. He points out that while Omega is seldom used as a radio-navigational aid above the Antarctic icescape, the effects could apply over significantly large areas of the Pacific.

Hazards

Dr P.S. Excel (Bradford University) who is examining probabilistic factors in the spark and ignition hazards arising from electromagnetic radiation is clearly convinced that the present British standards (BS6656 and BS6657) do not take enough account of the unlikelihood of a number of theoretically possible hazards arising at the same time. He questions, for example, "Why are not petrol stations blowing up willy-nilly around high-power m.f. transmitters?" and points out that most other industries accept some small level of "statistical" risk in their operations. I suppose he is right, although it does appear to some of us that his probabilistic theories fly in the face of Murphy's Law that if anything can possibly go wrong it will do so at the most inopportune moment. Perhaps of equal concern was his open admission of what has long been evident: that BSI committees are being leaned upon by Government, including the Health and Safety Executive as well as industry representatives, to accept compromises rather than to stick rigidly to "worst case" solutions.

Cross-polar puzzle

At Birmingham, J.E. Doble of British Telecom Research showed how even the relatively stable microwave spectrum can still spring curious surprises that can cause unexpected outages of digital links.

An experimental 6GHz link over a 51km hop is designed to pass 140Mbit/s data in a cross-polarization mode. Initially problems were experienced during cross-polar interference due to the lack of off-axis cross-polar isolation of the dish antennas. These were redesigned to provide some 48dB isolation reducing to not less than about 38dB off-axis, and it was expected that this would solve all the problems. A nasty shock came in April 1984 when cross-polar degradation occurred not only in the form of short frequency selective spikes but closely correlated to the slow fades that commonly denote tropospheric propagation, resulting in outages extending over five hours on circuits intended not to show outages not exceeding 28 seconds in any month.

Nor did this prove to be a one-off event. Similar effects were observed in February 1985 and enquiries showed that this unusual effect has been observed from time to time in West Germany, though this had not been reported internationally. It is now believed that such conditions can occur perhaps once or twice a year although difficult if not impossible to predict.

Present thinking suggests that in certain weather conditions a temperature inversion can occur about 200 metres above ground level and super-refraction conditions tends to be forced down even below the height of the microwave towers.

British Telecom are being forced to undertake an extensive monitoring programme to determine whether such conditions occur only in the coastal areas of East Anglia or, as seems likely, over the whole country. It is leading to the conclusion that if communicators are to use spectral-efficient systems operationally somebody will have to do a lot more work on cancellation techniques.

Communicating

A major part of British communications R&D is directly linked to defence applications. There were times, particlularly at Bangor, when one felt that engineers are endlessly involved in chasing their own tails. First you develop a system. Then you develop electronic countermeasures against your own system. Then you change your own system to provide electronic counter countermeasures... and then knowing the weaknesses of your own system you once again set out to destroy its capability. Gradually the systems become more and more complex, more and more under software control (despite the difficulty of finding and correcting software errors under field conditions). Then you start a programme to reduce size and cost and based on the assumption that the Services are morons led by donkeys, and already leading to a confusion of the role of, for example, the Royal Signals with that of the Platoon signallers.

In the second of two 'key note' addresses at Bangor, Professor William Gosling of Plessey spoke eloquently of the danger of explosive growth of communications traffic but warned that we are taking too little account of the need for spectrum conservation. He bitterly attacked the use in the sections of Band III released to land mobile of "Armstrong's nightmare child" (i.e. frequency modulation) and the widespread use of excessive transmission powers. He regretted that the study of transmitters is not a fashionable subject, with only one university group engaged in such work. More should be done to develop digital vocoders which, combined with voice synthesizers, could result in voice channels narrower than that of 100-baud teleprinter circuits, he suggested.

Listening to the many new ideas for real-time channel evaluation, the wonders of spread spectrum and the like, it at times seemed that it might be more sensible to investigate not how much more information we can cram into the finite radio spectrum but whether users really need to be given an open-ended facility. Traffic expands to fill the channels available. But do we, civilian or military, really need to be able to speak to anyone at any time? Tell someone that they are limited to a few short telegraphic signals per day and it can concentrate the mind wonderfully.

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E55L	56 00	EL803S	9 95	3 500Z	85 00	6CB6A	1 80	5867A	140 00
E80CC	14 00	EL821	13 75	3B28	15 00	6CJ3	2 30	5879	6 15
E80L	21 00	EN32	16 25	3C45	24 50	6CW4	6 30	5965	2 20
E88CC	3 90	EN91	2 00	3CX100A5	35 00	6DQ6	2 45	5991	32 00
E90CC	7 50	EZ80	1 60	4 65A	52 50	6E5	4 20	6130	24 50
E130L	21 25	EZ81	1 50	4 125A	60 00	6EA8	2 25	6146A	9 00
EB91	1 35	EZ90	1 50	4 250A	76 00	6GK6	2 50	6146B	9 00
EBC91	1 10	FG17	24 50	4 400A	80 00	6HF5	4 25	6360A	4 95
EBF89	1 35	FG105	160 00	4 400B	80 00	6HS6	3 95	6550A	7 25
EC90	1 25	GXU1	15 00	4 400C	80 00	6JB6A	4 20	6883B	8 70
ECC32	3.25	GXU4	45 00	4B32	30 50	6JE6C	6 25	6973	3 95
ECC81	1 60	GZ34	2 10	4C35A	135 00	6JS6C	4 70	7027A	6 50
ECC82	1 60	KT66	9 00	4CX250B		6K7	2 50	7199	4 20
ECC83	1 60	KT77	8 75	EIM AMP	55 00	6K11	2 25	7247	3 20
ECC85	1 85	KT88	24 95	4CX250B		6KD6	5 90	7262A	26 00
ECC88	2 00	ML8536	275 00	NAT	48 00	6KD8	2 00	7360	12 20
ECC91	2 00	ML8741	265 00	4CX350A	87 00	6L6GC	3 90	7586	11 50
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ECF80	1 50	QQV02-6	22 00	5AR4	2 10	6Q11	2 25	7591A	4 65
ECF86	1 65	QQV03 10	5 30	5AS4A	2 10	6SL7GT	2 25	7815AL GE	48 00
ECF801	1 80	QV03 12	7 00	5R4GYA B	3 50	6SN7GTB	3 05	7815R	53 00
ECH81	2 30	QY3 65	57 50	5U4GB	2 10	6U8A	2 00	8122	101 00
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EF85	3 00	RG4 3000	90 00	6AK6	1 95	12BA6	1 80	807	2 90
EF86	2 30	XG1 2500	52 50	6AL5W	1 80	12BA7	2 35	810	75 00
EF89	2 30	XG5 500	24 50	6AQ5A	1 75	12BE6	2 00	812A	36 85
EF91	2 95	XR1 3200	72 50	6AQ5W	1 80	12BY7A	2 70		
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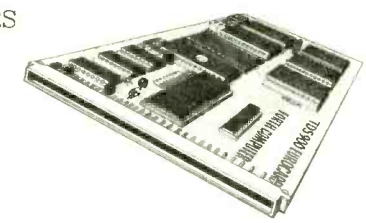

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Lifelong morse

The Department of Trade and Industry has agreed to a significant change in respect of Class A licences. For many years new licences have been issued only to applicants who have passed the official morse test within the past twelve months. This has meant that almost invariably candidates seek to obtain a pass in the Radio Amateurs' Examination (RAE) before attempting the morse test, otherwise there is always the possibility that the time may have expired before the RAE is passed with the result that the candidate has to retake the morse test.

It has also had the effect that those holding Class A licences are reluctant, even if inactive over a considerable period, to give up their licences since they have had to retake the morse test if they later re-apply. Another result tends to be prompt payment of licence fees to avoid the risk of having the licence cancelled and then having to retake the morse test to get it reactivated.

However the DTI has now ruled that the validity of the morse test, like that of the RAE certificate is unlimited in time. Onced passed it need never be retaken.

The RSGB, following dissatisfaction expressed by would-be candidates for morse tests, has been able to announced the setting up of test centres in a number of counties, apart from the facilities being provided at mobile rallies.

It would appear that the establishment of the test centres, each able to call upon two approved volunteer examiners, received a set-back when British Telecom unexpectely ordered its employees to take no part in the running of the RSGB tests, whether or not morse is involved in their work for BT. This followed the change when BT suddenly decided it would like to continue administering the tests after having formally given notice that it wished to hand this over to some other body.

The DTI is prepared to permit amateur operation from oil rigs and platforms, granting them the status of off-shore islands. However DTI stipulates that permission must always be obtained from the owners or lessees of the rig, the safety officer and the radio officer and that any restrictions imposed by them must be followed.

Space

Although this year's series of launch vehicle disasters has thrown the West's space programme into near disarray, planning for various scientific and experimental projects is still continuing in the hope that, come the day, launchers and funding will be AOK.

Dr D.L. Croom (SERC/RAL) described the ambitious plans for a NASA international space station programme to establish a multi-element, multi-user manned or serviced space facility by the mid-1990s. The European Space Agency contribution ("Columbus") includes one of the manned modules of the main core station plus one of the 'Polar Platforms' for Earth observation and other payloads.

Dr J.R. Norbury (SECR/RAL) described the feasibility studies for a mobile radio payload for T-Sat which has picked up some of the ideas of the CERS project that was abandoned in 1984.

The plan is based on the idea that communications satellites are still based on the geostationary concepts of the mid-1960s. It is hoped that T-Sat will carry time-division-multiplex transponders into an elliptic Molinya-type 12-hour orbit in which the satellite would hover directly above the UK for eight hours, with an operational system comprising three orbiting satellites but each requiring only half the launch-energy of a comparable geostationary satellite. This would radiate L-band signals down to the UK for reception on flat 50cm square antennas mounted on the horizontal roof of vehicles.

It is argued that there would be much less signal variation than with the low elevation of geostationary satellites (only about 2dB fade margin) and little or no screening from building or vegetation. Mobile transmitters of 10 to 20 watts power with the simple flat antennas would suffice. But so far only the study work has been funded. Early in 1987 the Government will have to decided whether to fund at least the next phase of the work or whether, like CERS, the projects will be abandoned.

RAE courses

As usual a number of courses for the RAE are due to start in September or October at local adult education or further education centres.

There are also a gradually increasing number of courses in practical electronics construction; for example the one at Paddington Green aims to provide an elementary grounding in electronics, using the college facilties, as well as preparing candidates for RAE.

John Lawrence, GW3JGA, who provided the RAE course at the Prestatyn Evening Institute has for several years run instead a "Practical Amateur Radio Class".

The students — all from previous RAE classes – have had to choose from several constructional projects of varing complexity such as morse oscillator, v.h.f. reflectometer h.f. directional power meter, 100-watt dummy load, f.e.t. dip oscillator etc. Some projects were designed by GW3JGA from scratch, others based on existing designs, but in each case all the information together with a built and working sample was available on the first evening so that the level of constructional work and performance of the unit could be judged by students.

Then the first 20 minutes each week were spent on some aspect of construction or practical setting up of amateur radio station equipment, including soldering, fitting coaxial plugs, simple metal work, antenna construction, tuning up of transmitters, testing for television interference, safety aspects etc. The rest of the evening was spent with John Lawrence assisting students with constructional projects.

At first there was a great lack of confidence – some in the class, although holding amateur licences, had never used a soldering iron. Many had difficulty in equating the circuit diagram with physical components and wiring. The physical wiring of switches was regarded as difficult.

The subsequent de-bugging of projects that did not work first time needed to be covered in easy stages: visual examination, point-to-point checking; voltage measurements. In future John Lawrence intends to cover simple fault-finding at an earlier stage so that the students can make checks as the work proceeds.

In practice, all students completed their projects successfully. Several entered equipment in the constructional competition at the local club.

The general use nowadays by newcomers to amateur radio of entirely factory-built equipment has clearly left a gap that needs to be filled.

In brief

Oxfam are seeking volunteers with a good knowledge of the safety aspects etc of electrical appliances to help sort out and check electrical goods donated for sale at their 750 shops throughout the UK (offers to Faye Wark, Oxfam, Freepost, London N12 9BR)...Shozo Hara, JA1AN, president of the Japanese Amateur Radio League has been awarded a "Ranjuhosho" blue ribbon medal by the Japanese Ministry of Posts and Telecommunications, regarded as a high honour in Japan ... JAS-1 the first Japanese amateur radio satellite is due to have been launched on a Japanese H-1 vehicle by the time these notes appear... A new amateur radio emergency service has been established in Denmark... BARTG has its own rally at Sandown Park Racecourse, Esher, Surrey on Sunday, August 24... The rtty group is concerned that about 1000 of its members have failed to renew their subscriptions this year... Problems which arose on Oscar 10 during May which locked the satellite into Mode B still persisted in early July but there are hopes that they can be overcome. Uosat has also experienced some operational problems. The Uosat radiation detector (Channel 3) had been proving unreliable and had been switched off during the week following the Chernobyl disaster but during the following week recorded high radiation readings in the course of orbits that passed close to the Chernobyl area. – **PAT HAWKER G3VA**

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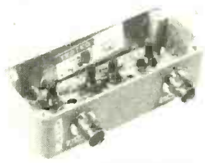

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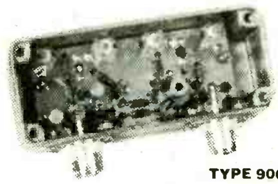

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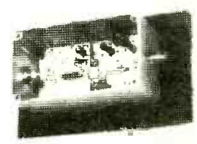

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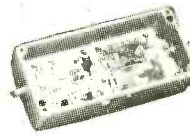

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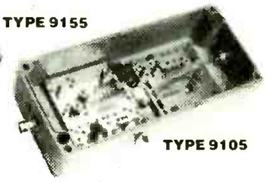

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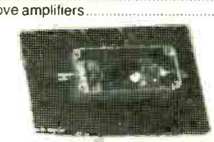

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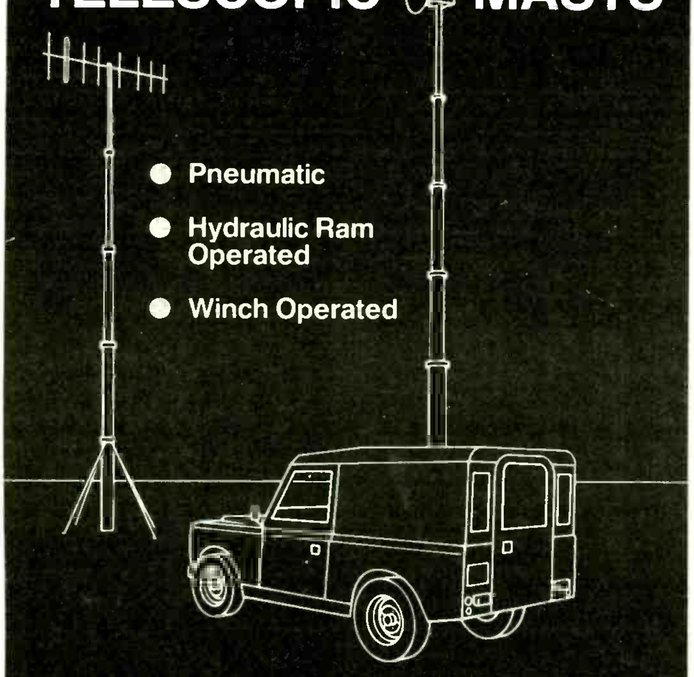

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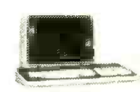

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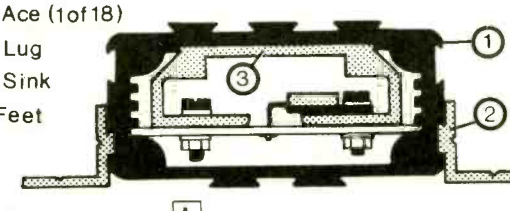

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FEEDBACK

RELATIVITY

Michael Dobson, in the August issue, claims that I neglect 'the force accelerating the clock balance wheel round'. I am careful that this is not so. For this reason I used a freely rotating disc as my clock. I specifically say in the section on Time and Relative Motion that 'to quantify the motion of a spring and balance wheel requires relativistic knowledge which we do not have at this stage of the argument'.

If one accepts that mechanical force as we experience or measure it is given by

force = rate of change of linear momentum $= \frac{d}{dt}(mv)$,

then it is easy to show that

torque = rate of change of angular momentum $= \frac{d}{dt}(I\omega)$

follows irrespective of how I is changed. My freely rotating disc experiences zero torque; hence its angular momentum is constant and it slows down (ω reduces) as its moment of inertia I increases and, conversely, speeds up as I reduces.

This phenomena is commonly observed, for example, in skating. When a skater is spinning we have all seen his (her) speed of rotation increase as he (or she) pulls in legs and arms. In this case the moment of inertia, I, is reduced and ω increases to keep $I\omega$ constant.

This answers the rest of the letter; for example, I do not need to argue about table recoil and no ambiguous equations are used to describe experimental affects.

A.H. Winterflood clearly understands why I reverse the usual argument but regards the hypothesis that 'energy has inertia mass' as equally crazy as the usual one about the speed of light.

It is generally accepted that

force = rate of change of momentum $= \frac{d}{dt}(mv)$

provides a recognition of mechanical force and a basis for measuring it. When force is zero we get Newton's first law and momentum, mv, is what Newton meant by 'quantity of motion' in his second law.

Accepting this definition of force and also that

Mechanical work = force × distance

there is shoals of evidence that energy and mass go together in the way I express it. This evidence lies in particle accelerators, radiation effects, interactions between particles, nuclear energy etc, etc.

If you insist that the concept 'energy has inertial mass' is crazy, then in order to explain what is consistently observed, you have to reconstruct the whole system of measurement and definition of energy. You will, for example, need to say that what is felt as a severe bang is not energy and/or propose complex laws such as in Michael Dobson's letter according to which the action of force in some unexplained way depends on velocity with a factor $(1 - v^2/c^2)^{1/2}$. You end up with far more 'mind boggling' rules than the one simple rule I propose, and also a requirement to explain them.

The task may be beyond human wit so far but it is not impossible. As commented in my article I am convinced that nature is essentially simple and that the basic laws are virtually self evident propositions. Newton's laws of motion and conservation of energy can be seen in this way. James MacHarg in his letter perhaps gives a basis for thinking that 'energy has inertial mass is also a self-evident proposition.

James MacHarg describes the concept of inertial mass very clearly as requiring acceleration and therefore preventing instantaneous change. He implies an objection to the proposition that energy has inertial mass but does not explain why. On the contrary his own idea makes it very reasonable. Since a packet of energy should not be instantaneously movable from A to B as we see it, then it must have inertial mass! The only other step that he needs to make to agree my line of argument is that the packet of energy sees itself as one event.

He makes another important point that we only see what we see and not what actually happens. This is why it is essential to base any positive theory on experimental procedures, i.e. measurements and definition of time, distance, energy, mass etc.

Albert was, of course, swallowed by the lion. When the savage understood he swallowed his ego and re-instated Albert.

M.H. Butterfield
Wimborne
Dorset.

May I thank all those readers who, as well as taking the trouble to fill in the recent questionnaire, wrote to offer criticism and to express their views on content and presentation. These opinions are helpful to the editorial team and are not treated lightly. In the very near future, readers will see many of their suggestions implemented.

EDITOR

MATHEMATICAL RAKE'S PROGRESS

Wireless World is to be congratulated for providing a forum for discussion of various 'non-establishment' views. I am thinking particularly of those of Ivor Catt, but there have been others in the past. Unfortunately, a subject (whether it be maths, physics or ice-skating) is easy when you cannot do it, but very difficult when you can do it – or in other words a little knowledge is a dangerous thing. It is apparent that many of your correspondents fall into this trap, though I must qualify this with the thought that I may be falling into it too.

C.F. Coleman (Letters, July 1986) seems to doubt the 'well-known' phenomenon that the output of a low pass filter happens before the input pulse arrives. Well it *does*. If a perfectly square pulse or edge is fed to a perfect low-pass filter (by which we mean one that passes all frequencies below the cut-off with zero attenuation, and that stops all frequencies above the cutoff with infinite attenuation), the calculated output starts to happen before the input. This is, of course, impossible, so we deduce that either the maths is wrong, or that it will be impossible to make such a filter in the real world. The maths is quite a simple application of a Fourier transform and I can supply Mr Coleman with a derivation if he requires one. I am surprised that Mr Coleman has apparently not heard of this phenomenon, since he seems to be a firm believer in Fourier transforms. There are times however, (for example when a voltage step travels down a transmission line), when to dress the problem up in Fourier transform theory would make it needlessly and horribly complicated.

The situation as it relates to the 'low-pass filter' problem is that Fourier transforms are an abstract tool (one of a family of integral transforms) which bear no relation to the physical world. When we try and use them, we can only do so if they are a good model for observed phenomena. The ideal low-pass filter is outside our experience, and it is a difficult thing to say whether the maths is right or wrong. If it is wrong then the theory needs modifying just as Newtonian dynamics needs modifying to take into account certain conditions.

Mathematics can be studied in its own right, but when it is used to help solve physical problems we must remember that it is a tool, and one does not use a sledgehammer to crack a nut. We must choose the right tool for the job, and this means a level of understanding to which people are not always trained.

David Gibson
Broadstone
Dorset.

S5/8

While I would endorse one of Mr Hardie's objections to RS232, i.e. the lack of connector standardization, I must take issue with almost every aspect of the proposed S5/8.

What is the use of introducing this standard in Britain without first reaching agreement with other countries; in particular America and Japan? The use of S5/8 in this country alone will result in even more of the "break out boxes" and adaptors rightly despised by Mr Hardie.

Having slated the industry standard D type connectors, Mr Hardie proposes to use one of the worst connectors on the market! The DIN connector is only just suitable for the domestic audio equipment, for which it was introduced. It is certainly not robust enough for office use, and beyond consideration in an industrial environment.

The high-voltage bipolar signalling of RS232 is criticized, and a low-voltage ground-reference system proposed. This is surely retrograde. Where mains powered equipment is used, ground potentials can easily exceed the logic margins. This is the very reason for which RS232 was designed!

With good design it is quite possible to incorporate RS232 into battery equipment. Epson, for example, produce a small portable computer with RS232 and disc drive – all battery powered.

If a new standard is to be introduced, I would prefer to see a differential, line-matched system, based upon RS422. Suitable interfaces for this such as the MC3486/7 have been with us for years, and are inexpensive. This would have the added advantage of much longer lead lengths than presently practicable.

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Finally, I think it is foolish to specify signalling rate and data structure. There will always be differing requirements, and to tightly specify these will lead to problems.

Much as I would like to see Britain in the forefront of standardization, such standards *must* have international agreement to be successful, and I doubt very much that S5/8 would find such agreement.

L. Hayward
Technical Director
Eastpoint Ltd
Wareham
Dorset

SIMPLE PULSE GENERATOR

Having had no end of trouble with 4528 monostables myself, I was not surprised to find in Brian Frost's article in August 1986 familiar phrases like "...between 15V and 9V a change in pulse width of around 15% can be expected" and "Due to the nature of the 4528... an accuracy of around 20% will be quite good." I suspect also that the two pulse width controls interact to some extent, because the 4528's pulse width varies with repetition frequency as well as just about everything else!

If Mr Frost were to throw away his 4528 and replace it with a 4538, he would find that these problems have gone away. Accuracy would still depend on the capacitor tolerance and potentiometer calibration, of course, but at least the results would be repeatable, making it worthwhile to trim the capacitors.

Peter A. Ferris
Acton
London W3

SEEING REDDER

One may perhaps quote without permission from private communications when what is quoted is non-personal, confidentiality is not requested, and the sender, at odds with one, talks of his own genius. What follows may be found helpful by some readers of Alex Jones's letter in the April issue.

In one letter to me, he uses the expression 'sources of monochromatic light (clocks)', agrees that

$$\sqrt{1-v^2/c^2}$$

is involved in red-shifting, but then states: '. . . the rate of clocks themselves remains invariant.' As in the published letter, he very much seems to think that the

$$\sqrt{1-v^2/c^2}$$

effect is somehow a part of the Doppler shifting *per se*, for light, as distinct from any clock-slowing. Why though, then, should he bother to stress that sources of light are clocks? He also says that 'we are forbidden to know' which of two relatively-moving observers was subjected to acceleration, that 'perhaps both were but it does not matter', that 'the situation is one of pure symmetry'. This, from a professed anti-Einsteinian. Whilst overt Einsteinians negate absolute motion but imply it, he attacks relativity but implicitly upholds the relativity principle.

Subsequently, I pointed out that an observational pure-symmetry could, indeed must, result from counterbalancing asymmetries – but not merely equal-and-opposite ones. Any relativist will imply this when showing how application of

$$\sqrt{1-v^2/c^2}$$

to both moving-source and moving-observer situations results in equivalent formulae, i.e. eliminates the classical difference which could betray absolute motion. This application of a real factor, given that it is real, implies something real applied-to, and must itself be done somehow asymmetrically in order to obtain the symmetry. There is equality of extent of the

$$\sqrt{1-v^2/c^2}$$

effect in the two cases, but these equal extents must of course be in opposite (quantitative) directions: the moving observer's real clock-slowedness causing an illusory violet-shift effect for incoming light, so as to bring what he observes down to midway between the two classical extents of red-shift; his own light, of course, brought *up* to that median red-shiftedness, for resting observers receded from. (It can be readily shown that observational symmetry will be preserved also when both observers have significant absolute speeds.) Mr Jones's response, essentially, was to restress that the symmetry was a *fact* (italics his), in a manner suggesting that there was simply no question of any more complex reality inferably underlying a fact. An evasive, simplistic concentration on what may be sheerly observed is characteristic also of relativists.

In stressing 'pure symmetry', he says that it 'has nothing to do with whether there is an aether or absolute frame of reference'; but of course if there is a light medium, then *ipso facto* there cannot be such a (real) symmetry except in the case of equal and opposite velocities. And consider: the shifting can occur only at emission and/or reception (for it to occur in transit would of course mean *c*-violation); but if it is meaningless to ask whether either observer is really in motion or at rest, then the situation (a) surely requires that the shifting occurs either all at emission or all at reception, and (b) affords no imaginable determinant of which. Since there must be some such determinant, it must in some sense be meaningful to envisage the motional state of each observer independently, and so their situation cannot be really symmetrical except in the equal/opposite case (in which they would be equally physically deluded).

As to increase of mass with increased velocity, Mr Jones's denial of this is associable with his denying that there is any limit to velocity. It seems odd that one elsewhere so fundamentalist about facts should ignore the evident fact of such a limit; his reason for doing so would seem to be the unlimitedness of the scale of integers. Numbers determining Nature: something else appropriate to an unwitting crypto-relativism.

Finally, as to: 'It is central to the teaching of electromagnetism that for all observers the product of frequency and wavelength shall be the constant c.' This is a most oddly roundabout way of saying that all electromagnetic waves have the same speed *c*; the fact that a wave's speed is given by the product of frequency and wavelength is hardly a specifically electromagnetic one.

Stephen Grieve,
Reigate,
Surrey

Sample calculation
Consider two observers A and B, receding from each other at *relative* speed of 1·4C (as inferred by an observer between them, who, observing no deviation from

$$\sqrt{1-v^2/c^2}$$

is able to regard himself as having negligible absolute motion) — A having an absolute speed of 0·6c and B one of 0·8c. Each beams to the other with an identically-manufactured light source, whose normal frequency is n. What frequency of light received will each measure?

(i) **For light from B measured by A:**

(a) real frequency for

$0{\cdot}8c = n \times \sqrt{1-v^2/c^2} = 0.6n$

(b) real Doppler shift:

$$\frac{0.6n}{1+v/c} = \frac{0.6n}{1.8}$$

(c) illusory Doppler shift due to A's own 'absolute recession' (illusory in the sense that the light *per se* retains its proper, absolute, frequency):

$$\frac{0.6n\times(1-v/c)}{1.8} = \frac{0.6n\times0.4}{1.8}$$

(d) illusory violet-shift effect according to $\sqrt{1-v^2/c^2}$ for A ($\sqrt{1-v^2/c^2}$ for $0.6c = 0.8$):

$$\frac{0.6n\times0.4}{1.8\times0.8} = \frac{0.24n}{1.44} = {}^1\!/\!_6 n$$

(ii) **For light from A measured by B:**

(a) 0.8n

(b) $\dfrac{0.8n}{1.6}$

(c) $\dfrac{0.8n\times0.2}{1.6}$

(d) $\dfrac{0.8n\times0.2}{1.6\times0.6} = \dfrac{0.16n}{0.96} = {}^1\!/\!_6 n$

(N.b. Symmetry is also preserved when both observers are moving in the same 'absolute direction.)

MOISTURE MEASUREMENT

In Mr Linsley Hood's article in your July 1986 issue, on a moisture meter, he shows as Fig. 3 a "modified Schering bridge". Surely this is modified beyond all reasonable claim to the name, for all four arms are capacitances, whereas in the Schering bridge one arm is a standard resistance in terms of which the unknown capacitance and its loss are compared. The bridge used seems to be most like the Fleming & Dyke's four-capacitance type.

M.G. Scroggie
Bexhill
Sussex.

Having read 'An engineers log—moisture measurement', by J.L.Linsley Hood, July 86, I am left wondering, where are all these "electronics engineers with industrial or manufacturing experience" who are "no longer young"? Have they all faded away?

I have tried, and failed, on many occasions to find just such people, both for our electronics services and for various research groups. Other departments and colleges throughout London University are in the same position.

For many young engineers and technicians our salary scales are poor compared with outside industry and we are unable to keep the people we train. However, for those in, say, their early fifties to whom money is not everything, a great deal of interesting and varied work goes on in universities, much of it pioneering new techniques. This is now in danger of drying up for lack of experienced staff.

In a country committed to high-technology advancement, I believe this would be disastrous; so please, if there's anybody interested spare us a thought.

D.R. Stone
Physics Department
Superintendent
Queen Mary College
London E1

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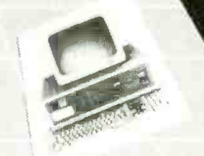
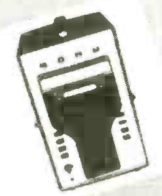


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Developments in radio receivers

Whistlers, twitterings, noise and a diversity of radio systems, from the IERE's recent conference

The IERE's fourth international conference on radio receivers and associated systems was held in July at the University College of North Wales, Bangor. A set of conference papers is available as publication no. 68 from the Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ, for £32 including postage (£37 outside Europe).

Sessions began with a tutorial day featuring presentations on various fields of current interest, including frequency synthesis and phase-locked loops, digital signal processing, cryptography, spread-spectrum techniques and applications for gallium arsenide. Many of these topics were to be raised again in the conference itself, which opened the following day with a keynote address by Dr Geoffrey Phillips, former head of the radio frequency group at the BBC research department.

Digital processing was now replacing analogue techniques in many areas of receiver design, though Dr Phillips recognized that manufacturers would adopt a cautious approach because of the high cost of very large scale integration, essential for some of the developments he spoke of.

Technical advances in terrestrial tv broadcasting were on the way: in two years' time, the BBC planned to offer a full digital sound service on its existing tv services. The new transmissions, which had undergone extensive field trial, would be compatible with the present f.m. subcarrier but would offer a marked inprovement in sound quality, with stereophony besides. The system was based on a p.s.k. subcarrier at 6.55MHz with a data rate of 730kbit/s.

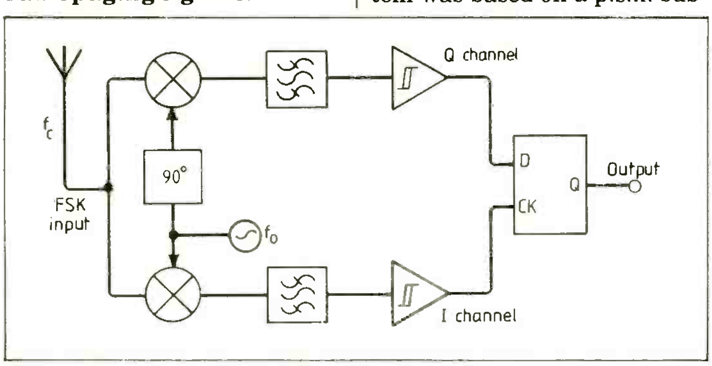


Fig. 1. Digital detector for frequency-shift-keyed data transmissions such as radiopaging signals.

Digital processing

The theme of digital signal processing was taken up by John Masterton of STC Technology, who reviewed some of the options for integrating digital receivers. Digital techniques had been applied predominantly in control circuits and frequency synthesizers, but it was becoming increasing practical to consider their use in the signal path. Attractive prospects were offered by the zero-i.f. or direct-conversion receiver, which enabled digital signal processing to be carried out at the lowest frequency possible.

In a zero-i.f. receiver the incoming signal is mixed with a local oscillator at the same nominal centre frequency and the input is so translated to a band centred on zero frequency. But 'negative' frequencies are folded over on to the positive frequencies, producing an ambiguity. Masterton explained the method of resolving it using a quadrature local oscillator with two i.f. channels.

STC had applied digital techniques to the demodulator stage. In an experimental zero-i.f. receiver for f.s.k. signals such as those used in radiopaging, the quadrature i.f. channels are filtered, limited and applied to a D-type flip-flop, Fig. 1. One limiting amplifier provides the clock for the flip-flop, the other the D input. This arrangement can demodulate the signal because the output changes state whenever the relative phase of the two inputs is reversed: that is, when the carrier deviation changes from positive to negative.

Improvements in performance could be obtained by using more complex decoding logic. By increasing the number of pulse edges to be examined, the edge jitter (or distortion) could be reduced, Fig. 2.

Both types of receiver had been realized in integrated form by STC using a bipolar process. A photograph of the i.c. showed the outward simplicity of the design: the antenna connected to one pin and received data emerging from another. Receiver sensitivity at 150MHz was said to be good and power consumption low.

Masterton also described a two-i.c. design for f.m. speech and an h.f./v.h.f. programmable receiver using digital signal processing. This unit covered a.m., f.m. and s.s.b. plus commercial n.b.f.m., with software control of mode. The digital filter card, implemented in 5-6 micron c-mos, featured a d.s.p. chip said to be one of the largest ever produced in the UK – 1cm square.

Microwave integrated circuits

Monolithic integrated circuits for microwaves were the subject of an interesting survey by Andrew Hughes of GEC's Hirst Research Centre. These devices, he said, offered attractive alternatives to conventional microwave construction techniques in many areas of receiver design: examples of these were satellite tv receivers, collision avoidance systems and mobile radio.

Microwave i.cs had been demonstrated at frequencies up to 100GHz and transistors existed with gain as high as 13dB at 35GHz or 6dB at 60GHz. Among devices which could be integrated easily were mesfets, p-n, Schottky and p-in diodes. Capacitors could be fabricated in values up to 10pF, transmission lines were possible with characteristic impedances in the range 25 to 95 ohms for stubs and interconnections, and spiral inductors could be contrived in the range 0.5 to 10nH. These last were awkward to produce and their Q was relatively low. The difficult part was making the so-called air-bridges for completing the spiral.

Navaids for the motorist

An interesting i.c. from another source formed part of a low-frequency receiver system for the Loran-C and Omega radionavigation systems. Presenting it, Dr Durk van Willigen of the Delft University of Technology explained that although military users of these systems were now switching to satellite navigation, there existed a vast potential market for privately-owned navigational receivers.

In Europe alone, there were some 300 000 small aircraft, and 40 million cars were being built every year. All were possible users of route-planning systems based on Loran-C.

Each vehicle would have on board a map stored in CD-rom. The driver would simply tell the system where he wanted to go and it would respond by giving directions from moment to moment as necessary. By sending traffic via the best route, such a system could yield real savings in time and fuel. It could be cheap to implement and would be usable worldwide.

Answering questions, Dr van Willegen said that the CD maps could be highly detailed: they would show one-way streets and the whereabouts of police stations. They would even mark varieties of restaurant: Indian ones, for example.

Loran-C was being phased-out for military purposes outside the US, though it would remain in operation beyond the year 2000. And European countries were being offered the opportunity to take over the system.

The accuracy of a Loran-C fix was about 200m and so the navigational system would have to rely on dead-reckoning for keeping track of a vehicle's exact position. But radio fixes would be needed to find its starting point and subsequently to forestall any blunders due to ambiguities in the map.

Dr van Willegen said his i.c. could provide all the r.f. gain for the receiver and so would reduce the hardware complexity considerably. Limiter gain was better than 100dB at 100kHz and the receiver had perfect zero-crossing tracking ability at inputs as low as 0.75 microvolts r.m.s.

Whistlers

Another low-frequency project was described by Hal Strangeways of Leeds University, who with Neil Thomson of the University of Otago in New Zealand has built a v.l.f. receiver for the British Antarctic Survey's Faraday Base on Galindez Island, and went there last January to install it. This location, by an accident of geography, is at the far end of lines of the Earth's magnetic force which emerge in Maine, USA, where the US Navy has a 1MW transmitter on 24kHz. As such it is an ideal site for studying field-aligned whistler mode propagation, by which transmissions are ducted through a kind of natural waveguide.

With such a receiver, it is possible to measure doppler shifts in the region of 10 millihertz which speak of events up to 100 000km away in the magnetosphere.

Ignition noise

For many receiving systems it is not sensitivity but ambient noise that sets the limit to performance. Dr Adel Turkmani of the University of Liverpool described a receiving system for measuring the characteristics of impulsive noise. This system covered 20MHz-1GHz, a range of considerable commercial importance.

Dr Turkmani explained that ignition noise from motor vehicles was now the dominant noise source at h.f. and v.h.f. in cities; and because of its random nature it had to be quantified statistically rather than just measured.

To avoid disturbing the signals under observation, his receiver was designed for high linear dynamic range and for an impulse response with very low time side-lobes. Digital signal processing stages followed the detector.

Already the unit had been tried in Liverpool for measuring noise at frequencies used for land mobile radio, both at base-stations and in vehicles. The system was easy to calibrate and use, according to Dr Turkmani, and it produced an accurate and useful characterization of the noise amplitude distribution.

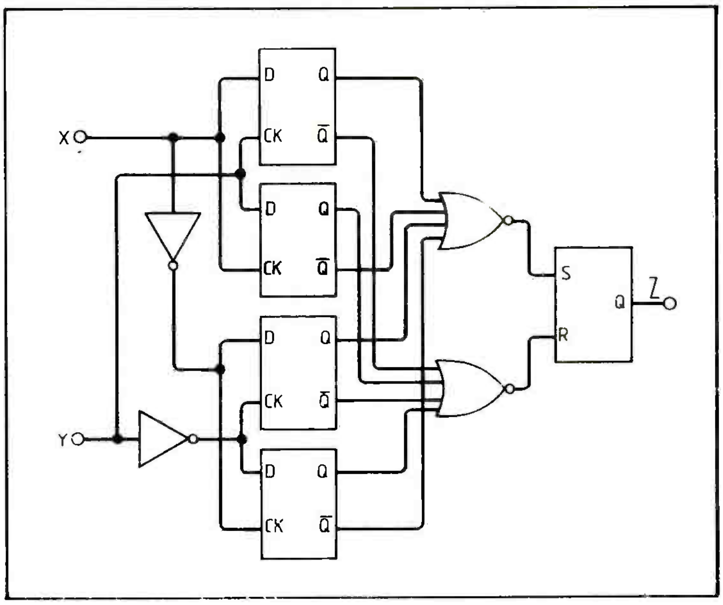


Fig. 2. With a more complex detector than the D-type flip-flop of Fig. 1, the number of edges examined can be increased and performance improved.

Radio nasties

Dynamic range is a quality where practical receivers often leave something to be desired, especially with domestic broadcast receivers where specmanship in the hi-fi market has resulted in sensitivity being valued much more than selectivity or freedom from intermodulation.

An alarming report from the BBC revealed that v.h.f. transmitter planning was almost being undermined by the apparent indifference of some setmakers to these important characteristics. The broadcasters are concerned at the large number of sets which do not meet internationally-agreed protection ratios for interfering signals. And the spread of pirate stations with over-deviating transmitters may mean that interference is even worse than the figures suggest.

Alan Hall, a service planning engineer, described tests the BBC carried out last year on 20 domestic stereo receivers. The tests were made objectively, following methods set out by the CCIR. Five sets were rejected right at the start as being unable to produce in stereo a signal-to-noise ratio of 52dB from a 1mV input, even in the absence of other signals. The remainder varied widely in their immunity to unwanted signals, some doing especially badly with transmitters spaced 10.9MHz and 10.8MHz apart. A high price appeared to be no guarantee of excellence.

Fortunately, the especially troublesome 10.7MHz spacing has been avoided in the UK band-plan, apart from an instance in Kent where BBC Radio Kent at Dover is 10.7MHz above Radio 4 from Wrotham. However, no complaints have arisen because the Radio Kent listeners affected get their Radio 4 from Dover too.

One cause of poor performance, according to the BBC, is that manufacturers often leave a.m. intermediate-frequency transformers in circuit during f.m. reception, giving an unwanted peak in response at 500kHz.

Using recorded examples, Mr Hall demonstrated the severe twittering and noise produced by one set, a £120 tuner with digital display. "Next time signals are good and r.f. is rolling in from everywhere", he said, "don't blame the planners straight away!" ■

Further reports from the conference are included in Pat Hawker's Communications Commentary on page 9.

by Mike Catherwood

Microcontroller chip includes peripherals

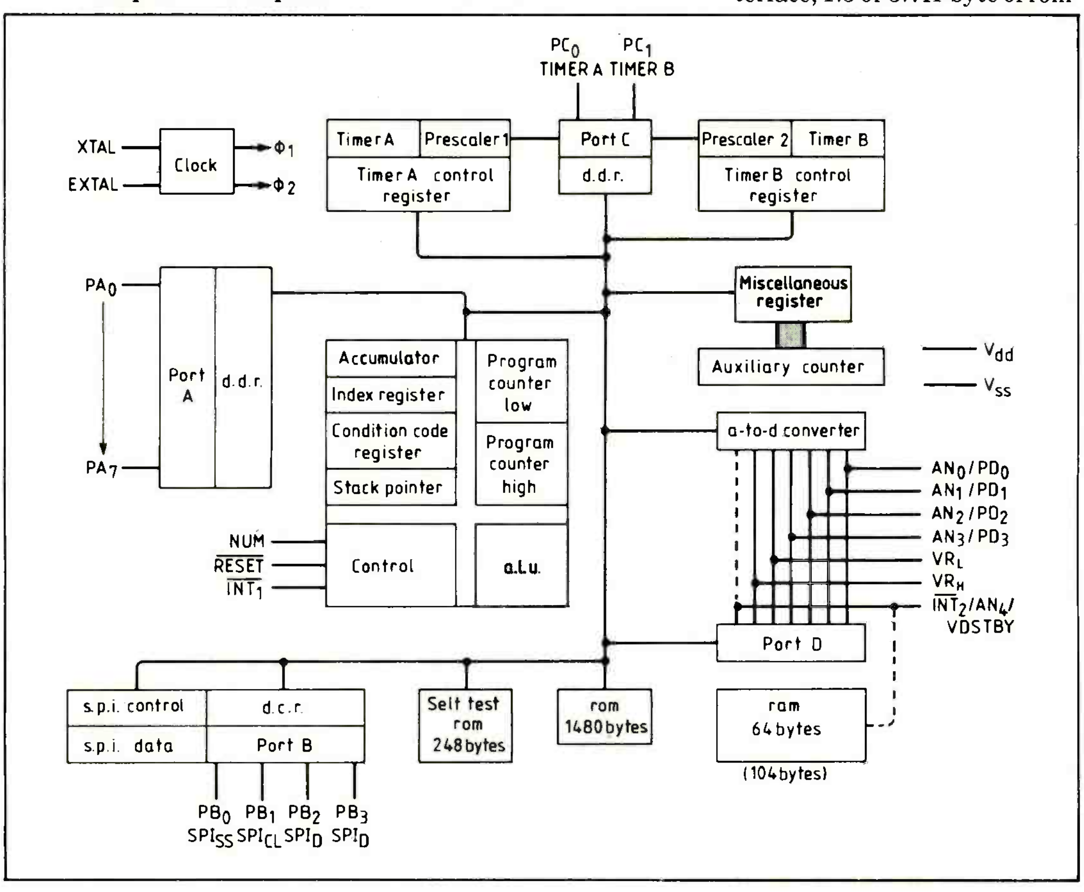
Using built-in peripherals gives versatility, as illustrated by a limited issue of specially-programmed microcomputers.

There is a great variety of single-chip microcomputers for control applications. Many recent devices contain not only ram and rom, but also peripheral functions such as a-to-d converters, serial interfaces, phase-locked subsystems and multiple timers.

Motorola's M6805 microcomputer family currently consists of 30 devices: some high-density mos and others c-mos, but all with instruction sets based on that of the 6800, which simplifies software writing.

Mike Catherwood is a systems engineer at Motorola's Semiconductor Products Division in East Kilbride.

Fig. 1. Block diagram of the S2 single-chip microcomputer.



Microcomputers for medium and large-volume production applications have mask-programmed rom; software designed by the user is programmed into this rom by the manufacturer. But for small-scale production and development, every mask-programmed rom part has an equivalent eprom part that can be programmed directly by the user.

The most versatile h-mos family members are the MC6805S2 and the larger-memory version, MC6805S3. Designed in Geneva, these 28-pin microcomputers feature a four or five-channel a-to-d converter, three timers, two prescalers, a serial-peripheral interface, 1.5 or 3.7K-byte of rom and 64 bytes of ram, 16 bytes of which may be used as standby battery-backed ram. An additional timer is included in the S3.

Fourteen of the devices' twenty-one i/o port lines are bidirectional; eight of these, port A of Fig. 1, may optionally be made c-mos compatible as outputs through the addition of a depletion-mode pull-up device on each line.

High-current sinking is possible on four lines of port B. A novel feature of these microcomputers is the software-programmable open-drain outputs associated with the serial interface, described later. To fit the device into a small 28-pin dil package, many pins have a dual function.

Both a crystal and RC network are suitable timing elements for the S2/S3 on-chip oscillator producing a clock frequency of typically 4MHz. Internal dividers quarter this frequency to provide the bus clock.

Figure two shows the S2's 4K memory map with the top half of page zero, addresses 0-$7F_{16}$, expanded to show i/o, ram and data/control registers more clearly.

As with all 6805-family members, the S2 may be operated in self-check mode, enabling the device to perform a 90% functional test on itself through execution of a small amount of reserved rom code. Additionally, the S2 includes a small bootstrap routine, entered through the self-check mode, which transfers user-defined code such as an evaluation test routine from an external eprom into ram and then executes it.

For development purposes and small production runs, there is an eprom-based ver-

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Table 1. Analogue-input multiplexer selection

Control register ACR_2	ACR_1	ACR_0	Input	Digital value min.	typ.	max.
0	0	0	AN_0			
0	0	1	AN_1			
0	1	0	AN_2			
0	1	1	AN_3			
1	0	0	V_{RH}*	FE	FF	FF
1	0	1	V_{RL}†	00	00	01
1	1	0	$V_{RH}/4$†	3F	40	41
1	1	1	$V_{RH}/2$†	7F	80	81

* AN_4 may replace the V_{RH} calibration channel (mask option).

† Internal calibration levels.

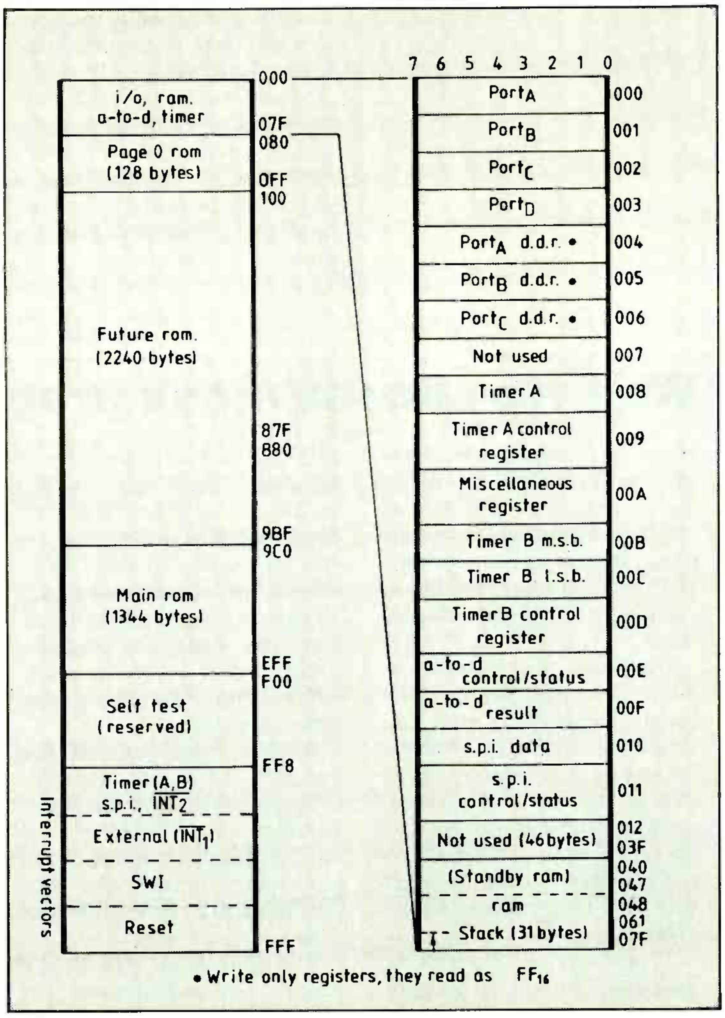

Fig. 2. Memory map. There is a version of this processor with eprom instead of rom.

sion of the S2 called the MC68705S3.

Analogue-to-digital conversion

Successive approximation is used for the S2's built-in eight-bit analogue-to-digital converter, Fig. 3. Up to four – or five by a mask option – external analogue inputs, via port D, connect to the converter through a multiplexer. Overall accuracy is typically ±1 l.s.b. Four internal channels are also available for calibration.

Multiplexer selection is controlled by the lowest three bits of converter-control register ACR at address 0E, Table 1. Whenever the a.c.t. is written to, the conversion in progress is aborted, conversion-complete flag ACR_7 is cleared and the selected input is sampled and held internally.

The converter operates continuously using 36 machine cycles to complete a conversion of the sampled input. When conversion is complete, the digitized sample or digital value is placed in the converter result register (ARR) at address 0F, the conversion complete flag is set, the selected input sampled again, and a new conversion started.

The converter is ratiometric. Two reference voltages, V_{RH} and V_{RL} are supplied to the converter via port-D pins. An input voltage equal to V_{RH} converts to FF_{16} (full scale) and an input voltage equal to V_{RL} will convert to zero.

Timers

The S2 contains one eight-bit and one 16-bit timer, timers A and B respectively, whose clocks may be derived from 8 and 16-bit prescalers. Either prescaler may drive either timer under software control, as shown in Fig. 4.

An auxiliary counter is available for use as a fixed rate polled timer or as a system watchdog. All the timer operating modes are software programmable.

Timer A incorporates a modulus latch which allows the timer to be reloaded with the latch contents when either the timer decrements to zero (auto-reload), or a rising edge is detected on the second interrupt line, port D_6. This is called an asynchronous external event load.

The timer can of course be configured to allow loading at any time by a write to the timer data register at address location eight (direct load). Timer operation is controlled through control register TCRA at address location nine.

On timer overflow, i.e. at value zero, the interrupt-request flag, bit seven of timer-A control register ($TCRA_7$), is set. Provided the timer and c.p.u. interrupt-mask bits $TCRA_6$ and I respectively are clear then an interrupt occurs on completion of the current instruction.

The timer overflow signal may also be used to toggle the state of either port B_0 or B_1 data register bits. This feature, with the auto-reload function, is used to automatically generate the 50% duty-cycle s.p.i. clock on port B_1, when required.

The modulus latch is loaded with the number of timer decrements per half cycle so that at every timer overflow, port B_1 toggles and the modulus latch

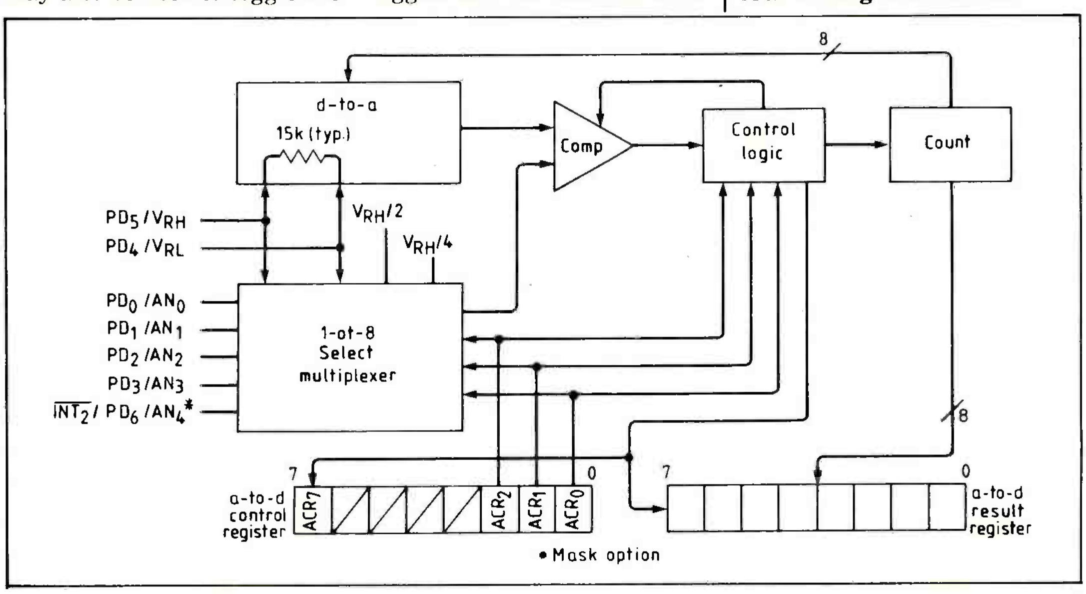

Fig. 3. Using a multiplexer, the single successive-approximation converter in the S2 reads four analogue channels.

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contents are transferred into the timer data register to time the next half cycle.

Prescale values are software selectable from divide-by-one (bypass) to divide by 2^7 (8-bit) or 2^{15} (16-bit). Clock sources of the prescaler may be either the bus clock, gated bus clock, an external clock or no clock, Fig.4.

Sixteen-bit timer B offers the same interrupt and port-toggle features and operates through a control register similar to that of timer A. However, to effectively remove the delay between a read or write of each half of the 16-bit timer data register, a pipeline latch is included. This latch captures the contents of the m.s.b. during a read of the l.s.b. and transfers the contents of itself into the m.s.b. during a write to the l.s.b. Provided that the timer is accessed in the correct sequence, any timer counts occurring between m.s.b. and l.s.b. transfers will not cause any problems.

When using a processor in an electrically noisy environment, it is wise to include some sort of protection against the possibility of system failures. One common method that provides a good level of protection is to include a watchdog timer in the system. A watchdog timer is essentially a free-running counter which the processor clears on a regular basis. Should the system fail, then it is highly likely that the processor will not be able to clear the timer, letting it overflow and subsequently reset the system. Having regained control over itself, the processor can take recovery action.

The S2 auxiliary counter can be configured to operate in this manner. Alternatively, it may be used as a fixed-interval polled timer using 4095 bus cycles in applications which require lengthy delays.

Serial data

Within the S2 is a clocked serial interface capable of operating either as a master (clock generator) or a slave. In master mode the serial-peripheral interface produces clock signals for synchronous operation and in slave mode it depends on clock signals from outside.

The s.p.i. is intended to be used for moving data between the S2 and serially-loaded peripherals, like certain display drivers, memory devices, etc., and/or other processors, releasing the S2 c.p.u. for other tasks during transfer.

Arbitration logic in the s.p.i. allows several S2 devices to interface to networks supporting multi-master-type protocols. A slave-select line is provided which can act as a slave chip select in a single-master, multi-slave system.

The s.p.i. operates via port B and communicates with the processor through data and control registers at addresses 10_{16} and 11_{16} respectively. Essentially consisting of an 8-bit shift register, a divide-by-eight counter, some slave-elect and arbitration logic and a control register, Fig.5, the s.p.i. may function in full or

When to choose mask-programming

Used in numbers above the minimum-order quantity, microcomputer units with mask-programmed rom are cheaper than eprom versions but they are less flexible and cannot be bought off-the-shelf.

Consequently, eprom versions are used for development, prototyping and pre-production runs. In addition, eprom microcomputer units, m.c.us, are ideal for small to medium production runs of up to 10 000 units and for applications where the software will or might need altering.

Prices depend on quantity, features, fabrication technology and device maturity; eprom m.c.us from Motorola start at under $5. For software security, devices with a feature which inhibits any access to the eprom after programming are available.

All mask-programmed rom m.c.us are subject to a minimum-order quantity of between 1000 and 10 000 units, the actual value being determined primarily by die size. A mask charge of typically $3500 is also levied, so it is almost always uneconomical to use a mask-programmed device in quantities below the minimum-order quantity.

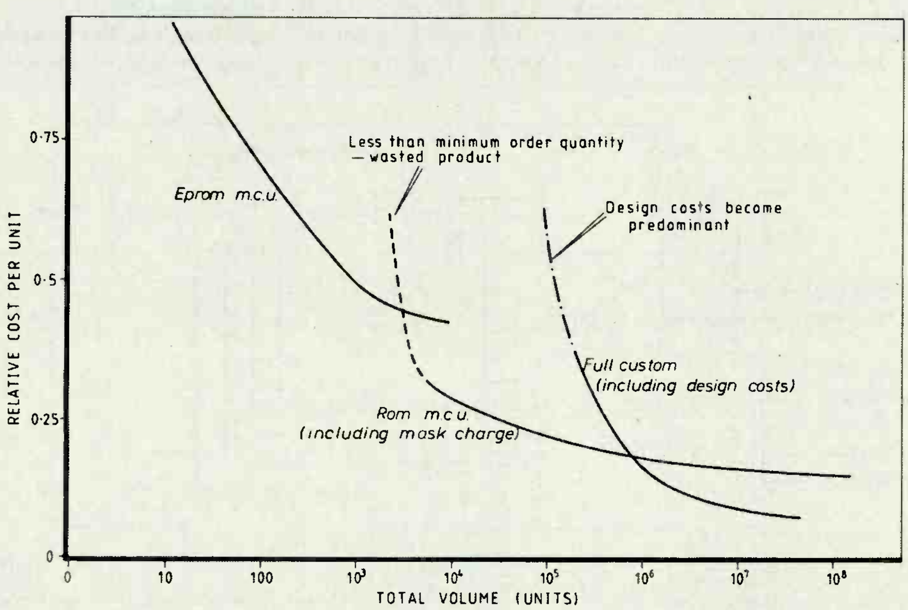
At the upper end of the quantity scale, the general-purpose nature of the rom-based m.c.u. is reflected in a slightly higher cost compared with an efficient but less flexible fully-customized design.

For rom-based m.c.u. designs, availability of in-circuit real-time emulators and eprom-based equivalents shortens development time and allows users to be confident of their designs before committing them to a mask.

Assuming that an m.c.u. is suitable for the task in hand – environmental and application-related problems may make an m.c.u. an impractical solution – the rom-m.c.u./full-custom break-even point is difficult to accurately predict as it depends on many less quantifiable factors than unit cost.

With a full-custom solution for example, consideration must be given to ease of testing, cost/time of test-philosophy, cost/time of program-development, long and short-term quality issues, acceptability of a single-source supply and the inevitable uncertainty associated with functioning of the first-pass silicon.

On the positive side, a fully-customized design gives users almost complete control over how the product functions and a greater influence over items such as electrical specifications and packaging.



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half-duplex transfer modes with or without clock arbitration and/or slave-select operation.

Transfer rates for the eight-bit data blocks may be up to 125Kbit/s, depending on the modulus-latch value, and therefore overflow rate, chosen for timer A. Single-wire auto-clocked transfer such as for n.r.z. data is possible using interrupt line INT to synchronize the start of the transfer.

In many systems, an individual chip enable for each slave device connected to the serial bus is not feasible. In this situation, each slave can be configured to respond to a unique address, which the master transmits prior to transmission of the data destined for that device.

As all transmissions are one byte long, distinguishing between address and data fields might be seen as a problem for the S2. In common with many standard systems however, the s.p.i. recognizes a unique change of state on the clock and data lines that it interprets as the start condition, setting a register bit, after which the software expects an address byte.

When enabled the s.p.i. will receive all data transmitted on the serial bus. However, once the processor has found an address field which does not contain its own address, the s.p.i. can be configured so as not to interrupt the processor again until another start bit is recognized, allowing the processor to continue with other tasks.

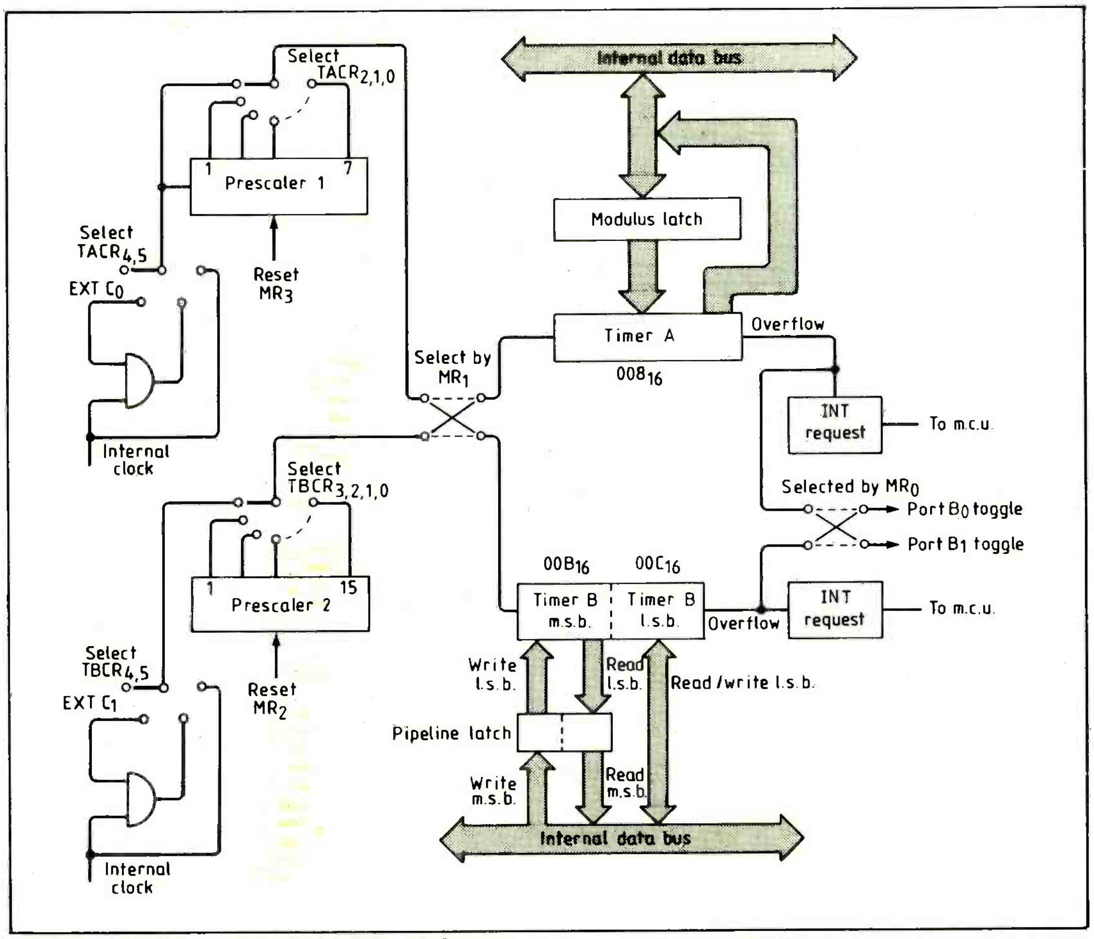

Fig.4. Besides these 8 and 16-bit timers the S2 has an auxiliary timer that can be used as a system watchdog.

Table 2. A port code determines which routine runs.

Code PA_3	PA_2	PA_1	Routine
1	1	1	Monitor
1	1	0	A-to-d converter evaluation
1	0	1	Auxiliary counter demonstration
1	0	0	Pulse-burst generator
0	1	1	Audio-communications link, master
0	1	0	Audio-communications link, slave
0	0	1	Frequency meter

Demonstration devices

For new rom-based m.c.u. products Motorola generally produces an evaluation device containing a demonstration code; Table 2 lists the demonstration packages contained in the S2 demonstration device XC6805S2P1. After reset, a common initialization routine reads a code on port A_1 to A_3 to determine the selected demonstration package. It then jumps to the corresponding code.

Table 3. Monitor command set

Command	Action
R	Displays registers on stack+1 page-zero memory location as HINZC AA XX PPP VV = XY for condition codes, accumulator, index register, program counter, page-zero address and address contents respectively.
A	Examine/change accumulator
X	Examine/change index register
V	Examine/change page-zero address
M	Examine/change memory. Subcommand 'period' re-examines the same byte, 'circumflex' examines previous byte and carriage-return examines next byte.
C	Continue using present stack content, including PC.
Ennn	Executive from nnn_{16} using current stack content except PC
Lmmm	List two 128-byte pages from address mmm_{16}. A BREAK character terminates listing.

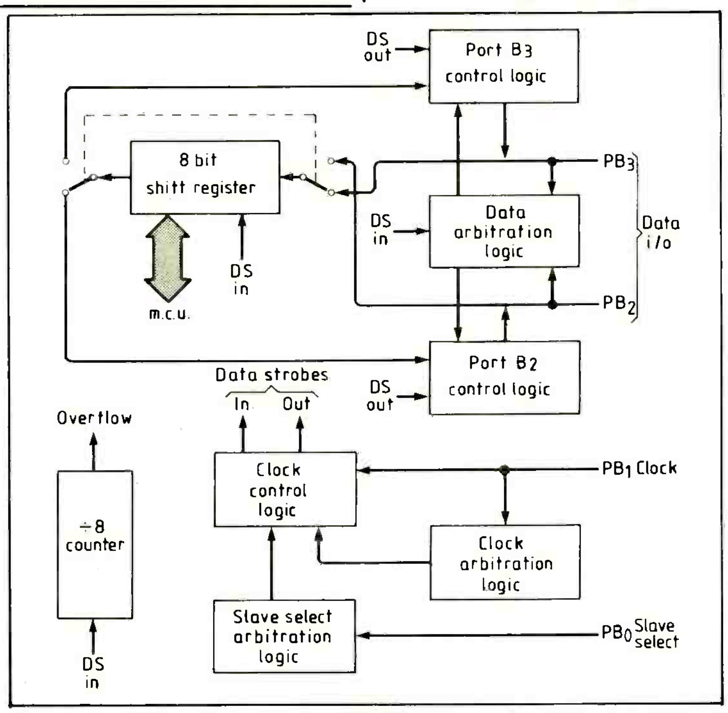

Fig. 5. The serial-peripheral interface communicates with the processor through registers at address locations 10_{16} and 11_{16}.

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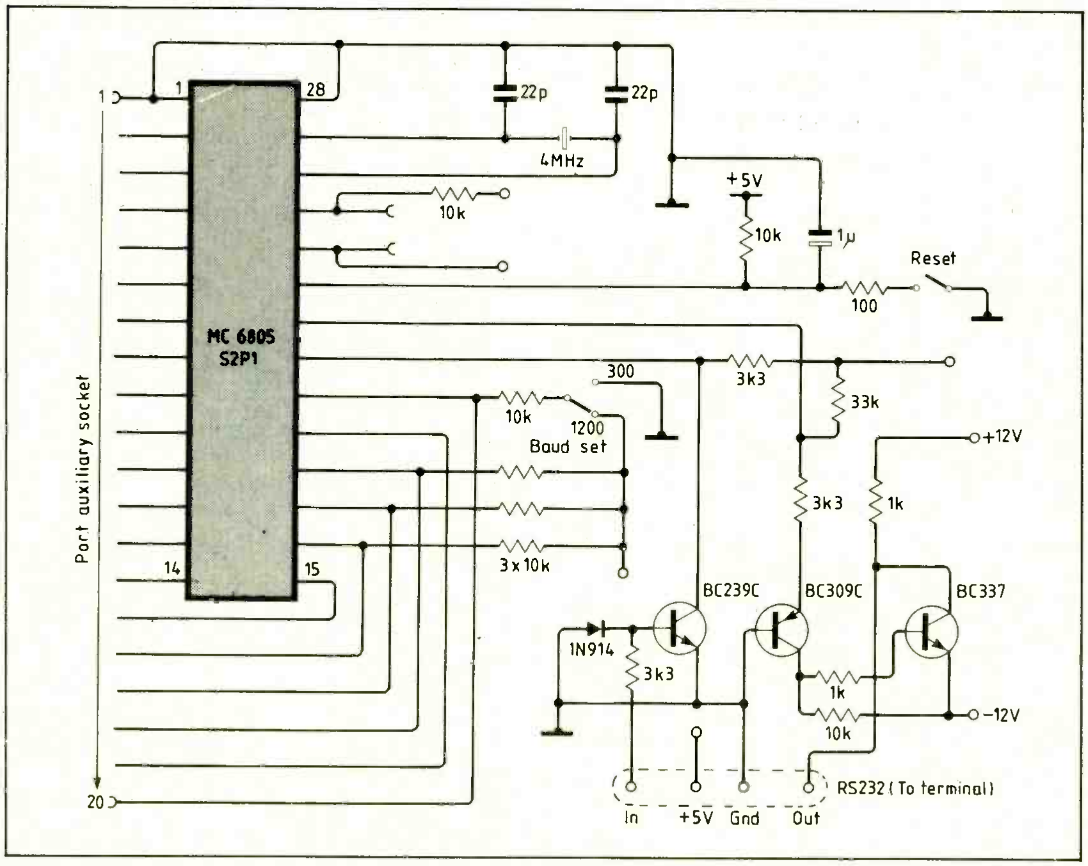

Fig. 6. An evaluation version of the S2 is available with a monitor program and other software programmed into it.

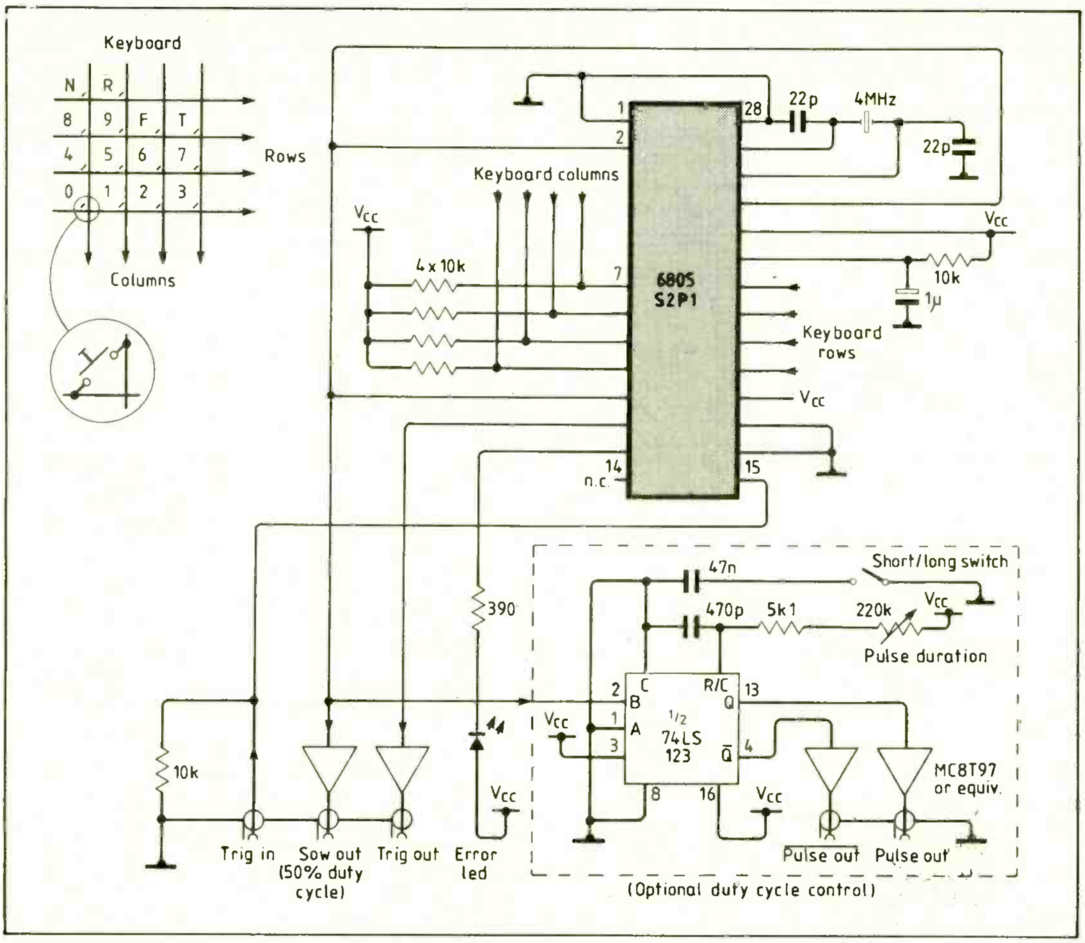

Fig. 7. One routine in the S2 evaluation version turns the device into a pulse-burst generator producing up to 9999 cycles at 1Hz to 10kHz.

jumps to the corresponding code.

Monitor. The monitor will communicate with any terminal supporting an RS232 interface at either 300 or 1200 baud and is useful for evaluating the special features of the S2 or for testing short pieces of code.

Through a set of simple commands, the user can enter and debug code within the on-board ram area. Calls to any useful rom based subroutines are also permissible. The command set is shown in Table 3 and the circuit in Fig.6.

Pulseburst generator. A pulse train containing a predetermined number of pulses can be useful when trying to debug synchronous logic circuitry. The pulse-burst generator can generate bursts of up to 9999 cycles at 1,10,100, 1k and 10kHz with a 50% duty cycle. Although programmed and operated through a small keyboard, the generator can produce a burst initiated by a digital input. Additionally it is possible to generate a positive-going trigger pulse on the rising edge of any of the 9999 pulses. Width of the trigger pulse is a half of the pulse-burst period.

Keyboard assignment is indicated in Table 4 and a diagram is shown in Fig.7. The keyboard does not require isolation diodes. Figure seven also includes an optional circuit to provide some control over pulse duty cycle.

Frequency Meter. In this application advanced timer facilities have been used to produce a simple but useful four-and-a-half-digit frequency meter. It will accept an input frequency of between 0.1 and 530kHz using four switchable gate periods, Fig.8. An input amplifier and a divide-by-100 prescaler would greatly extend its usefulness, creating a very cheap 50MHz frequency meter.

The demonstration device's audio communications and watchdog timer software are described in the next short article.

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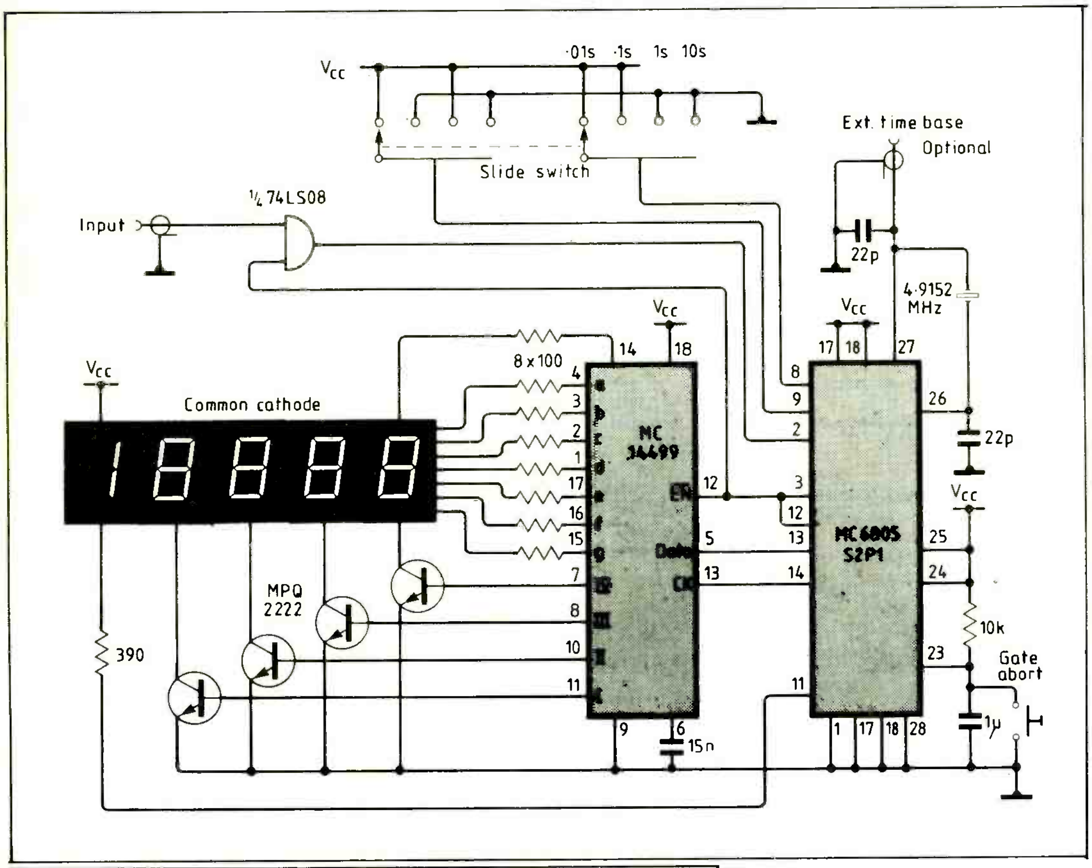

Fig. 8. Using a serial-input display driver, the S2 can be turned into a frequency meter for between 0.1 and 530kHz using four switchable gate periods.

Stages in obtaining a rom- based m.c.u.

When the development team is satisfied that its code is fully debugged and unlikely to require change, the object code in eprom or on disc is simply submitted to a distributor or sales engineer with an order form.

This code, referred to as a pattern, is assigned a unique part number. Next the code is loaded into a main-frame computer which generates a series of coordinates for shapes on the mask that define the rom content.

Mask options are also encoded on the program layer and a rom test-pattern database is produced. Remaining masks needed to make the device are generic and already exist.

A further program reconstructs the original binary file from the newly created mask data. This file, referred to as the verification file, is returned to the customer for checking against the original binary file to minimize the chance of errors on the program-layer mask.

Simultaneously with returning the verification file, the mask-coordinate file is sent to the local mask shop so that manufacture can start as soon as the customer confirms the verification listing..

Once the new mask arrives in the factory and passes the quality-assurance tests, a rom-verification wafer lot is produced. Following fabrication, the wafers are tested (probed) then cut (scribed) and a few good die are assembled locally.

Further testing is used to select ten devices which form what are called 'rom-verification units'. These ten are sent to the customer who evaluates them and if all is well, permission is given to make production quantities.

Remaining dice are simultaneously sent for assembly to become the pre-production batch, which will be sent out a few weeks later provided that the verification devices are satisfactory.

Both probe and final test programs use the rom test pattern database created during the computer processing of the customer's pattern.

In the UK, the cycle from the customer verifying the reconstructed pattern to production of the rom-verification units takes four weeks or less using Motorola's mos facility in East Kilbride.

Table 4. Pulse-burst generator keyboard operation

Key	Function
Fx	Set frequency, where x is an integer between zero and four representing the frequency exponent, i.e. 10^0 to 10^4Hz.
Nxxxx	Set number of pules, where xxxx is four digits representing the number of pulses between 0000 and 9999.
Txxxx	Set trigger point, where xxxx is four digits representing when the trigger pulse is to occur, between 0000 and 9999.
R	Run. If F or T parameters are not entered, R will cause a burst of 65536 pulses with no trigger pulse.

Unacceptable entries cause the command to be aborted and the error led to flash.

Limited-issue m.c.u.

Around 300 S2 microcomputers with mask-programmed demonstration software have been made exclusively for *E&WW* readers. Besides monitor, pulse-generator and frequency-counter software, these devices include two routines for full-duplex audio communication and one for demonstrating use of the auxiliary counter as a watchdog timer.

This limited number of single-chip microcomputers together with an MC14499 four-digit serial-input display driver and data are available for £11.45 including postage but excluding vat from Gothic Crellon Ltd, 3 The Business Centre, Molly Millar's Lane, Wokingham, Berkshire RG11 2EY. Mark your request, with cheque or order made out to Gothic Crellon Ltd, for the attention of Paul Gillman.

Assembly-language software listings are available from *E&WW*'s editorial offices at Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS in return for a large, addressed envelope (at least A4) and £2.50 to cover copying and postage costs. Please mark your envelope "S2".

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A3M ... £549 (a)

PRINTER ACCESSORIES

We hold a wide range of printer attachments (sheet feeders, tractor feeds etc) in stock. Serial, parallel, IEEE and other interfaces also available. Ribbons available for all above plotters. Pens with a variety of tips and colours also available. Please phone for details and prices.
Plain Fanfold Paper with extra fine perforation (Clean Edge):
2000 sheets 9.5" × 11" **£13(b)** 2000 sheets 14.5" × 11" **£18.50(b)**
Labels per 1000s: Single Row 3½" × 1 7/16" **£5.25(d)** Triple Row 2-7/16" × 1 7/16" **£5.00(d)**

MODEMS

MIRACLE WS 2000 – The world standard BT approved modem covering all standard CCITT and BELL (outside UK only) standards up to 1200 baud. Allows communication with virtually any computer system in the world. Expandability to Auto Dial and Auto Answer with full software control enhance the considerable features already provided on the modem. Mains powered. WS 2000 **£79 (c),** Data Cable **£7 (d),** Auto Dial Cord **£26 (d),** Auto Answer Cord **£26 (d).**

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.

WS3000 V21/23 (V21 & V23 + Bell **£295 (a). WS3000 V22** (as above plus 1200 baud full duplex **£495 (a). WS3000 V22bis** (as above plus 2400 baud full duplex) **£650 (b).**

BBC Data Cable for WS3000 **£6 (d).** Data Cables for other micros available. The WS3000 range all have BT approval.

NEW WS 4000 'SCHOOLS' MODEM – a new low-cost high performance 'Hayes' intelligent modem with A/Dial and A/Answer and V21/23 **£149 (a).**
A V22 upgrade can be added at **£250** and V22 bis at **£405.** Other options available, please send for details.

GEC DATACHAT 1223 – An economically priced BABT approved modem complying with CCITT V23 standard capable of operating at 1200/75bps and 75/1200bps and 1200/1200bps pseudo full duplex. It is line powered, does not require external power source. It is supplied with software suitable for connecting to PRESTEL, Micronet 800, Telecom Gold and a host of bulleting boards. Special Offer **£69 (b).**

SOFTY II

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)**
Adaptor for 2764/2564 ... **£25.00**

SPECIAL OFFER

2764-25 £2:00(d);
27128-25 £2:50(d);
6264 LP-15 £3:40(d);

DISC DRIVES

PD800P (2 × 400K/2 × 640K 40/80T DS) with built in Monitor stand ... £249 (a)
PD800 (2 × 400/K/2 × 640K 40/80T DS) ... £229 (a)

TD800 (as PD800 but without the psu) ... £205 (a)
TS400 1 × 400K/1 × 640K 40/80T DS ... £103 (b)
PS400 with psu 1 × 400K 40/80T DS ... £114 (b)

3.5" Drives
1 × 400K/1 × 640K 80T DS
TS35 1 ... £89 (b) **PS35 1 with psu** ... £99 (b)
2 × 400K/1 × 640K 80T DS
TD352 ... £155 (b) **PD35 2 with psu** ... £169 (b)

3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee Discs in packs of 10.

5¼" DISCS				3½" DISCS	
40 T SS DD	£10.50 (d)	40 T DS DD	£12.75 (d)	80 T SS DD	£20.00 (d)
80 T SS DD	£16.50 (d)	80 T DS DD	£16.50 (d)	80 T DS DD	£27.00 (d)

FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. **5¼" £12.50 (d)**
3½" £14.00 (d)

DRIVE ACCESSORIES
Single Disc Cable **£6 (d)** — Dual Disc Cable **£8.50 (d)**
10 Disc Library Casae **£1.80 (d)** — 30 x 5½ Disc Storage Box **£6 (c)**
50 x 5½" Disc Lockable Box **£9.50 (c)** — 100 x 5½ Disc Lockable Box **£13 (c)**

MONITORS

RGB 14"
1431 Std Res ... £179 (a)
1451 Med Res ... £225 (a)
1441 Hi Res ... £365 (a)

MICROVITEC 14" RGB/PAL/Audio
1431AP Std Res ... £195 (a)
1451AP Std Res ... £260 (a)
All above monitors available in plastic or metal case.

TAXAN 12" RGB
K12SV3 – Hi Res with amber/green options. IBM compatible ... £324 (a)

MITSUBISHI
XC1404 14" Med Res RGB. IBM & BBC compatible ... £219 (a)

MONOCHROME
TAXAN 12" HI-RES
KX1201G green screen ... £90 (a)
KX1203A amber screen ... £98 (a)

PHILIPS 12" HI-RES
BM7502 green screen ... £75 (a)
BM7522 amber screen ... £79 (a)

ACCESSORIES
Microvitec Swivel Base ... £20 (c)
Taxan Mono Swivel Base with clock ... £22 (c)
Philips Swivel Base ... £14 (c)
BBC RGB Cable ... £5 (d)
Microvitec ... £3.50 (d)
Taxan £5 (d) ... Monochrome £3.50 (d)
Touchtec – 501 ... £255 (b)

UVERASERS

UV1T Eraser with built-in timer and mains indicator. Built-in safety interlock to avoid accidental exposure to the harmful UV rays.
It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. **£59 + £2 p&p.**
UV1 as above but without the timer. **£47 + £2 p&p.**
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms. UV141 has a built in timer. Both offer full built in safety features **UV140 £69, UV141 £85, p&p £2.50.**

PRINTER BUFFER

The buffer offers a storage of 64K. Data from three computers can be loaded into the buffer which will continue accepting data until it is full. The buffer will automatically switch from one computer to next as soon as that computer has dumped all its data. The computer then is available for other uses. LED bar-graph indicates memory usage. Simple push button control provides REPEAT, PAUSE and RESET functions. Integral power supply. **£199 (b).** With 256K **£275 (b).**
BBC Cable Set £30.

Serial Test Cable

Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end — making it possible to produce almost any cable configuration on site.
Available as M/M or M/F **£24.75 (d)**

Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without rewiring the cable assay. Jumpers can be used and reused. **£22 (d)**

Serial Mini Test

Monitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines. Connects in Line. **£22.50 (d)**

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	—
St Hood	90	95	100	120
Screw Lock	130	150	175	—

TEXTOOL ZIF

SOCKETS 24-pin £7.50
28-pin £9.10 40-pin £12.10

EDGE CONNECTORS

	0.1"	0.156"
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12-way (vic 20)	—	350p
2 × 18-way	—	140p
2 × 23-way (ZX81)	175p	220p
2 × 25-way	225p	220p
2 × 28-way (Spectrum)	200p	—
2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22-way	190p	—
2 × 43-way	395p	—
1 × 77 way	400p	500p
2 × 50-way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612	Plug	Skt
2 X 32 way St Pin	230p	275p
2 X 32 way Ang Pin	275p	320p
3 X 32 way St Pin	260p	300p
3 X 32 way Ang Pin	375p	400p
IDC Skt A + B	400p	
IDC Skt A + C	400p	

For 2 X 32 way please specify spacing (A + B, A + C).

MISC CONNS

21 pin Scart Connector 200p
8 pin Video Connector 200p

AMPHENOL CONNECTORS

36 way plug Centronics (solder 500p (IDC) 475p
36 way skt Centronics (solder) 550p (IDC) 500p
24 way plug IEEE (solder) 475p (IDC) 475p
24 way skt IEEE (solder) 500p (IDC) 500p
PCB Mtg Skt Ang Pin
24 way 700p 36 way 750p

GENDER CHANGERS

25 way D type
Male to Male ... £10
Male to Female ... £10
Female to Female ... £10

RS 232 JUMPERS

(25 way D)
24" Single end Male £5.00
24" Single end Female £5.25
24" Female Female £10.00
24" Male Male £9.50
24" Male Female £9.50

DIL SWITCHES

4-way 90p 6-way 105p
8-way 120p 10-way 150p

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	—
20 pin	75p	—
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

ATTENTION

All prices in this double page advertisment are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TECHNOLINE VIEWDATA SYSTEM. TEL: 01-450 9764
Using 'Prestel' type protocols. For information and orders — 24 hour service, 7 days a week

www.americanradiohistory.com

LINEAR ICs

COMPUTER COMPONENTS

74 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	1.00
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.10
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.55
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.80
74154	1.40
74155	0.80
74156	0.90
74157	0.80
74159	1.75
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	3.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.10
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
74221	1.10
74251	1.00
74259	1.50
74265	0.80
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74742	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES

74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.26
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS48	0.90
74LS49	1.00
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS91	0.80
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	0.80
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.55
74LS136	0.45
74LS138	0.55
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.40
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166A	1.50
74LS168	1.30
74LS169	1.00
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.80
74LS245	1.10
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS2457A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	9.00
74LS293	0.80
74LS295	1.40
74LS297	9.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.90
74LS374	0.90
74LS375	0.75
74LS377	1.30
74LS378	0.95
74LS379	1.30
74LS381	4.50
74LS385	3.25
74LS390	0.60
74LS393	1.00
74LS395A	1.00
74LS399	1.40
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	19.00
74LS612	19.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.25
74LS640	2.00
74LS640-1	3.00
74LS641	1.50
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS645-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.70
74LS682	2.50
74LS683	3.00
74LS684	3.50
74LS687	3.50
74LS688	3.50
74LS783	21.00

74S SERIES

74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	0.50
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.60
74S40	0.50
74S51	0.60
74S64	0.45
74S74	0.70
74S85	3.00
74S86	1.00
74S112	1.50
74S113	1.20
74S114	1.20
74S124	3.00
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.00
74S158	2.00
74S163	3.00
74S169	5.50
74S174	3.00
74S175	3.20
74S188	1.80
74S189	1.80
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	4.00
74S241	4.00
74S244	4.50
74S251	2.50
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	4.50
74S373	4.00
74S374	4.00
74S387	2.25

74C SERIES

74C00	0.70
74C04	0.50
74C08	0.70
74C10	0.70
74C14	0.50
74C20	0.70
74C32	1.00
74C42	1.50
74C48	1.50
74C73	1.00
74C74	1.20
74C76	1.00
74C83	2.00
74C85	2.25
74C86	0.50
74C90	1.90
74C93	1.50
74C95	1.60
74C107	1.00
74C150	5.00
74C151	2.00
74C157	2.50
74C160	1.80
74C161	1.80
74C162	1.80
74C163	1.80
74C173	1.00
74C174	1.50
74C175	1.50
74C193	1.50
74C194	1.50
74C195	1.50
74C221	2.50
74C244	2.00
74C245	2.25
74C373	2.25
74C374	2.25
74C902	1.20
74C911	9.00
74C912	4.50
74C922	6.00
74C923	6.50
74C925	6.50
74C926	7.50

74ALS SERIES

74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.45
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

[illegible]

4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0,45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
4014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.80
4021	0.60
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.80
4055	0.80
4056	0.85
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.90
4095	0.95
4096	0.90
4097	2.70
4098	0.75
4099	0.99
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.75
4541	0.90
4543	0.70
4551	1.00
4553	2.40
4555	0.36
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.60
14490	4.20
14495	4.50
145000	6.50
4599	2.00
22100	3.50
22101	7.00
22102	7.00
40014	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.30
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	0.80
40110	2.25
40114	2.25
40147	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

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AM7910DC	25.00
AM-1-5050	1.00
AY-3-1350	3.50
AY-3-8910	4.90
AY-3-8912	5.00
CA3019A	1.00
CA3020	3.50
CA3028A	1.10
CA3046	0.70
CA3059	3.25
CA3060	3.50
CA3080E	0.70
CA3085	1.50
CA3086	0.60
CA3089E	2.50
CA3090AQ	3.75
CA3130E	0.90
CA3130T	1.30
CA3140E	0.45
CA3140T	1.00
CA3146	2.25
CA3160E	1.50
CA3161E	2.00
CA3162E	6.00
CA3189E	2.70
CA3240E	1.50
CA3280G	3.00
D7002	6.00
DAC1408-8	3.00
DAC0800	3.00
DAC0808	3.00
DG308	3.00
HA1366	1.90
ICL7106	6.75
ICL7611	0.95
ICL7650	4.00
ICL7660	2.50
ICL8038	4.00
ICM7216B	22.00
ICM7217	7.50
ICM7555	0.90
ICM7556	1.40
LC7120	3.00
LC7130	3.00
LC7131	3.50
LC7137	3.50
LF347	1.20
LF351	0.60
LF353	0.90
LF355	0.90
LF356N	1.10
LF357	1.00
LF398	4.00
LM10CLH	4.50
LM301A	0.30
LM307	0.45
LM308CN	0.75
LM310	2.25
LM311	0.60
LM318	1.50
LM319	1.80
LM324	0.45
LM334Z	1.15
LM335Z	1.30
LM336	1.60
LM339	0.40
LM348	0.60
LM358P	0.50
LM377	3.00
LM380N-8	1.50
LM380N	1.50
LM381AN	1.70
LM383	3.25
LM384	2.20
LM386N-1	1.00
LM387	2.70
LM389	1.89
LM391	1.80
LM392N	1.10
LM393	0.85
LM394CH	4.00
LM709	0.35
LM710	0.48
LM711	1.00
LM723	0.60
LM725CN	3.00
LM733	0.65
LM741	0.22
LM7747	0.70
LM748	0.30
LM1011	4.80
LM1014	1.50
LM1801	3.00
LM1830	2.50
LM1871	3.00
LM1872	3.00
LM1886	6.00
LM1889	4.50
LM2917	3.00
LM3302	0.90
LM3900	0.80
LM3909	1.00
LM3911	1.80
LM3914	3.50
LM3915	3.40
LM3916	3.40
LM13600	1.50
M51513L	2.30
M51516L	4.50
MB3712	2.00
MC1310P	1.50
1413	0.75
MC1458	0.45
MC1495	3.00
MC1496	0.70
MC3340P	2.00
MC3401	0.70
MC3403	0.65
MF10CN	4.10
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NE531	1.20
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NE555	0.22
NE556	0.60
NE564	4.00
NE565	1.20
NE566	1.50
NE567	1.25
NE570	4.00
NE571	3.00
NE592	0.90
NE5532P	1.50
NE5533P	1.60
NE5534P	1.20
NE5534AP	1.50
OP-07EP	3.50
PLL02A	5.00
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RC4151	2.00
RC4195	1.50
RC4558	0.55
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SN76023N	3.00
SN76033N	3.00
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SN76489	4.00
SN76495	4.00
SN76660	1.20
SPO256AL2	7.00
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TA7120	1.20
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TA7204	1.50
TA7205	0.90
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TBA231	1.20
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TBA810	0.90
TBA20	0.80
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TBA950	2.25
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TCA220	3.50
TCA270	3.50
TCA940	1.75
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TDA1010	2.25
TDA1022	4.50
TDA1024	1.10
TDA1170S	3.00
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TDA2003	1.90
TDA2004	2.40
TDA2006	3.20
TDA2020	3.20
TDA2030	2.50
TDA2593	5.00
TDA2653	7.00
TDA3560	7.50
TDA3810	7.50
TDA7000	3.50
TEA1002	7.00
TL061CP	0.40
TL062	0.60
TL064	0.90
TL071	0.40
TL072	0.70
TL074	1.10
TL081	0.35
TL082	0.55
TL083	0.75
TL084	1.00
TL094	2.00
TL170	0.50
TL430C	1.20
UAA1003-3	9.35
UA759	3.20
UA2240	1.20
UAA170	1.70
UCN4801A	4.00
ULN2001A	0.75
ULN2002A	0.75
ULN2003A	0.75
ULN2004A	0.75
ULN2068	2.90
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ULN2803	1.80
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ZNA234E	9.50

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1A FIXED VOLTAGE PLASTIC TO220

+VE			−VE	
5V	7805	0.45	7905	0.50
6V	7806	0.50	7906	0.50
6V	7808	0.50	7908	0.50
12V	7812	0.45	7912	0.50
15V	7815	0.50	7915	0.15
18V	7818	0.50	7918	0.50
24V	7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V 78L05	0.30	5V 79L05	0.45
6V 78L06	0.30	12V 79L12	0.50
8V 78L08	0.30	15V 79L15	0.50
12V 78L12	0.30		
15V 78L15	0.30		

OTHER REGULATORS

FIXED REGULATORS		
LM309K	1A 5V	1.40
LM323K	3A 5V	3.50
78H05KC	5A 5V	5.40
78H12	5A 12V	6.40
78P05	10A 5V	9.00
VARIABLE REGULATORS		
LM305AH		2.50
LM317T	TO-220	1.50
LM317K	TO3	2.40
LM337T		2.25
LM350T	10A+VAR	4.00
LM396K	10A+VAR	15.00
LM723N		0.50
78HHO5KC	5A 5V	5.75
78HGKC	5A+VAR	6.50
78GUIC	1A+VAR	2.25
79HGKC	5A—VAR	6.75
79GUIC	1A—VAR	2.50
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SG3524		3.00
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TL497		3.00
78S40		2.50
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6502	4.50
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6502B	8.00
6800	2.50
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6803-2	12.00
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68B09	10.00
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68000-LB	36.00
8035	3.50
80C35	6.00
8039	4.20
80C39	7.00
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8088	17.50
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TMS9980	14.50
TMS9995	12.00
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Z80A	2.90
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Z80H	7.50

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2651	12.00
3242	8.00
3245	4.50
6520	3.00
6522	3.50
6522A	5.50
6532	4.80
6551A	6.00
6821	1.50
68B21	2.50
6829	12.50
6840	3.75
68B40	6.00
6850	1.60
68B50	2.50
6852	2.50
6854	6.50
68B54	8.00
6875	5.00
8154	8.50
8155	3.80
8156	3.80
8205	2.25
8212	2.00
8216	1.60
8224	P.O.A
8226	4.25
8228	5.50
8243	2.60
8250	9.50
8251A	3.25
8253C-5	3.50
8255AC-5	3.20
8256	18.00
8257C-5	54.00
8259C-5	4.00
8271	P.O.A
8275	29.00
8279C-5	4.80
8282	4.00
8284	4.60
8287	3.80
8288D	9.50
8755A	16.00
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TMS9901	5.00
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TMS9914	14.00
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Z80APIO	2.75
Z80CTC	2.50
Z80ACTC	2.75
Z80DART	6.50
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Z80ADMA	7.50
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Z80BPIO	5.00
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BPW21	2.80
OCP71	1.80
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ORP60	1.20
ORP61	1.20
SFH205	1.00
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TIL78	0.55
TIL31B	1.20
TIL81	1.20
TIL100	0.75

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FND507/TIL729	1.00
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TIL729	1.00
TIL7300	1.00
MAN8910	1.50
MAN8940	2.50

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2107B	5.00
2111A-35	4.00
2114	2.50
2114-2	3.50
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4116	2.00
4116-20	1.50
41256-207	0.50
41256-157	0.50
4164-15TI	3.00
4164	2.00
4164-20	2.00
4416-15	3.50
4532-20	2.50
4816AP/3	2.00
5101/5501	4.00
5514/5114	4.00
5516	6.00
5517AP	6.00
6116P-3	3.50
6116LP-3	3.50
6264-12	12.00
6264P-15	7.50
6264LP-15	3.40
6514-45	4.00
6810	1.60
74S189	1.80
74S289	2.25
93415	6.00
93L422	7.50
93425	6.00

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28L22	4.00
24S10	2.50
18S030	2.00
18SA030	2.00
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74S287	2.25
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9306 256bits (16×16)	4.50

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GRN TIL211	0.16	TIL222	0.18
YEL TIL212	0.20	TIL226	0.22
Rect LEDs (R/G/Y)	0.30		
CXQ (Bi colour)	1.00		
10 LED Bar Graph: Red	2.25		
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UDN6118	3.20
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ULN2003	0.90
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ULN2068	2.90
ULN2802	1.90
ULN2083	1.80
ULN2804	1.90
75491	0.70
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2732A-30	6.00
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27C64-25	10.00
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CRT6545	9.00
EF9364	8.00
EF9365	25.00
EF9366	25.00
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MC6845SP	6.50
MC6847	6.50
SFF96364	8.00
TMS9918	15.00
TMS9928	10.00
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AD561J	20.00
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AM25LS2521	3.50
AM25LS2538	3.50
AM26LS31	1.20
AM26LS32	1.20
AM7910DC	25.00
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DM8131	6.00
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DS3691	3.50
DS8830	1.40
DS8831	1.50
DS8832	1.50
DS8833	2.25
DS8836	1.50
DS8838	2.25
D7002	8.00
MC1488	0.60
MC1489	0.60
MC3446	2.50
MC3459	4.50
MCS3470	4.75
MC3480	8.50
MC3486	2.25
MC3487	2.25
MC4024	5.50
MC4044	5.50
MC14411	9.00
MC14412	7.50
75107	0.90
75108	0.90
75109	1.20
75110	0.90
75112	1.60
75113	1.20
75114	1.40
75115	1.40
75121	1.40
75122	1.40
75150P	1.20
75154	1.20
75159	2.20
75160	5.00
75161	3.50
75162	4.00
75172	3.00
75182	0.90
75188	0.60
75189	0.60
75365	1.50
75450	0.80
75451	0.50
75452	0.50
75453	0.70
75454	0.70
75480	1.50
75491	0.65
75492	0.65
8T26	1.20
8T28	1.20
8T95	1.20
8T96	1.20
8T97	1.20
8T98	1.20
81LS95	1.40
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88LS120	3.00
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2.00MHz	2.25
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2.45760MHz(S)	2.50
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2.662MHz	1.75
3.276MHz	1.50
3.5795MHz	1.00
4.00MHz	1.50
4.194MHz	2.00
4.43MHz	1.00
4.9152MHz	2.50
5.00MHz	1.50
5.068MHz	1.75
6.00MHz	1.40
6.144MHz	1.40
7.00MHz	1.50
7.16MHz	1.75
8.00MHz	1.50
8.867MHz	1.75
10.00MHz	1.75
10.50MHz	2.50
10.70MHz	1.50
11.00MHz	3.00
12.00MHz	1.50
14.00MHz	1.75
14.31MHz	1.60
14.756MHz	2.50
15.00MHz	2.00
16.00MHz	2.00
17.734MHz	1.50
18.00MHz	1.50
18.432MHz	1.50
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MAN4640	200p
MAN6610	200p
MAN8910	120p
NSB5881	570p
SFH305	100p
TIL31A	120p
TIL32	75p
TIL78	55p
TIL81	120p
TIL100	90p
TIL311	650p

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CIRCLE 33 FOR FURTHER DETAILS

COMPACT disc DIGITAL AUDIO

Subcodes explained

by J.R. Watkinson M.Sc.

How control signals are combined with and separated from audio samples

This definitive compact disc series, introduced in January 1985, featured

- **Principles of optical storage, March 1985, pp 70,71 April pp 43-46**
- **Channel code and disc format, May pp 27,28, June pp 80-82**
- **Compact disc mastering, February 1986, pp 47-50 & 62**
- **Compact disc mastering, February 1986, pp 47-50 & 62**
- **Digital audio editing, March pp 29-32, April pp 52-54.**

It is very difficult in analogue audio recording to simultaneously convey control information without some degradation of the audio quality. Applications range from the simple pulsing of a slide projector to the recording of time code to synchronize to film video. In the digital domain no such problems arise because all information conveyed is numerical. A digital recording is not concerned with the meaning of the numbers it is entrusted with, it is only charged with recovering the same numbers later.

Provided that a standard format is used, it is possible to combine control signals in numerical form with audio samples, and achieve complete separation on replay. This is the function of the subcode system of CD. The purpose of the control signals is flexible, but definitions exist for the essential functions of locating the beginning of the different musical pieces on a disc, and providing a catalogue of their location on the disc and their durations. A further vital function is to convey the status of pre-emphasis in the recording, so that de-emphasis can be automatically selected in the player.

The subcode information in CD is conveyed by including an extra byte, which corresponds to one EFM symbol, in the main frame structure. As the format of the disc is standardized, the player is designed to route the subcode byte in the frame to a different destination to the audio sample bytes. The separation is based on the physical position of the subcode byte in the frame. The player uses the sync. pattern at the beginning of the frame to reset a byte count so that it always knows how far through the frame it is. As a result, subcode bytes will be separated from the data system at frame frequency.

In the article on disc format (May 1985 issue, pages 27/8) I showed that the frames contain among other things six samples for each channel. As the sampling rate is 44.1kHz, the frame rate must be 44.1/6 = 7.35kHz. The subcode bytes have their own block structure, and one block consists of 98 subcode bytes, each of which has come from a different frame. The choice of 98 bytes was carefully made, and results in a subcode block rate of exactly 75Hz. This frequency can be used to run the playing time display. Fig. 1 shows the relationship between all of the major data and signal rates in the CD system. This diagram first appeared in the June 1985 issue when it contained some errors; the version shown here has been corrected.

It is necessary for the player to know when a new subcode block is beginning. This is the function of the subcode sync. patterns which are placed in the subcode byte position of two successive frames. There are more than 256 legal 14-bit patterns, and two of these additional legal channel bit-patterns are used for subcode block synchronizing. The EFM decoder will be able to distinguish them from the patterns used to represent subcode data bytes. For this reason it is impossible to describe the subcode sync. patterns by a byte, and they have to be specific as 14 channel bits.

The subcode sync. patterns, and the contents of the subcode block, are shown in Fig. 2.

After the subcode sync. patterns there are 96 bytes in the block. The block is arranged as eight 96-bit words, labelled PQRSTUV and W; the choice of labelling is unfortunate because the letters P and Q have already been used to describe the redundancy in the error correction system. The subcode P and Q data have absolutely nothing to do with that. The eight words are quite independent and each subcode byte in a disc frame contains one bit from each word. This form of interleaving reduces the damage done to a particular word by an error.

The P data word is used to denote the start of specific pieces in the sound recorded. The entire word is recorded as data 'ones' during the start flag

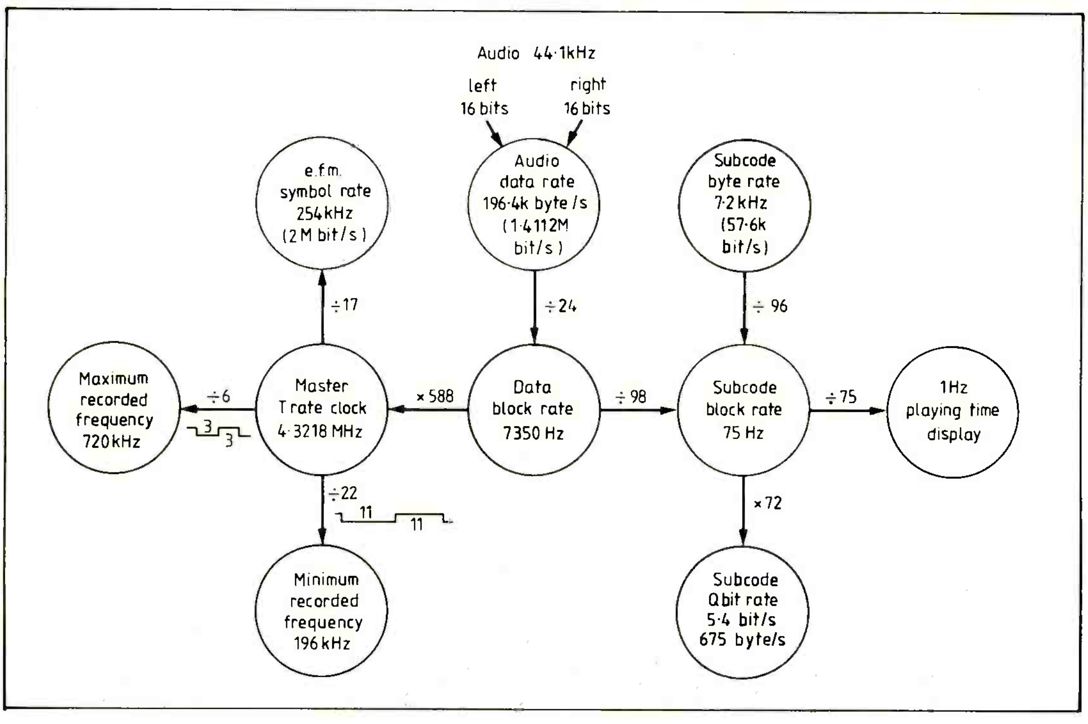

Fig. 1 Relationship between major data and signal rates in a compact system. This diagram supercedes that shown in the June 1985 article.

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period. It can be used even where there is no audible pause in the music, since the start point is defined as where the P data becomes zero again. The CD standard calls for a minimum of two seconds of start flag to be recorded which seems wasteful but it allows a very simple player to recognise easily the beginning of a piece by skipping tracks. The fact that every bit is a 'one' means that it is not necessary to wait for subcode block sync. to be found before finding pause status on the disc track. The two-second flag period means that the status will be seen a few tracks in advance of the actual start point, helping to prevent the pickup overshooting. If a genuine pause exists in the music, the start flag may be extended to the length of the pause if it exceeds two seconds. Again for the benefit of simple players, the start flag alternates on and off at 2Hz in the leadout area at the end of the recording.

Subcode editor uses timecode readers and autolocator of audio editor, allows entry of subcode parameters and provides printout.

Sony Broadcast

At the time of writing the only other defined subcode data word is the Q word. This word has numerous modes and uses which can be taken advantage of by CD players with greater processing and display capability.

Fig. 3 shows the structure of the Q subcode word. In the 96 bits following the sync. patterns, there are two four-bit words for control, a 72-bit data block, and a 16-bit c.r.c. character which makes all 96 bits a codeword.

The first four-bit control word contains flags specifying the number of audio channels encoded, to permit automatic decoding of future four channel discs, the copy prohibit status and the pre-emphasis status. Since de-emphasis is often controlled by a relay in the analogue stages of the player, the pre-emphasis status is allowed to change during a P-code start flag.

The second four-bit word determines the meaning of the subsequent 72-bit block. There can be three meanings: mode 1 which tells the player the number and start times of the recordings on the disc, mode 2 which carries the disc catalogue number, and mode 3 which carries the disc i.s.r.c. (the international standard recording code). Of all the subcode blocks on a disc, the mode 1 blocks are by far the most common.

Mode 1 has two major func-

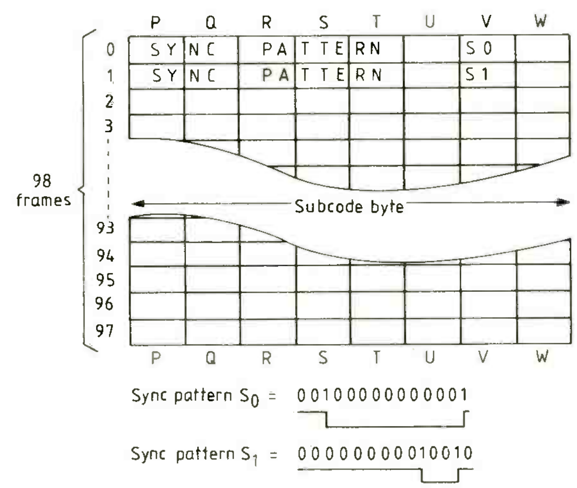


Fig. 2. Frame contains one subcode byte; after 98 frames, the structure repeats. Each subcode byte contains one bit from eight 96-bit words following the two synchronizing patterns.

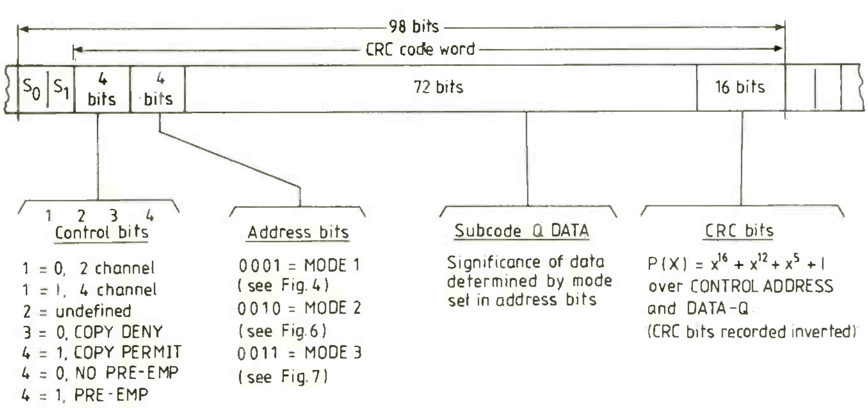


Fig. 3. Structure of the Q-data block: the 72-bit data can be interpreted in three ways, determined by the address bits.

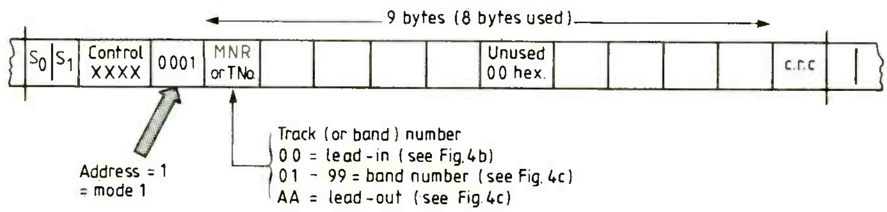
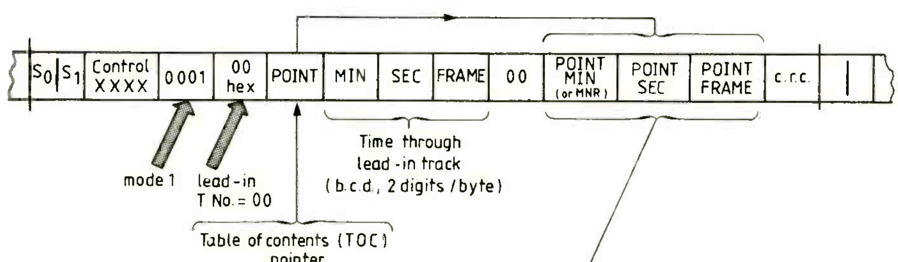


Fig. 4(a), above: General formal of Q subcode frame in Mode 1. There are eight unused bits, leaving eight active bytes. First byte is music or track number, which determines meaning of remaining bytes. (b), right: During lead-in T no. is zero, and Q subcode builds up a table of contents using numbered points with starting times. Point limit Codes A0 and A1 specify range of bands on multi-disc sets. Example shows two-disc set, with five bands on first disc and six bands on second. (c) bottom: During music bands T no. is 01-99 and subcode shows time through band and time through disc. The former counts down during pause, see Fig.5. Each band can be subdivided by index count.

	FRAME No.	POINT	POINT MIN	SEC	FRAME
First disc 5 bands 1–5	n, n+1, n+2	01	00	02	00
	n+3, n+4, n+5	02	12	09	10
	n+6, n+7, n+8	03	24	11	20
	n+9, n+10, n+11	04	36	59	74
	n+12, n+13, n+14	05	48	50	22
	n+15, n+16, n+17	A0	01	00	00
	n+18, n+19, n+20	A1	05	00	00
	n+21, n+21, n+22	A2	59	27	31
Second disc 6 bands 6–11	n, n+1, n+2	06	00	02	10
	n+3, n+4, n+5	07	10	03	20
	n+6, n+7, n+8	08	20	05	11
	n+9, n+10, n+11	09	30	04	03
	n+12, n+13, n+14	10	40	02	19
	n+15, n+16, n+17	11	50	59	70
	n+18, n+19, n+20	A0	06	00	00
	n+21, n+22, n+23	A1	11	00	00
	n+24, n+25, n+26	A2	59	20	74

(b)

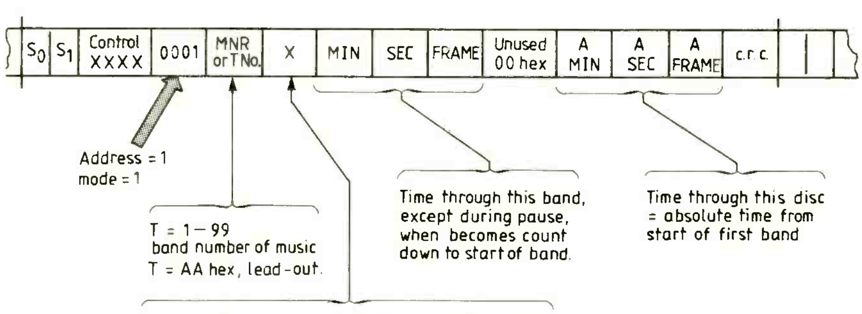


POINT = 00–99, POINT = MNR, and POINT MIN, SEC FRAME denotes absolute starting time of that MNR. This forms an entry in TOC.

POINT = A0 hex, POINT MIN byte = MNR of first band on this disc denotes beginning MNR of TOC.

POINT = A1 hex, POINT MIN byte = MNR of last band on this disc denotes end MNR of TOC.

POINT = A2 hex, POINT MIN, SEC, FRAME denotes absolute starting time of lead-out track.



X = 01—99, index no. subdivides one MNR or band

X = 00 = pause between bands (not same as P flag – see Fig. 5)

X = 01 in lead-out

tions. During the lead in track it contains a table of contents (TOC), listing each piece of music and the absolute playing time when it starts. During the music content of the disc it contains running time.

The 72-bit block is subdivided into nine bytes, see Fig. 4 (a), one of which is unused and permanently zero. Each byte represents two hexadecimal digits where not all codes are valid. The first bytes in the block is the music number (MNR) which specifies the number of the track on the disc, where in this context track corresponds to the bands on a vinyl disc. The tracks are numbered from one upwards, and the track number of 00 indicates that the pickup is in the lead-in area and that the rest of the block contains an entry in the table of contents.

The table of contents is built up by listing points in time where each track starts. One point can be described in one subcode block. Fig. 4 (b) shows that the second byte of the block is the point number. The absolute time at which that point will be reached after the start of the first track is contained in the last three bytes as point minutes, point seconds and point frames. These bytes are two b.c.d. digits, where the maximum value of point frame is 74. As there is only error detection in the Q data, the point is repeated in three successive subcode blocks. The number of points allowed is 99, but the track numbering can continue through a set of discs. For example, in a two disc set, there could be five tracks, 1 to 5 on the first disc, and six tracks, 6 to 11 on the second disc. Clearly the first point on the second disc is going to be point 6, and to prevent the player fruitlessly looking for points that are absent, the point range is specified.

If the point byte has the value $A0_{16}$ the point minute byte contains the number of the first track on the disc, which in the example given would be 6. If the point byte has the value A1 the point minute byte contains the number of the last track on the disc, which would here be 11. A further point is specified, which is the absolute running time of the start of the leadout track, which uses the point code of A2. These three points come after the actual music start points.

During the lead-in track, the running time is counted by the minute, second and frame bytes in the block. If the first byte of the block is between 00 and 99, the block is in a music track, and the meaning shown in Fig. 4 (c) applies.

The running time is given in three ways. Minute, second and frame are the running times from the start of that track, and A(absolute)Min, ASec and AFrame are the running times from the start of the first track on the disc. The third running time mode employs the index or x-byte. When this is zero, it denotes a pause, which corresponds to the P subcode being 1. During this pause, which precedes the start of a track, the running time counts down to zero, so that a player can display the time to go before a track starts to play. The absolute time is unaffected by this mode.

Non-zero values of x denote a subdivision of the track into shorter sections. This would be useful to locate individual phrases on a language course disc, or the individual effects on a sound effects disc.

Figure 5 shows an example of the use of P and Q subcode information in a hypothetical recording consisting of several pieces of music.

Mode 2 of the Q subcode allows the recording of the barcode number of the disc, and is denoted by the address code of 2 in the block as shown, in Fig. 6. The 52-bit barcode, along with 12 zeros and a continuation of the absolute frame count are protected by the c.r.c. character. If this mode is used, it should show up at least once in every 100 subcode blocks and the contents of each block should be identical. The use of the mode is not compulsory.

Mode 3 of Q subcode is similar to mode 2, except that a code number can be allocated to each track on the disc. Fig. 7 shows the i.s.r. code requires five alphanumeric characters of six bits each and seven b.c.d. characters of four bits each. Again the mode is optional, but if used, the mode 3 subcode block must occur at least once in every 100 blocks.

The R-to-W subcode is currently not standardized, but proposed uses for this data include a text display which would enable the words of a song to appear on a monitor in synchronism with the sound played from the disc. A difficulty in this area is the requirement to support not only the kind of alphanumerics this article is written in but also the complex Kanji characters which would be needed for the Japanese market.

The second proposed mode is to support colour graphics display, and the third mode would be to store colour television stills. A frame store would be necessary in the player to refresh the c.r.t. The large number of pixels needed for a tv still would require some 2.5 seconds of playing time to read each one from the disc. A future article will describe the R-to-W subcode details as soon as the standardization process is completed.

The master tape from which a compact disc is cut contains the exact audio sample values which will be transferred to the disc. All timing for the insertion of subcode information during cutting must therefore be derived from the timecode on one of the linear tracks of the cassette. It should be clear from Fig. 1 that the timecode must be locked to the sampling rate for CD mastering. Most p.c.m. adaptors and editors offer this feature. Drop-frame timecode is obviously unsuitable for a synchronized application such as this.

A further constraint is that the timecode on a master tape should not roll across midnight i.e. it should not overflow from 24 hours. The actual timecode start on the mastertape is irrelevant because the disc cutting computer subtracts the start timecode from all even timecodes, to obtain times with respect to the start of the disc. There is also need for some translation, since the master-tape timecode uses 525/60 video related frames, of which there are 30 in one second, whereas there are 75 CD subcode frames in the same period. The cutting computer also takes care of this.

The subcode data, containing table of contents and the timing of all pauses can be submitted on a standard form along with the cassette, or it can be recorded on the cassette itself. The timecode occupies analogue audio track 2 on the cassette, thus subcode is recorded on audio track 1. The standard for subcode recording specifies a block structure where TOC data an P-flag timings are coveyed along with an error correcting code. The channel coding is f.m. as in the timecode track.

The CD cutting computer needs to have read all of the TOC data from the subcode recording before commencing cutting the disc, since TOC is in the lead in area. It is also proposed that the subcode track will be available for recording R-to-W subcode in the future throughout the length

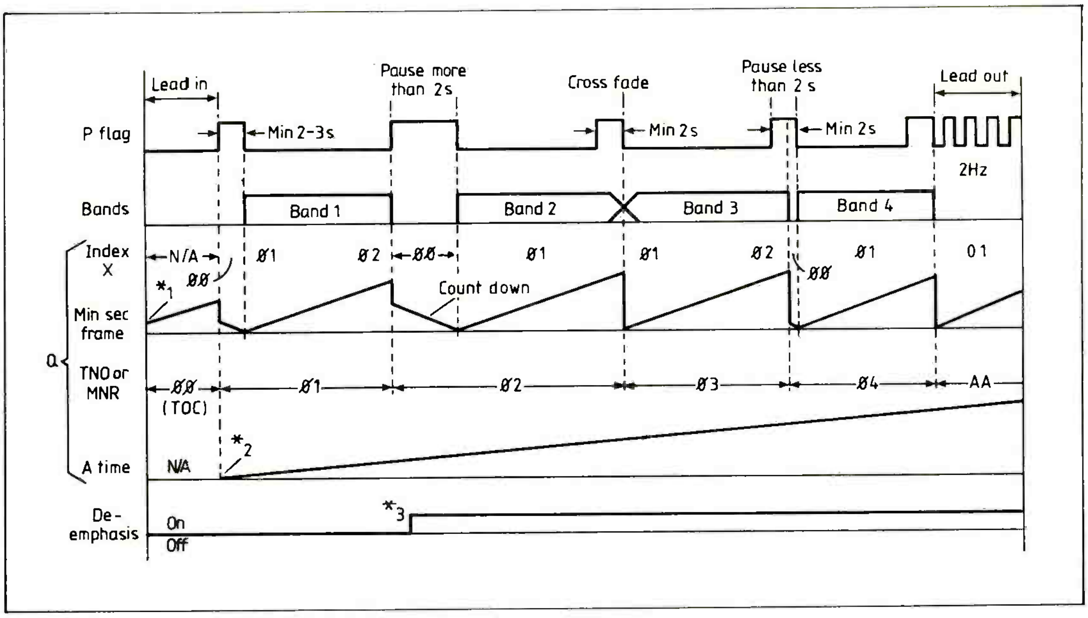


Fig. 5. Relationship of P and Q subcode tuning to the music bands. P-flag is never less than 2s between bands, whereas INDEX reflects actual pause, and vanishes at a cross-fade. Time counts down during INDEX = 00. *1: lead-in time does not have to start from zero. *2: A-time must start from zero. *3: De-emphasis can only change during pause of 2s or more.

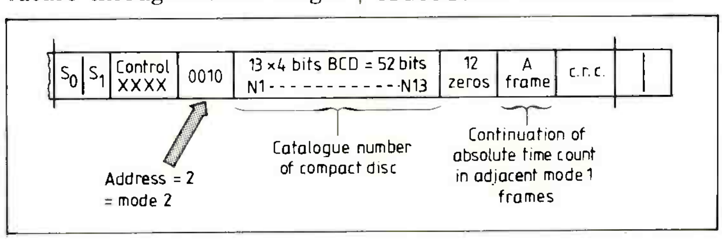


Fig. 6. In mode 2, catalogue number can be recorded, but must be the same throughout the disc and appear in at least one out of 100 successive blocks.

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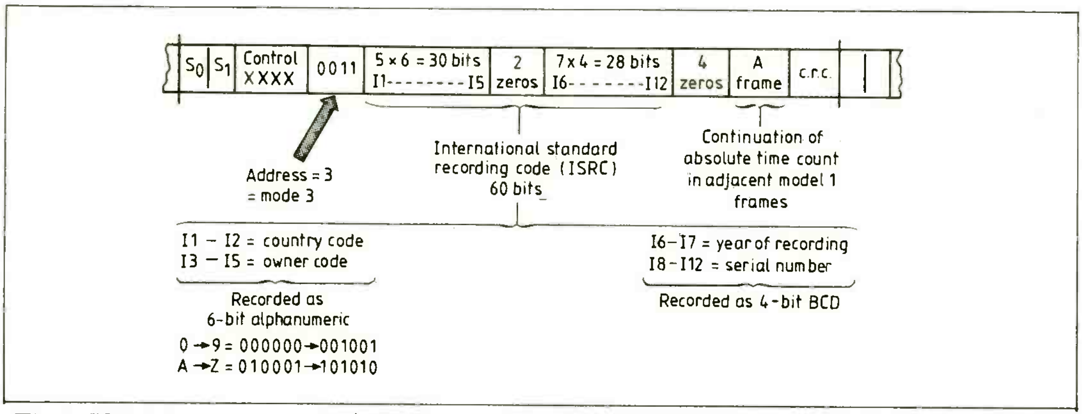


Fig. 7. ISRC format in mode 3 allows each band to have a different code. All mode-3 frames must be the same within same T number, and must appear in at least one out of every 100 successive blocks. (Not present in lead-out tracks.)

of the recording. For these reasons, the P and Q subcode information is placed on the cassette prior to the beginning of the first music track.

Specialised equipment is avaiable for the generation of subcode recordings from time-code charts. Fig. 8 shows a subcode editor intended for use in conjunction with a digital audio editor, as it makes use of its time code reading and audio monitoring ability. The subcode editor is connected by interposing it in the audio keyboard cable, where it can pick-off timecode from the v.c.r. going to the display on the keyboard, and where it can control the recorder by simulating transport commands from the editor keyboard. In this way the subcode editor can record the subcode data block in the correct place at the beginning of the cassette before the first music. The time codes entered into the subcode block can also be used to position the mastertape using the autolocate function of the audio editor, so that the operator can verify that the P flags have been inserted at the correct time with respect to the music.

This concludes the Compact Disc series, which has been most satisfying to research and write. I have been surprised and delighted by the response to the series, which has added to the satisfaction. I should like to thank the following people for their helpful discussions: Dr Kees Immink of Philips, Dr Toshi Doi of Sony, and Dr Roger Lagadec of Studer (now also with Sony). – JRW. ■

The 1986 satellite and cable tv show

Our roving reporter focuses on d.b.s. opportunities – as seen at Cable '86

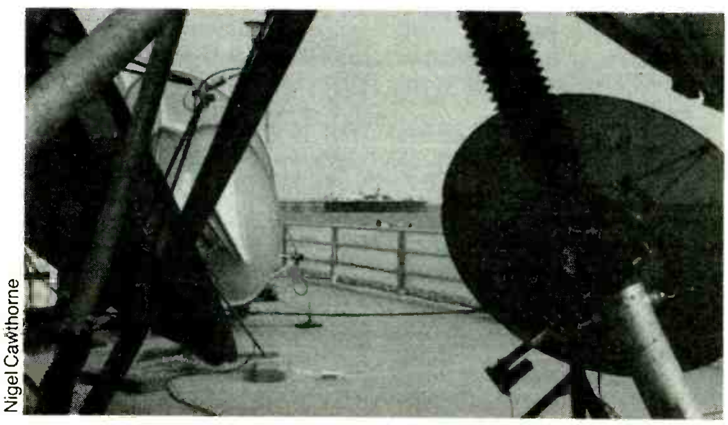
The problem of cable in Britain is "to make those millions of Britons who do not have cable wish they had." So said Bryan Cowgill, head of Robert Maxwell's cable and tv interests, in his opening speech at Cable 86. "Cable and satellite" predicted Cowgill "will no longer be a small matter on the periphery of broadcasting." But in trying to answer the question of how successful cable has been so far in attracting new subscribers, Ian Young of Ewbank Preece told his audience that in the UK the answer is shrouded in "complications and secrecy".

Complications come from the confusion of existing low-capacity systems and upgraded cable systems, many of which offer only limited services. Surprisingly, official figures show that between February 85 and January 86, whilst there has been a 39% increase in the number of households 'passed' by new-build systems, the actual number of households in total subscribing to cable services fell over 18,000. This statistical freak was caused by mixing both old and new cable system into the same computation. Young wondered why, when clear information is required, the UK cable industry has allowed such confusion to occur in the basic data.

Ian Young explained that his attempts to get accurate information on existing subscribers totals and growth projections on specific cable systems were usually met "with aimiable but resolute evasion". Young's own estimates suggested that less than 20,000 subscribers are connected to 'new-build' cable tv networks in the UK. Penetration (numbers of households connected as a percentage of the numbers of houses passed) is around 21%.

From Finland, Helsinki Cable TV's (HTV) Esa Malm said that over 200,000 out of Finland's 1.8 million households are connected to cable networks. Helsinki alone has 110,000 households connected. Current estimates for Finland are that over 50% of all urban households will be connected by 1990. HTV aim to provide 38 channel capacity to all viewers by 1987.

Nigel Cawthorne



This display of satellite feeds included a stunning demonstration of low-power tv reception using only a 0.8m dish made by D H Satellites and supplied by Harrison Electronics.

DBS: risks and opportunities

Jon Chaplin of ESA, the European Space Agency, in analysing the risk and opportunities of d.b.s. listed the four major risks as: loss of satellite (particularly at its launch), 'green field' operation (concerning the provision of suitable receivers and their installation in homes), regulation and government policy (where there are still some unkowns) and finally the uncertainty in thw growth of revenue.

Chaplin believes that the crucial factor in d.b.s. is to maximise the probability of realising predicted growth of revenue. The extraordinary high levels of front-end investment have to begin to be paid for as quickly as possible by providing a sufficient variety of services. DBS services should include not only radio and tv broadcast services but also closed user-group video services and specialist information services. Accurate local weather reports for farmers are an example of a service that could be marketed as part of the d.b.s. package. The sale of such d.b.s.-borne services could be used to off-set some of the front-end investment and help to build up revenue quickly.

Chaplin complained that "more imagination" was needed by the UK government on the use of d.b.s; it could also be used for innovative educational and training services. Chaplin forecast that it will be the "primary medium by the end of the century".

But in the meantime d.b.s. has to get over the launch problem. Launch failures only have disastrous consequences for systems relying on single new types of

Continued on page 51

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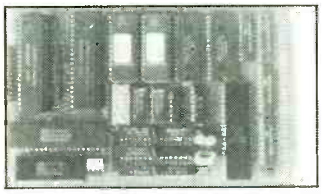

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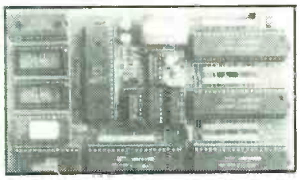

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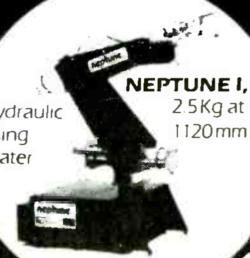

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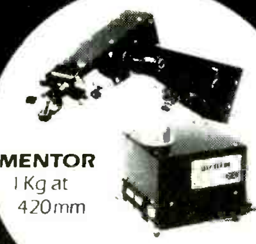

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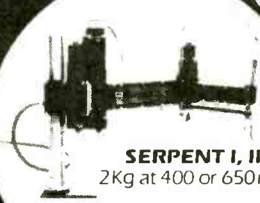

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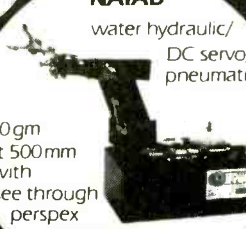

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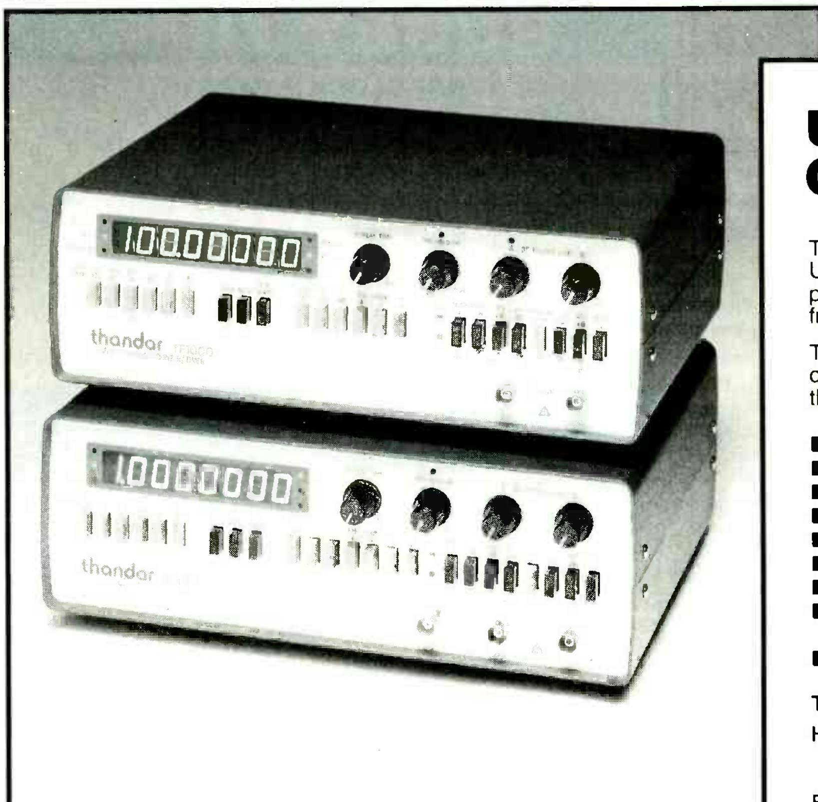

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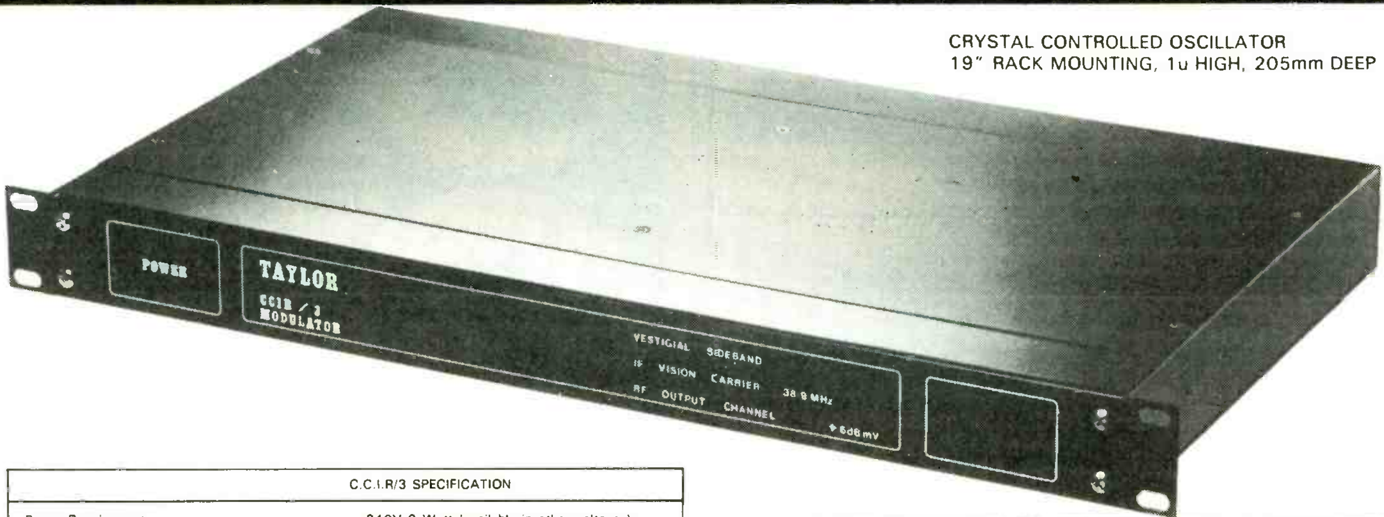

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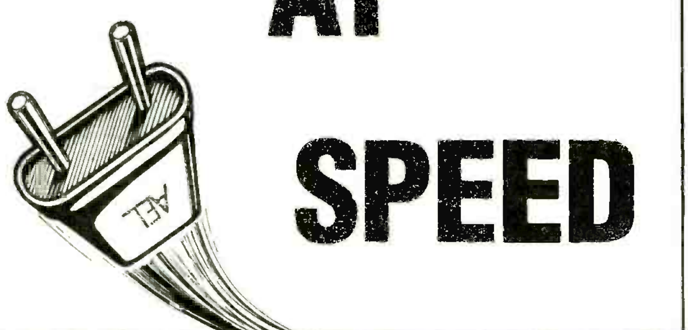

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Solid-state logo player

by I.G. Brown

Thames tv plans to switch its familiar logo from film to silicon

Ivan Brown T.Eng. (CEI) is a senior project engineer with the research and development group of Thames Television Ltd. His recent work includes investigations into new video systems, including variations on PAL, analogue t.d.m. and p.c.m. systems. In his spare time he is studying psychology with the Open University.

Thames Television's station identification appears at the start of every programme: in the Thames area alone, it is screened on average 50 times each week.

At present, the ident is televised from film, and usually the replay process also includes at least one videotape stage. To improve the consistency of replay quality and relieve pressure on expensive studio equipment, generating the logo from solid-state memory seemed an attractive alternative.

The memory capacity needed to store this type of material depends on two factors: the duration of the animated sequence and the amount of picture detail. Fully detailed pictures in full colour and with a full grey-scale range demand about eight million bits per picture. An animation sequence lasting only three seconds would therefore call for some 600M-bits of storage. Even with current chip capacities of 1M-bit per chip, a solid-state store of this size would still be somewhat unwieldy.

However, the idea of committing frequently-used station idents to solid-state memory is by no means new. At the BBC*, the recording capacity limitation has been overcome in the case of material containing large areas of identical data effectively by storing only data changes which occur at transitions. In this way it has been possible to produce very efficient equipment.

*Lawrence, R.K., and Mason, B.R. 1982 IBC, 71,72.

Such memory conservation measures cannot be applied to Thames's main ident symbol, which is a highly detailed photo-montage of the London skyline. However, its saving grace lies in the nature of the animation sequence: in essence, the sequence is composed by read-and-reflect operations on a single master frame (Fig. 1).

A solid-state picture store can be considered as a two-dimensional array. The horizontal index represents the address of a pixel relative to the start of a television line and the vertical index corresponds to the line number. In the present case, the memory array is filled with data representing the picture in Fig. 1.

The moving sequence is synthesized by memory addressing which scans vertical segments of the stored picture. At any one time, only 50% of this picture is used in composing the output. The complete image is obtained by re-reading the first 50% in reverse to produce a reflected mirror image in the lower half of the output frame.

Figure 2 shows the scene which opens the ident. Picture data is derived from the upper half of Fig. 1, together with its vertical mirror-image. To synthesize the scene, the array is first read from top to centre, producing the top half of the cloudscape. Then the vertical index counters are cued to count backwards so as to produce the reflected lower half.

As the animated sequence develops, new picture data emerges from the central line (Fig. 3). This effect is achieved by incrementing the vertical index start address by six lines at the start of each field.

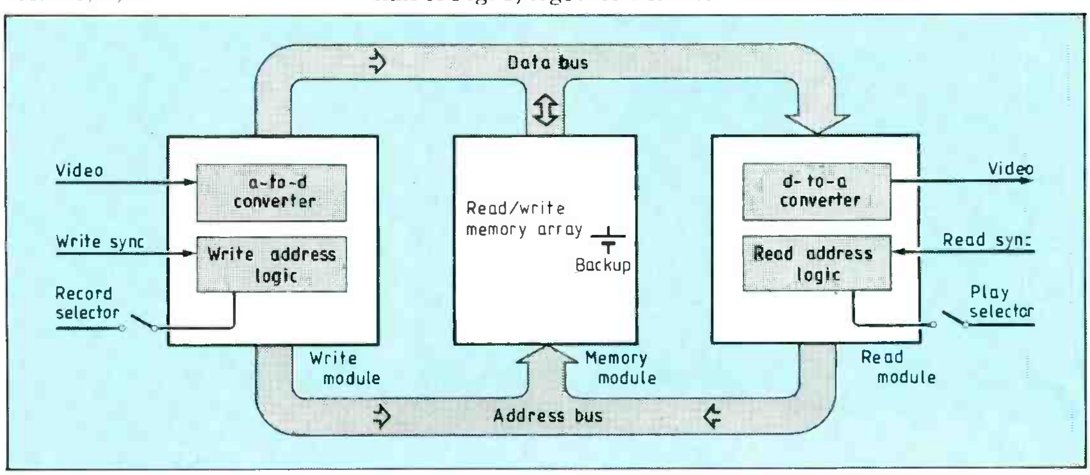
The final image is shown in Fig. 4, which is made up entirely of data from the lower half of the array. In all, the animated sequence lasts about two seconds.

Hardware

Two main sections make up the equipment required to generate the video sequence: an acquisition system, to convert the original artwork into digital form, and a read-out unit.

Design of the data acquisition hardware is in part determined by the read-out strategy. Our initial thoughts were to base the memory array on read-only memory chips

Fig. 5. Block diagram. This simple system meets Thames's experimental requirement. But a dedicated computer-controlled version could be more versatile.



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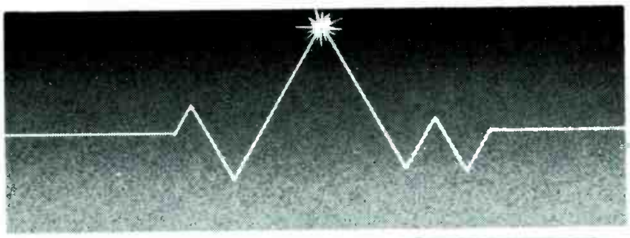

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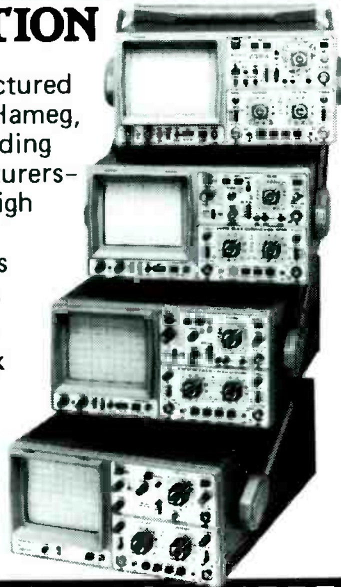

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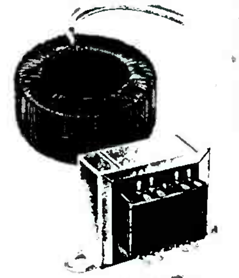

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Designing with dynamic memory

by Alan Clements
Teesside Polytechnic

Dynamic rams are not as complex as their timing diagrams suggest

The write cycle timing diagram of a dynamic ram is not as simple as a read cycle diagram because of the more stringent requirements placed on the $\overline{W}$ and data inputs. As the first part of this article (August issue) worked through the read cycle timing diagram, it is not necessary to plough through all the same material again. Fig. 10 gives the full timing diagram of a HM4864 64K × 1 dynamic ram during a write cycle; Fig. 11 is a copy but includes only parameters that differ between the read and writes cycles. You can see that all the timing requirements of the $\overline{RAS}$, $\overline{CAS}$ and address inputs are identical in both read and write cycles.

Write timing

Consider first the requirements of the $\overline{W}$ input, which signal has to satisfy six conditions. It is latched by the falling edge of the $\overline{CAS}$ clock, and has a setup time of t_{WCS} seconds. The minimum value of t_{WCS} is −20ns, implying that $\overline{W}$ can be asserted as late as 20ns *after* the falling edge of $\overline{CAS}$. Once asserted, it has a minimum down-time of t_{WP} seconds (write pulse width 45ns), and must not be negated until at least t_{WCH} seconds (write pulse hold time 45ns) after the falling edge of $\overline{CAS}$.

In addition to these parameters, $\overline{W}$ must be asserted at least t_{RWL} (write command to row strobe lead time) before the rising edge of $\overline{RAS}$, and at least t_{CWL} (write command to column strobe lead time) seconds before the rising edge of $\overline{CAS}$. These are both quoted as 45ns. Finally, $\overline{W}$ must not be negated at least t_{WCR} seconds (the write command pulse hold time referenced to $\overline{RAS}$) after the falling edge of $\overline{RAS}$.

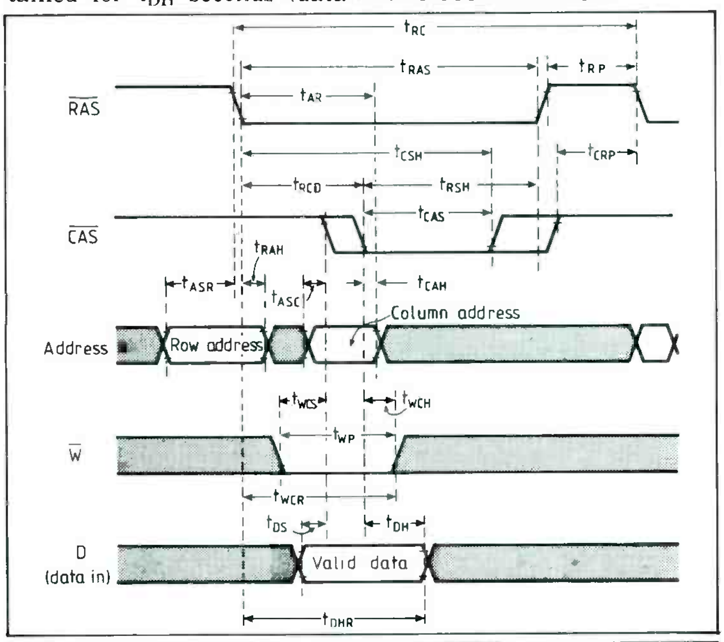
At this point, dear reader, you can be forgiven for thinking that the dynamic ram is a hideously complex device and that you would rather stick to static ram. There is an old saying "Look after the pennies and the pounds take care of themselves". So it is with dynamic ram. Look after the $\overline{RAS}$ and $\overline{CAS}$ clocks and the $\overline{W}$ input will take care of itself.

To illustrate this point consider a simple example in which the write pulse is made equal to the $\overline{CAS}$ clock, see Fig. 12. The $\overline{RAS}$ pulse is given the minimum possible value of t_{RAS} = 150ns. $\overline{CAS}$ is derived from $\overline{RAS}$ by delaying its falling edge by 50ns from $\overline{RAS}$, to yield a value for t_{RCD} of 50ns, and for t_{CAS} of 100ns, its minimum permissible down time. The $\overline{W}$ signal is obtained by gating the R/$\overline{W}$ output of the processor with $\overline{CAS}$.

Below the Fig. 12 timing diagram are the six parameters associated with $\overline{W}$ during a write cycle and their minimum requirements, together with the values achieved by this circuit. In each case the righthand column gives the margin by which the requirement is satisfied. A negative value would indicate a failure to meet a requirement. As no entry in this column is negative, it can be concluded that this circuit satisfies all constraints on $\overline{W}$. Note that the margin on the write command setup time is only 20ns, of the order of the propagation delay through two gates in series. A margin as low as this would require careful attention to fine detail in a real circuit.

Data timing in a write cycle

Data is written into the memory on the falling edge of the $\overline{CAS}$ clock. The requirements for data-input timing are entirely straightforward and involve only three parameters (see Fig. 11). The data to be written into the memory must be valid for t_{DS} seconds (data setup time) before the falling edge of $\overline{CAS}$, and must be maintained for t_{DH} seconds (data



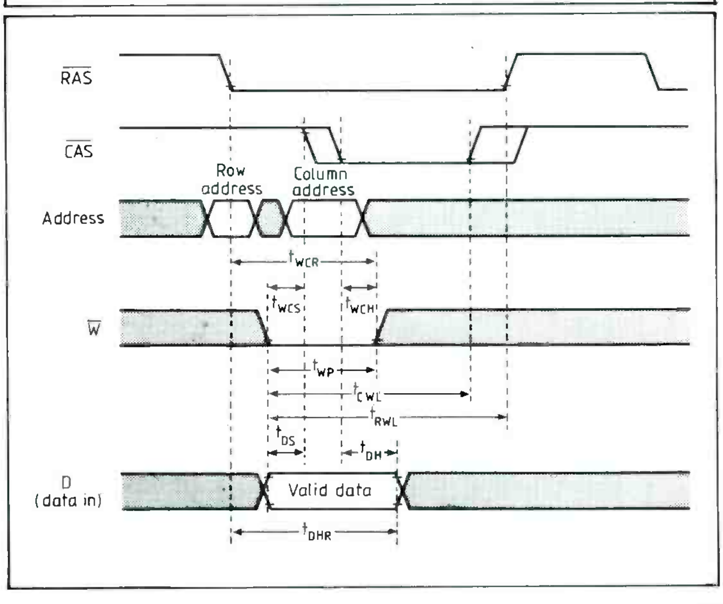


Fig. 10. Full timing diagram of a dynamic ram in a write cycle (top).

Fig. 11. In this detail of the write cycle timing diagram (bottom) the 'critical event' is the falling edge of $\overline{CAS}$ which latches the $\overline{W}$ and the data input to the d-ram. Only parameters directly related to the write cycle have been included.

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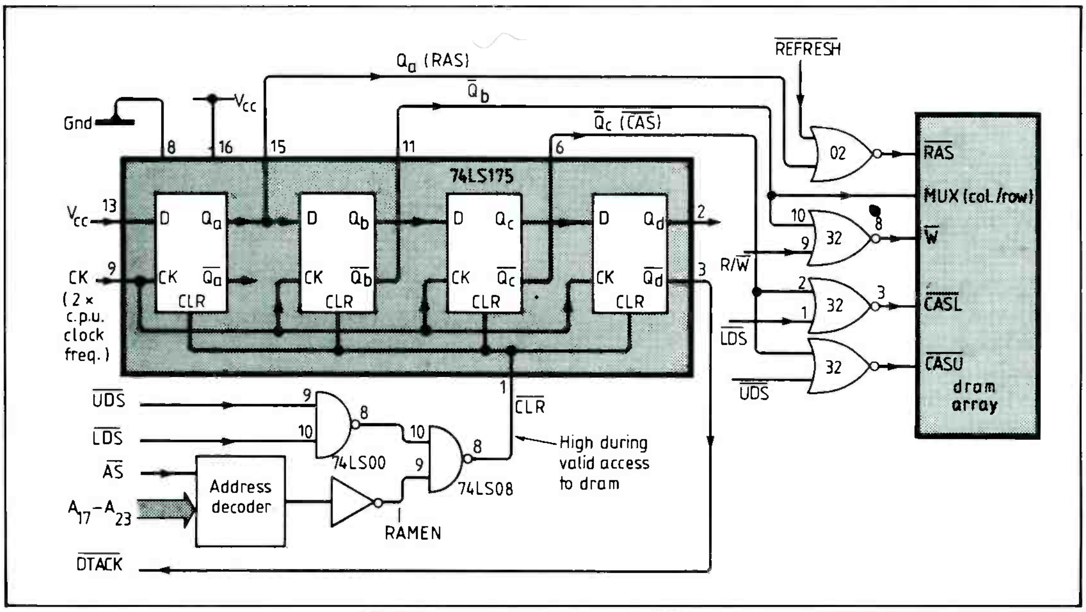

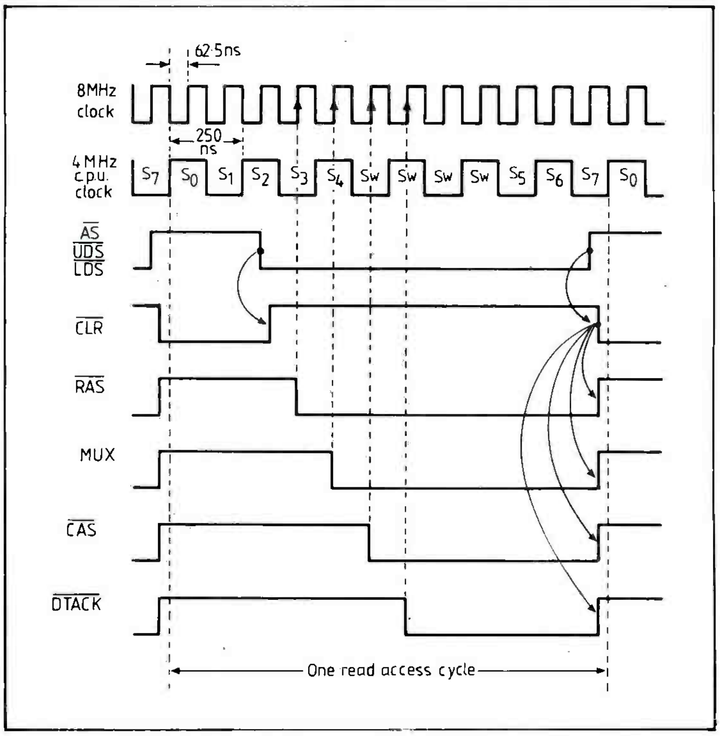

Fig. 18. In dynamic memory control on the 68000 board, valid access to d-ram array forces four-bit shift register out of reset (clear) state. Each clock pulse causes 1 to be shifted down the register to general $\overline{\text{RAS}}$, $\overline{\text{MUX}}$, $\overline{\text{CAS}}$ and $\overline{\text{DTACK}}$ signals in sequence.

Fig. 19. Read cycle timing diagram for Fig. 17.

Typical time values (ns)

t_{ASR}	row address setup command	0
t_{CWL}	write-to-col strobe lead time	45
t_{DH}	data hold time	45
t_{DH}	data hold time ref. to RAS	95
t_{DS}	data setup time	0
t_{FC}	refersh cycle time	270
t_{FI}	REFRESH inactive time	60
t_{FP}	REFRESH pulse period	60-2μ
t_{FRD}	REFRESH-to-RAS delay	320
t_{FRI}	RAS inactive time during refersh	370
t_{FRL}	RAS-to-REFRESH lead time	370
t_{FSR}	REFRESH-toRAS setup time	−30
t_{RAS}	row address strobe pulse width	150-10μ
t_{RAH}	row address hold time	20
t_{RC}	random access read cycle time	270
t_{RFD}	RAS-to-REFRESH delay	−10
t_{RWL}	write command-to-row strobe lead time	45
t_{RP}	row address strobe precharge time	100
t_{WCH}	write command hold time	45
t_{WCR}	write command time ref. to RAS	−20 95
t_{WCS}	write command setup time	−20

ledge) input. If $\overline{\text{DTACK}}$ is not asserted in state S_4 the 68000 inserts wait states and idles until $\overline{\text{DTACK}}$ goes low. This feature permits the 68000 to be operated with a mixture of fast and slow peripherals.

A difficulty associated with 16-bit systems is the need to carry out byte operations on only half a word. While it would be possible to design two completely independent memory systems, one for the lower and one for the upper byte, such an approach would be hopelessly inefficient. To access data in a dynamic memory, both $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ are involved in a cycle. Therefore, by negating either $\overline{\text{RAS}}$ or $\overline{\text{CAS}}$ to one half of a word, that byte is disabled and takes no part in the memory access. As refresh operations are applied to all bits of a word, $\overline{\text{RAS}}$ should not be gated with $\overline{\text{UDS}}$ or $\overline{\text{LDS}}$. In any case, it should not be gated with $\overline{\text{UDS}}/\overline{\text{LDS}}$ because the data strobe is asserted late in a 68000 write cycle. In Fig. 16, the $\overline{\text{CAS}}$ inputs to the 16 d-rams are divided into two groups of eight, $\overline{\text{CASL}}$ and $\overline{\text{CASU}}$: $\overline{\text{CASL}}$ is formed by gating $\overline{\text{CAS}}$ with $\overline{\text{LDS}}$, and $\overline{\text{CASU}}$ by gating $\overline{\text{CAS}}$ with $\overline{\text{UDS}}$.

Control of 68000 board

An example of a 68000 dynamic memory system is provided by the Motorola 68000 single-board educational computer. This uses 16K × 1 components, but the principles are valid for components of any size. Figure 18 gives the basic circuit of the timing generator for the read and write cycles. The arrangement of the dynamic memories and the row/column/refresh address multiplexers is not included here, as it is entirely straightforward. The read cycle timing diagram for this circuit is in Fig. 19.

The component at the heart of the controller is a 74LS175 four-bit shift register, clocked at twice the rate of the processor clock. As long as the dynamic memory block is not being accessed (that is both $\overline{\text{LDS}}$ and $\overline{\text{UDS}}$ high, or RAMEN low), the output ($\overline{\text{CLR}}$) of the two-input and-gate is low and the shift register is cleared with $Q_a = Q_b = Q_c = Q_d = 0$. Whenever the processor addresses the array, RAMEN goes active-high, enabling one input to the and gate. As soon as $\overline{\text{LDS}}$ or $\overline{\text{UDS}}$ is asserted, the second input to the and-gate rises and its output, $\overline{\text{CLR}}$ becomes high. The shift register is now enabled and a logical one is shifted along on each rising edge of the 8-MHz clock. Note that the educational board has a 4MHz version of the 68000.

On the first clock pulse, the Q_a output rises to a high level, because the serial input to the shifter is tied to V_{cc}. The Q_a output from the shift register is 'NOR ed' is with $\overline{\text{REFRAS}}$ from the refresh circuitry (to generated $\overline{\text{RAS}}$ pulses during refresh cycles), and inverted by a nor-gate to provide the system $\overline{\text{RAS}}$. On the next rising edge of the 8MHz clock, Q_b goes high and $\overline{Q}_b$ low; $\overline{Q}_b$ acts as the row/column multiplex control signal and also gates the $R/\overline{W}$ signal from the 68000. The next rising edge of the 8MHz clock sets Q_c and resets Q_{c^*} to generate $\overline{\text{CAS}}$. This is followed one clock pulse later by $\overline{\text{DTACK}}$. The falling edge of $\overline{\text{DTACK}}$ is recognized by the 68000 and the memory access continues with state S_5. During S_7, $\overline{\text{AS}}$ is negated (together with $\overline{\text{UDS}}$ and $\overline{\text{LDS}}$) and the shift register cleared, forcing RAS, $\overline{\text{CAS}}$, $\overline{\text{MUX}}$, $\overline{\text{W}}$, and $\overline{\text{DTACK}}$ high.

(To be concluded).

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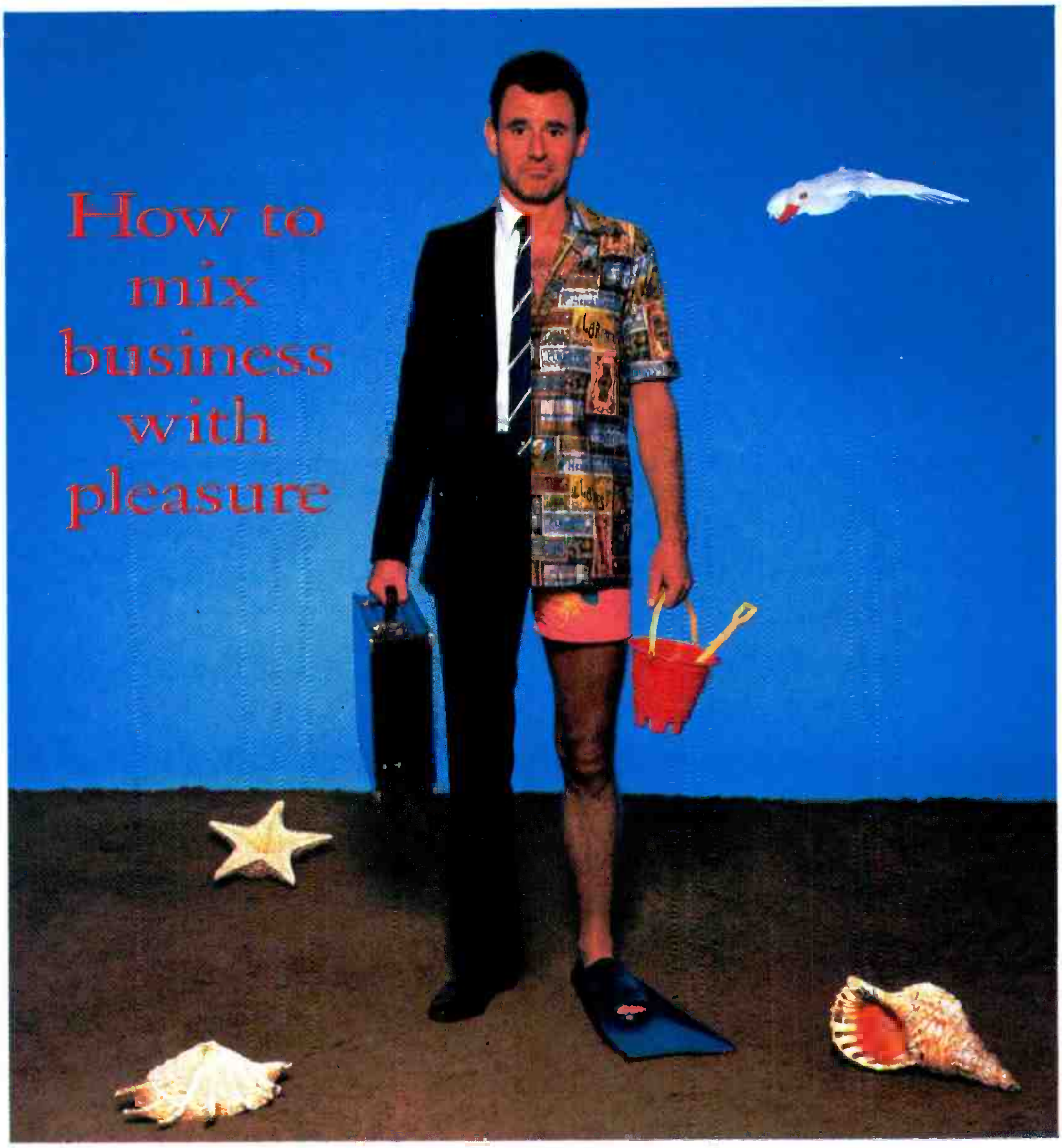

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CIRCUIT IDEAS

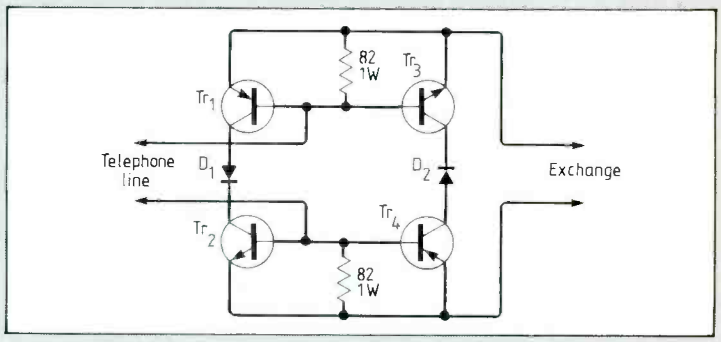
Loop-resistance corrector for telephone exchanges

This correction circuit was devised to rectify a fault which caused a lack of dialling tone in 2000Ω telephone lines connected to 700Ω telephone exchanges.

In a telephone exchange, maximum loop resistance is the highest value of resistance that a line can have without upsetting normal operation of the telephone set. When this resistance value is exceeded line current is insufficient to drive the line relays at the exchange even though the handset can operate at as low as 5mA. In a 2000Ω exchange, minimum line current for relay switching is 15mA.

Connected at the exchange end, this circuit rectifies this fault provided that line current is above 8mA. Relay current is doubled while handset current is reduced by 20%.

Base and emitter currents of the two transistor pairs act as telephone line current and relay current respectively. Two transistor pairs must be used to so that the circuit operates in either polarity.



Resistors reduce the ratio of these currents to 1:3 while providing a bidirectional communication path. The two diodes stop the transistors from acting as zener diodes while polarity is reversed. Ratings of all the transistors are 100V and 500mA.

D.P. Ediriweera
Tea Research Institute
Talawakele Sri Lanka.

Electromagnetic transducer using a flux guide

Magnetic pick-up coil transducers can be used in non-contact sensing applications but they have never been as popular as optoelectronic, inductive or capacitive proximity sensors because they tend to be large and clumsy.

Now though, miniature 3-by-2-by-1mm sintered samarium-cobalt magnets magnetized through their thickness are readily available from Mullard so a compact and inexpensive transducer can be made for inaccessible places.

A ferrite rod is used as a flux guide to couple flux from the magnet to the pick-up coil. The magnet is glued to the rotating target. Since mass of the magnet is only 50mg, the target's moment of inertia is not appreciably affected.

With a remnant dipole moment of the magnet as high as 4.24×10^{-3}A/m^2, the magnetic flux can be coupled to the pick-up coil with the ferrite rod 5mm away from the magnet.

The pick-up coil is a 21mm diameter Mullard FX2239 pot core wound with 250 turns of 0.224mm wire. The ferrite rod, fitting into the core, is about 50mm long and can be made up of segments to form a curved flux path for cases where the target is not accessible directly.

Magnitude of the induced e.m.f. is proportional to the rate of change of flux and even at 23Hz, as in the photograph, s/n ratio is high enough to allow processing with one op-amp and comparator i.c. like the LM392.

In the photograph, the top trace is output of IC_{1a} with Y deflection at 0.5V/div. Section IC_{1b} is used in Schmitt-trigger mode to produce output as shown in the lower trace with Y deflection at 5V/cm. For both traces, a 10ms/div horizontal deflection was used.

Power supply requirements are 4.5 and −4.5V at 2.5mA.

A.de Sa
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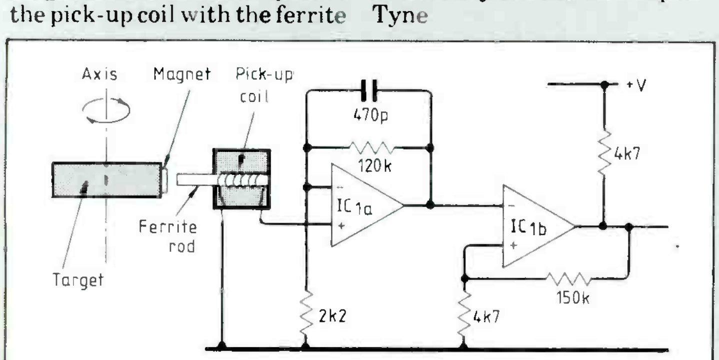


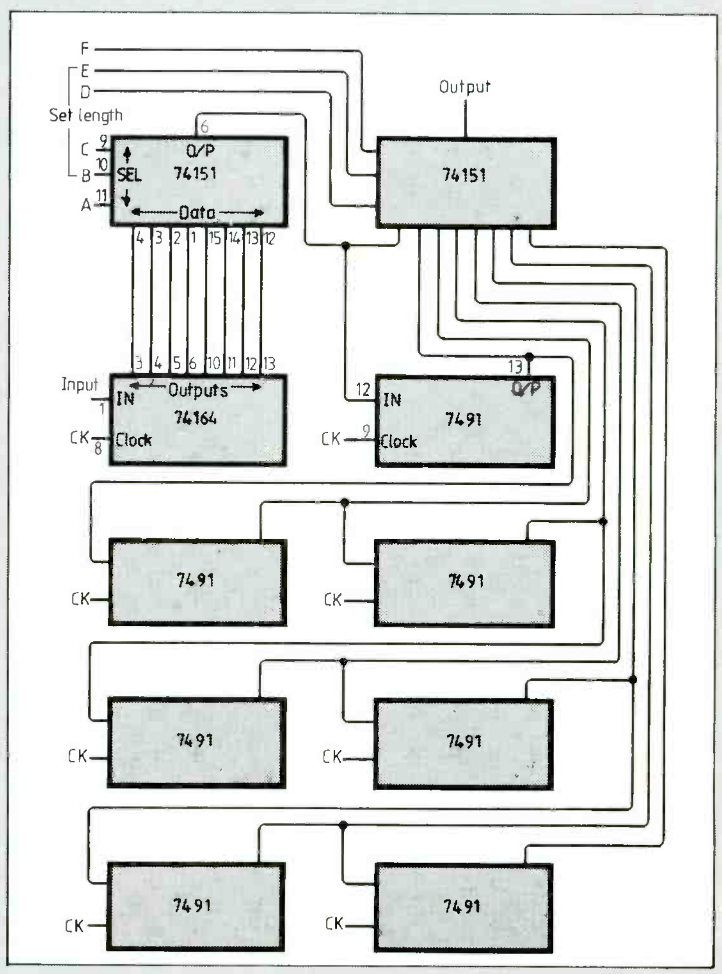
Variable-length shift register

Length of this shift register can be varied from one to 64 bits. It overcomes the speed limitation and signal-level difficulties of the c-mos 4557.

Data at select inputs of the two 74151's determines the shift-register length. Setting inputs A to F to zero gives a one-bit delay between input and output and setting all the inputs to one gives a 64-bit delay.

If need be, clock inputs of the 7491s can be gated with data selected lines D, E and F to avoid clocking unused registers on shorter shift sequences. This circuit could be extended using 16bit multiplexers and extra registers.

J.Jeffery
University of London



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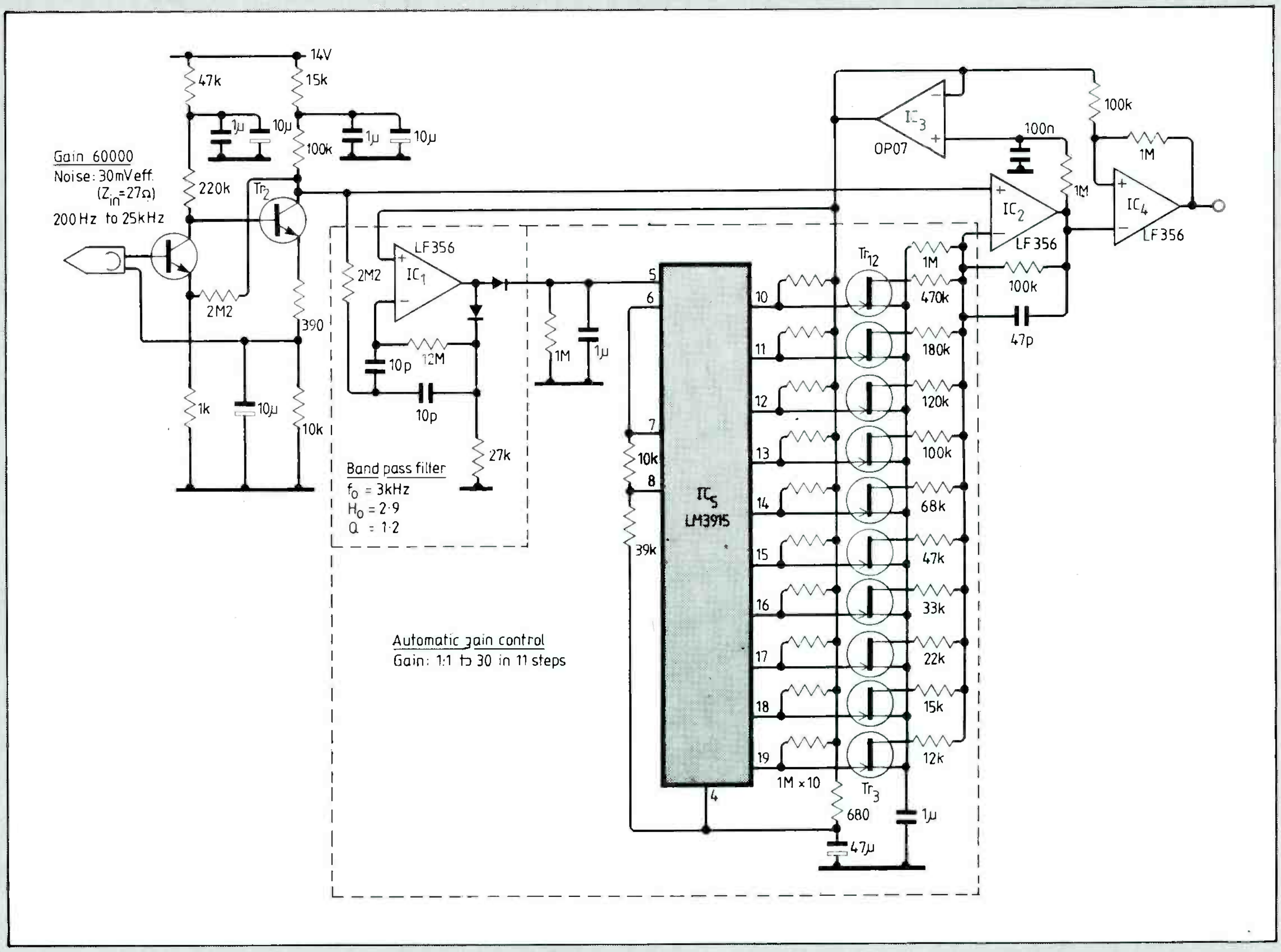


Low-noise preamplifier for data

When a magnetic medium such as ¼in tape is used for data storage there are numerous potential error sources including inconsistent tape width, tape stress, wow, flutter and dust between head and tape. As a result, a widely fluctuating playback signal can be expected.

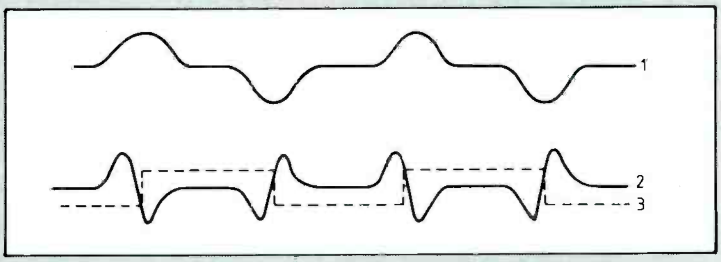
This circuit improves reliability by keeping digital output level constant over a wide range of input signals.

Output from the head is normally a few millivolts but flutter and dust can reduce the level significantly. With this circuit, a playback signal of 20µV still gives excellent results. To amplify a signal of 20µV, a very-low-noise amplifier is needed. Integration of the signal is impractical since the very high low-frequency gain required for the integration results in too much low-frequency noise. Here a flat-response amplifier is used.

Noise in modern very-low-noise integrated amplifiers is higher than the noise of two low-cost BC107-type transistors which have been selected for noise and frequency performance in the actual circuit.

By choosing the transistors in this way, an effective output-noise value of 30mV was obtained over the whole bandwidth and an input impedance of 27Ω. Referred to the input, this noise figure with a gain of 60 000 is 0.5µV effective which is five times higher than the noise of figure of a 27Ω resistor.

Direct-current drift of the two transistors is compensated for. Here a d.c. reference level is created by integrating output from the two transistors. The integration constant of 10ms, determined by an RC network, is long enough for the frequency of 3kHz used.



Gain correction is achieved with an LM3915 bar-display driver switching fet transistors which, with an op-amp, acts as a digitally-controlled-gain amplifier. In each step a parallel resistor is switched in or out to alter gain.

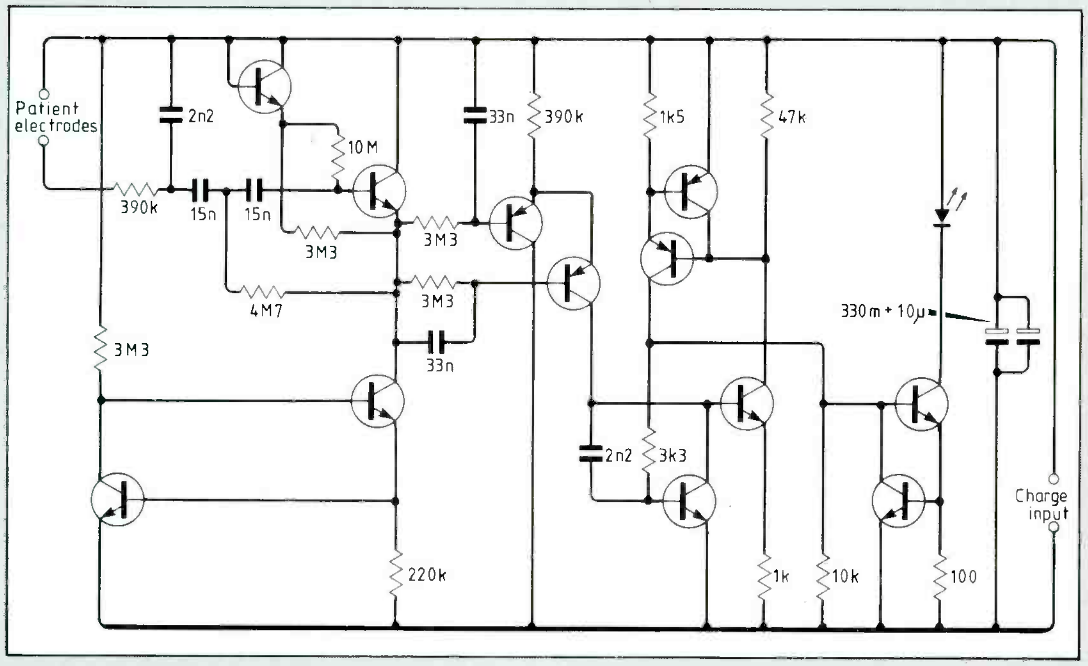
No feedback for the gain adjustment is used, therefore no pulses are lost due to overshoot, etc. Roll-off time for the gain adjustment is determined by an RC time constant; when the signal becomes smaller, the gain is doubled every 70ms.

Circuit IC_1 is a bandpass filter added so that unwanted noise spikes do not alter the amplifier gain. Gain correction response is mainly determined by the time lag of this filter.

The circuit could be improved by inserting a delay line between Tr_2 and IC_2 to overcome the bandpass-filter time lag.

F. Ypenburg
National Physical Research Laboratory
Pretoria

Capacitor-powered fibre-optic transmitter



This circuit takes electrocardiogram signals from a pair of electrodes and transmits down a fibre-optic link. It can be powered by a memory back-up type capacitor, 0.33F charged to 5V providing about five hours operation or it could equally well use a pair of watch type cells.

The circuit was designed for use in a nuclear magnetic resonance scanner, this being very sensitive to electrical noise as would be conducted down wires. Output is sufficient for transmission up to at least 10m using Honeywell "Sweet Spot" devices and 1mm polymer cable.

Input from the electrodes is bandpass filtered before being fed via a buffer to a long-tailed pair. The 33nF/3.3MΩ which filters a.c. from the drive to one side of the pair also forms the third stage of the high-pass Bessel filter. This long-tailed pair limits the linear range to about 20mV, but this is adequate for the purpose intended.

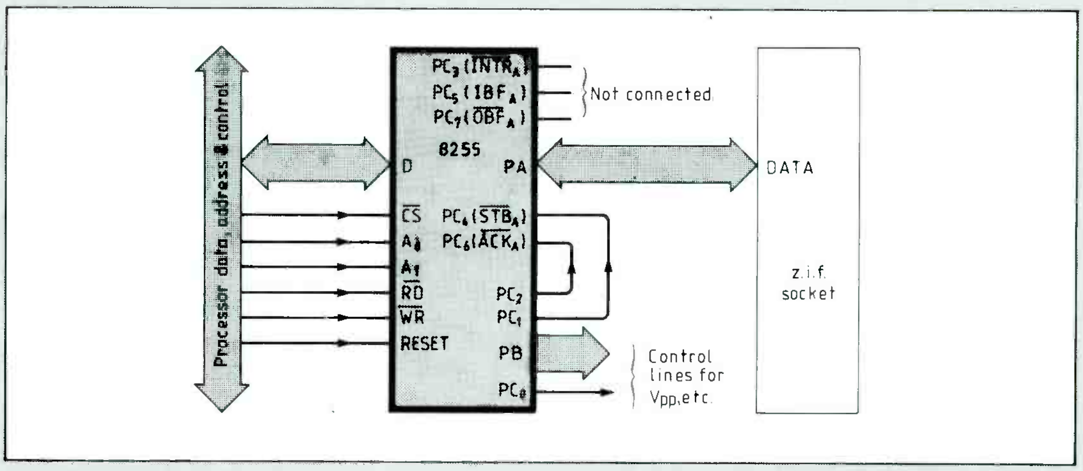
Current from one collector, which is a linear function of input voltage, is used to charge a capacitor in a current-to-frequency converter which in turn delivers approximately 3μs pulses to the led driver.

Extensive use of constant-current sources makes this circuit insensitive to supply voltage changes, the lower limit of 2V being dictated by the led.

Receiver design is not critical. The requirement is for a frequency-to-voltage converter, linear up to about 1500Hz.

G.G.R. Rutter
London W2

8255 port-direction changing



In eprom programmers, the 8255 programmable peripheral interface is often used. But a problem arises when you try to use one of its ports in mode 0 or 1 as a data port for the programming socket and some pins of the other ports as control pins for activating relays or selecting programming voltages for example.

The problem is that during the program/verify sequence you must first output then input data from the same port. When this port is programmed in mode 0 or 1, is necessary to send another control word to the 8255 to change direction of the port. On sending this control word, all outputs are set to zero so an undesired situation may occur such as changing the V_{pp} level or relay states during programming.

This problem is easily overcome by programming port A for example in mode 2 and activating both $PC_4(\overline{STB}_A)$ and $\overline{PC}_6(ACK_A)$ signals by a single bit set/reset operation on the two remaining pins of port C ($PC_{1,2}$).

Reading from port A is carried out by sending a zero then a one to PC_1. To output data on port A, first write the data to port A then set PC_2 to zero. Data is held on port A as long as PC_2 is kept low.

While $PC_{1,2}$ are high, port A is in its high-impedance state. During i/o to and from port A, pins, $PB_{0\text{-}7}$ and PC_0 remain unchanged.

Tadeusz Jarosiński
Warsaw

DON'T WASTE GOOD IDEAS

We prefer circuit idea contributions with neat drawings and widely-spaced typescripts, but we would rather have scribbles on "the back of an envelope" than let good ideas be wasted.

Submissions are judged on originality and/or usefulness so these points should be brought to the fore, preferably in the first sentence.

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2SC2078	1.45
2SC2091	0.85
2SC2098	2.95
2SC2166	1.95
2SC2314	0.80
2SC2371	0.36
2SD234	0.50
3N211	2.95
3SK88	0.95

DIODES

AA119	0.80
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BT199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	1.10
BZY95C30	0.35
CS4B	4.50
CS10B	8.45
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00
IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.20

ZENER DIODES

BZX61 Series	0.15
BZY88 Series	0.10

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CME1431W	39.00
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CME2024W	45.00
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CV429	89.00
CV1450	35.00
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CV2191	19.00
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D9-110GH	39.50
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D13-600GM	59.00
D13-610GH	59.00
D13-511GH	59.00
D13-611GM	59.00
D13-630GH	59.00
D14-150GH	75.00
D14-150GM	75.00
D14-162GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
D14-200BE	89.00
D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH/50	75.00
D14-310W	110.00
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D16-100GH-65	69.00
D16-100GH/67	65.00
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D18-160GH	69.00
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M31-101GH	55.00
M31-182GR	55.00
M31-182GV	53.00
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M31-184P31	65.00
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7709631	78.50

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17 watt	1R-15K	0.30

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Sanyo VTC 9300P	3.90
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Toshiba V5470	4.50

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SANYO ORIGINAL PART NUMBER	MODEL	DESCRIPTION	
4-529-10800B	VTC5150	Reel Motor 3.6W	9.95
4-527T-23501	VARIOUS	Motor Assy	9.75
4-527V-51000	5150	Capston Motor	29.95
143-0-4904-00900	FVHP615	Gear Idler Assy	5.95
143-2-457T-05900	VTC9455	Stopper Reel Base	0.55
143-0-545T-01701	VARIOUS	Pinch Roller Assy	8.95
143-0-545T-01700	VARIOUS	Pinch Roller Assy	1.95
143-0-551T-VTC9300		Idler Assy	0.95
143-0-661T-03800	VARIOUS	Loading Roller	0.95
143-0-662T-01201	VTC5150	Reel Drive Pulley	8.50
143-0-9974-00100	FVHP615	Mod Kit IC BA6304A	1.95

Video Head Cleaning Tape (VHS Automatic wet/dry)	6.50
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PHILIPS G8 550	6.96
RANK T20A	6.91
THORN 3000/3500	7.57
THORN 8500	8.00
THORN 9000	8.00
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ELC1043/06 MULLARD	8.65
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U322	8.25
U324	11.00

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100MA	8p each
200MA – 5 AMP	5p each

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VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

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FREEZE IT	0.95
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DET25	22.00
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DF92	0.60
DF96	0.65
DF97	1.00
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	0.90
DK92	1.20
DL35	2.50
DL63	1.00
DL70	2.50
DL73	1.50
DL92	0.95
DL93	1.10
DL94	2.50
DL96	2.50
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DY86/87	0.65
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EBC91	0.90
EBF80	0.95
EBF83	0.95
EBF85	0.95
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EBF93	0.95
EBL1	2.50
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EC52	0.75
EC70	1.75
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EC86	1.00
EC88	1.00
EC90	1.10
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ECC88	0.95
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ECC180	0.72
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ECC804	0.60
ECC2000	12.00
ECF80	1.15
ECF82	1.15
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	3.50
ECH42	1.50
ECH81	1.00
ECH83	1.00
ECH84	1.00
ECH2000	1.50
ECL80	0.60
ECL82	0.79
ECL83	2.50
ECL84	0.74
ECL85	0.69
ECL86	0.95
ECL805	0.69
EF37A	2.50
EF39	1.50
EF40	4.50
EF41	3.50
EF42	3.50
EF50	2.50
EF55	4.95
EF70	1.20
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.95
EF85	0.50
EF86	2.25
EF86 Mullard	4.50
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.95
EF95	1.95
EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF730	1.80
EF731	3.50
EF732	3.50
EF800	11.00
EF804S	19.50
EF805S	13.50
EF806S	14.50
EF812	0.65
EFL200	1.50
EH90	0.72
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EL32	0.95
EL33	5.00
EL34	2.25
EL34 Mullard/Philips	4.50
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EL38	6.50
EL41	3.50
EL42	2.00
EL81	6.95
EL83	5.95
EL84 Brimar	0.95
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EL85	4.50
EL86	1.25
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EL153	12.15
EL183E	3.50
EL18P	3.50
EL360	6.75
EL500	1.40
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EL519	6.95
EL802	3.65
EL821	8.50
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EM81	0.70
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
EN91	1.95
EN92	4.50
EY51	0.80
EY81	2.35
EY83	1.50
EY84	5.95
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EY91	5.50
EY802	0.70
EX35	0.75
EZ40	2.75
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EZ81	0.75
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GS10C	16.50
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M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	5.50
M8099	5.00
M8100	5.50
M8136	7.00
M8137	7.95
M8161	6.50
M8162	5.50
M8163	5.50

M8190	4.50
M8195	6.50
M8196	5.50
M8204	5.50
M8223	4.50
M8224	2.00
M8225	3.95
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ME1402	29.50
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MHL6	4.00
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MS4B	5.50
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OA2	0.85
OA2WA	2.50
OA3	2.50
OB2	0.85
OB2WA	2.50
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.75
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.55
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL800	0.80
PCL805	0.90
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PNE46	2.00
PE06-40N	42.00
PFL200	0.95
PL21	2.50
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	54.95
QB3-1750	139.50
QB5-3500	495.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
QQE03-12	7.95
QQE03-20	35.00
QQE06-40	45.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV06-40A	27.50
QQV06-40A Mullard	45.00
QQV07-50	63.50
QQZ03-20	42.50
QS75/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95

QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	5.75
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-208	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RSS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
A30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.59
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/200	9.00
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3-2000	395.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4 400	85.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.25
UBC81	1.50
UBF89	0.70
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	1.00
UCL82	1.75
UCL83	2.50
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.00
UL44	3.50
UL84	1.50
UL85	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V246A/2K	315.00
V2406/1K	225.00
V241C/1K	195.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00

VR75-30	3.00
VR101	2.00
V105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	4.50
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG1-2500	75.00
XG2-6400	135.00
XG5-500	22.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	115.00
Y502	25.00
Y65	6.95
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1060	195.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZM1005	8.00
ZM1020	6.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1AE4	3.50
1B3GT	1.95
1B22	10.00
1B27	55.00
1B35A	45.00
1B63A	75.00
1C1	2.50
1C5GT	2.50
1FD1	2.50
1G3GT	2.50
1J3GT	2.50
1K3	2.50
1N2	2.50
1N5GT	2.50
1P28	25.00
1P39	19.50
1R5	0.90
1T4	1.00
1U4	1.75
1U5	1.00
1X2B	1.40
1Z2	8.95
2AS15A	11.50
2B7	1.50
2B22	69.50
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C43	60.00
2C51	0.75
2C53	45.00
2CY5	1.50
2D21	1.95
2D21W	2.50
2E22	49.00
2E26	7.95
2J42	93.00
2J55	350.00
2K25	35.00
2K25 Raytheon	75.00
2K26	95.00
2K29	250.00
2K48	140.00
2K56	250.00
2X2A	5.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A/2	3.95
3A3A	3.95
3A4	1.10
3A5	4.50
31L5	0.95
3AT2	3.35
3B2	3.00
3B4	4.95
3B7	4.50
3B24	10.00
3B26	24.00
3B28	15.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN38A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50

3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3V4	1.75
3W4GT	2.50
4B5518	115.00
4-65A	59.00
4687A	9.50
4-250A	79.50
4-400A	87.50
4-1000A	425.00
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4C35	145.00
4CX1000A	425.00
4CX4000A	1100.00
4CX250B	49.00
4CX250B EIMAC	59.50
4D32	125.00
4CX250BN	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4XC1500B	398.50
4E27	195.00
4GS7	2.25
4J52	75.00
4JC6A	2.95
4KT6	1.50
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AM8	2.15
5AN8	1.20
5AR4	2.00
5AU4	1.50
5B.110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	15.00
5B-257M	15.00
5B-258M	14.50
5C22	125.00
5CL8A	2.50
5J180E	2950.00
5R4GB	3.50
5R4GY	3.50
5T4	5.95
5U4G	2.95
5U4GB	4.50
5V4G	1.50
5Y3GT	1.95
5Z4GT	1.50
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.95
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.95
6AN5	4.50
6AN8A	3.50
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AR8	3.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU5GT	4.50
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AX4GT	1.95
6AY3B	1.95
6AZ8	4.50
6B7	2.80
6B8G	1.50
6B10	1.95
6BA6	0.95
6BA7	4.50
6BA8A	3.50
6BE6	0.95
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.50
6BK4	4.00
6BK7A	1.95
6BL6	85.00
6BL8	1.15
6BM6	115.00
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	3.95
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50

6BZ6	2.50
6BZ7	2.95
6C4	1.25
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CN5	1.60
6CM7	2.95
6CS6	0.75
6CS7	0.95
6CW4	6.50
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	6.50
6DQ5	5.95
6DQ6B	2.50
6DT6A	1.50
6DW4	2.15
6E5	3.95
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	2.95
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GE5	3.95
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GM6	2.65
6GS7	2.15
6GV7	2.50
6GW6	2.50
6GW8	2.50
6GY5	3.95
6H1	9.50
6H3N	2.50
6H6	1.95
6H6GT	1.95
6HF5	5.50
6HF8	2.50
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	2.00
6J7	4.15
6JB6A	4.50
6JE6C	5.50
6JU8	2.50
6JS6C	4.95
6J7G	4.15
6K7G	2.00
6K8G	3.00
6KD6	6.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	4.50
6L6GT	1.95
6LD20	1.15
6LF6	7.50
6LJ8	2.50
6LQ6	5.50
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00
6P28	2.00
6Q7	1.75
6Q7GT	1.20

6R7G	3.15
6S4A	1.50
6SA7GT	1.35
6SC7	1.50
6SG7	2.50
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
6SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U6WA	3.50
6U8	1.15
6U8A	1.50
6V6G	1.25
6V6GT	1.50
6VGG	1.00
6Y6G	3.95
6X2N	1.00
6×4	1.50
6×5GT	1.00
6×5GTY	1.00
6×8B	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7AU7	1.50
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10EW7	2.95
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD12	0.65
11E2R	45.00
11E3	55.00
11R3	5.50
12A6	3.95
12AD6	1.50
12AH7GT	4.95
12AL5	1.00
12AT6	1.25
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12A17	0.65
12AV6	1.95
12AV7	2.50
12AX7GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	4.50
12BA6	1.50
12BE6	1.95
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12C8	2.50
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12E1	19.50
12E14	38.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J5GT	3.95
12J7GT	3.50
12JZ8	2.95
12K5	1.95
12K7GT	1.50
12K8	1.95
12SA7GT	1.95
12SG7	4.75
12SH7	1.95
12SK7	1.95
12SJ7	1.50
12SQ7GT	1.95
12SN7GT	1.85
12SR7	2.50
12X4	1.95
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
14S7	1.95
16GY5	2.95
17BE3	2.50
17DW4A	2.95
17EW8	0.95
17JZ8	4.50

18D3	6.00
18GB5	3.50
19AQ5	3.50
19AU4GT	2.50
19G6	9.00
19G3	17.00
19H4	35.00
19H4R	25.00
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	7.95
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21JZ6	4.95
21LU8	2.50
24B1	39.50
25DQ6B	2.95
25L6GT	1.75
25BQ6	1.75
29C1	19.50
29KQ6	6.50
30C17	0.40
30C18	1.48
3F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
80	4.50
83	8.50
84	3.00
85A1	6.50
85A2	1.95
90AV	15.00
90C1	3.50
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	15.00
95A1	6.50
100E1	10.00
108C1	1.50
150B2	6.50
150C2	2.50
150C4	2.15
155UG	25.00
185BT	1.50
211	33.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	4.50
572B	55.00
705A	8.00
708A	8.00
715C	45.00
724A	275.00
726A	75.00
803	14.95
805	59.00
807	1.95
810	85.00
811A	15.00
812A	35.00
813	23.50
829B	14.50
833A	95.00
866A	6.50
872A	20.00
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00

958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	6.95
2050	5.50
2051	5.50
3534	4.00
404A	10.95
927	15.00
1927	25.00
4212E	250.00
4313C	4.00
4328D	9.00
5636	5.50
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5675	28.00
5678	7.50
5687	4.50
5692	3.50
5696	3.50
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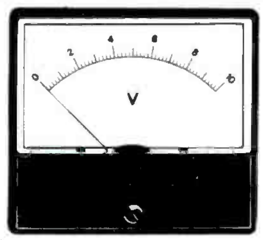

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Line scan camera

by L. Hayward
Technical director
Eastpoint Ltd

Considering the basic simplicity of linescan cameras – photosensitive array, lens and straightforward electronics – it is surprising they are not more widely used.

This article is based on results obtained using an EG&G Reticon LCO310 line scan camera together with some experimental electronics. The equipment was arranged to test the feasibility of a system for inspecting circular pressed metal lids passing along a conveyor. The report describes a practical system and suggests further work for improved operation.

The line scan camera operates like a normal optical television camera, with three important exceptions.

- Much higher stability, with no danger of burn due to continuous viewing of a stationary object.
- No field scan, so that instead of viewing an object using the raster principle, a single line only is viewed; consequently a movement of the item under inspection is required to view its complete area.
- The camera produces a 'clock' pulse for each picture element. This enables exact location of defects by counting clock pulses from start of scan.

The camera contains an array of photosensitive diodes (in our case 1024 but usually in multiples of 128 e.g. 256, 512 etc) mounted so that the image is focused onto it. Circuitry within the camera integrates the charge produced by the incident light, then clocks these representative charges out from the array by means of a shift register, thus providing a familiar video waveform. A sample and hold circuit provides a smooth transition from one element to the next. Electronics within the camera provide the clock timing pulses, and synchronized pulses for the analysing circuitry. The video waveform may be directly viewed on a oscilloscope to enable positioning, lighting, and focus.

As integration time varies with clock frequency, camera sensitivity to light varies. The amount of light required is greater the faster the camera is run. Maximum clock rate is 500,000 pulses per second, giving a minimum line scan time of 2.064ms, and 484 lines per second. From this it is possible to determine the maximum inspection rate, given required definition and object size.

Typical uses of such cameras are for determining overall dimensions of goods, for example paper width or box height. But the excellent stability and definition of the line scan camera should enable its use in much more detailed work.

Control electronics

The high definition electrical representation of the surface under inspection requires suitable electronics to analyse the results and take decisions. The product being inspected is a range of lids having various sizes and coatings. The difference in size is fairly well accomodated by altering the field of view of the camera. It is clearly desirable that the maximum dimension of the product should always fill the viewing width of the camera to maximize definition. Experiments showed two main problems.

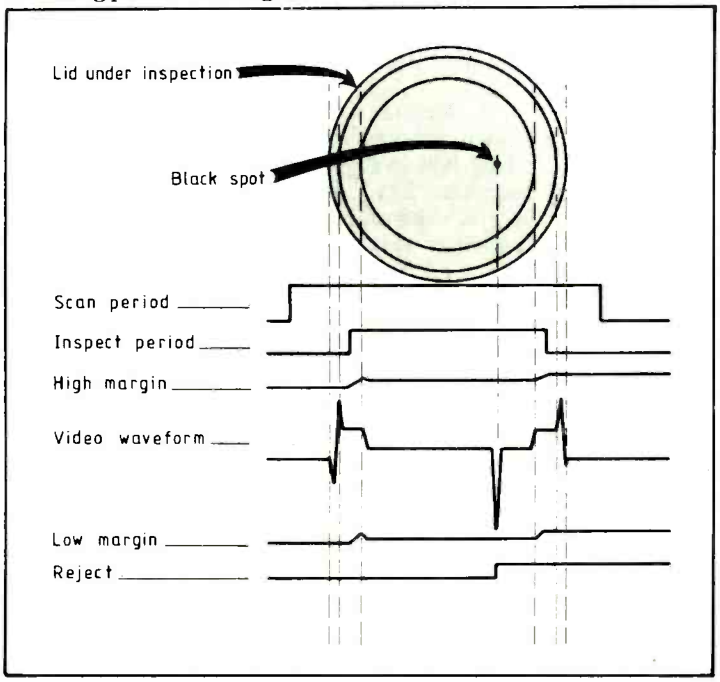
The extreme edge of the lid has a number of serrations, is folded at differing radii, and may be painted any colour. This makes total inspection of this area very difficult due to the randomness of the reflected light, and positional difficulty. This problem is still under investigation.

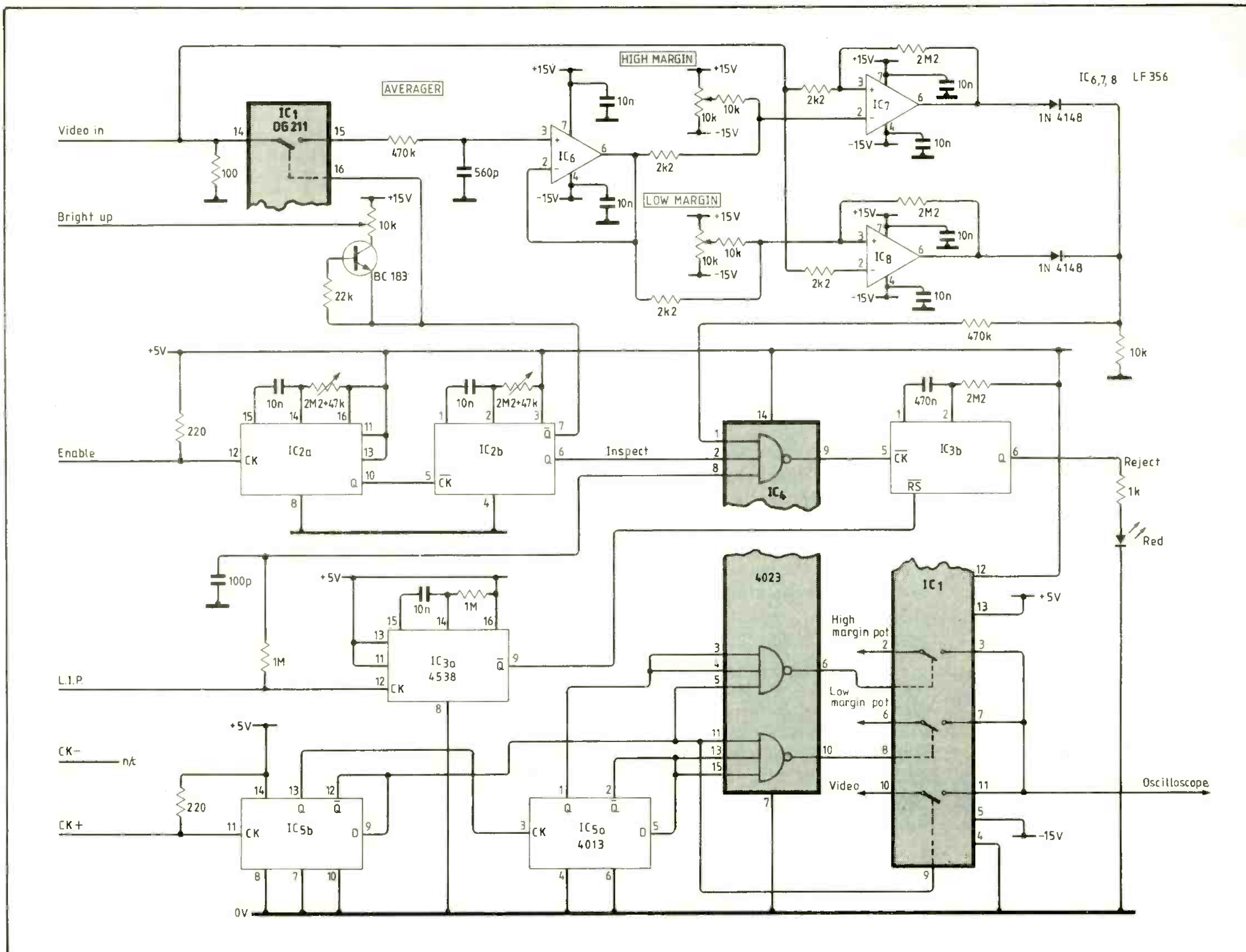
Lids may be coated with a light-coloured plastics material, which is easy to inspect, or not, in which case striations in the grain of the metal cause direct reflection of light from an unpredictable and wide range of angles. This should be overcome by using a very narrow angle of incident light with respect to the lid. At least two light sources will then be required to overcome shadow.

We constructed a form of optical bench that enabled lids of varying diameter to be placed at the camera's focal point. Using a local illumination of 50 watts at various angles and distances, the video waveform was observed. The definition was so good that the smallest visible blemish could be detected, and it is possible that 512 instead of 1024 pixels might be sufficient for the item in question, with a consequent saving of cost.

It was also clear from these tests that a fault might generate light levels either above of below that of the normal surface, particularly in the case of scratches, so that circuitry to detect this would be required. Circuitry to define a window of valid inspection would also be necessary to eliminate false rejection if the camera were scanning past the lid edge.

Black spot or scratch in this example of a bid returns strong reject signal.





Simple circuit detects flaws in material moving along a conveyor, provided that the inspected area is constant.

From these observations a basic detector unit was designed which works as follows. It is assumed that the lid can be fed intermitently, and rotated at least once in the camera field of view, and that a signal to indicate 'lid in position' can be derived.

The circuit of the detector electronics is shown above. Certain timing operations are generated by monostables. This was done for the sake of simplicity. A production unit would preferably have all timing derived from the camera clock for greater stability and ease of use. The camera is equipped to transmit differential data and clock signals, though this experimental circuit does not use differential receivers for the short range operation envisaged.

Operation

The video waveform from the camera is fed to two voltage comparators, IC_7 giving a positive output when the video is higher than threshold, and IC_8, when video is lower. The threshold voltage is an average of the video level, the waveform being integrated by the network at the input to IC_6. A voltage may also be injected from a high and low margin potentiometer to allow an additional offset in each case. Since the reference is in part derived from the average light level, reasonable variations in the light source are tolerable. The video waveform is only connected to the averaging circuit during the 'inspect' period, so that reflections from the edge and background do not distort the average.

At the start of each scan, the camera produces a positive going 'enable' pulse. This is used to trigger, in sequence, IC_{2a} and IC_{2b}, the first of which determines the non-inspect period from start to scan and the second determines the inspect period from then on. Two further monostables are used: IC_{3a} provides a delay to ensure a short scan period to allow the averager to settle after the lid is ready for inspection, while IC_{3b} is provided to light an indicator for about one second to indicate that a fault is present. The comparator outputs are OR-ed and gated with the 'lid in position' signal (LIP) The boolean expression for a reject then becomes

$$\text{REJECT} = (\text{COMP}_a + \text{COMP}_b).\ \text{LIP}.\ \text{INSPECT (after delay)}$$

It became obvious during early tests that a visual method of setting time and voltage margins would be required, and the remaining circuitry of Fig. 1 is designed to present all the necessary data on a single channel oscilloscope, having bright-up capability and sufficient speed (>10MHz bandwidth).

The camera clock drives a signal chopper, which splits the oscilloscope display up into a voltage displaying the high margin a voltage displaying the low margin and the video waveform. In addition the trace is brightened during the inspect period, so that its start and finish may be observed in relation to the video waveform. Page 49 shows a typical result.

A wideband buffer amplifier to drive the output to the oscilloscope is desirable for highest clock rate. Minimum times of the monostables will also need to be reduced. The trigger pulse for the oscilloscope time base is obtained directly from the camera, although the x-sweep could be generated directly from a digital-to-analogue converter driven by a counter of camera clock pulses.

The result of many tests using this method has shown

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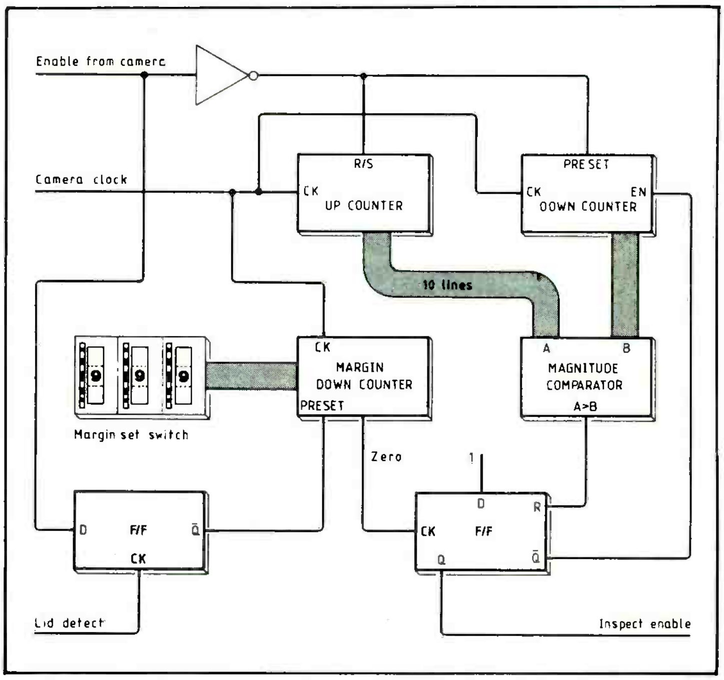
that a practical unit can be easily designed to fully inspect the interior face of lids of all practical diameters. The result of inspection using an intermittent and rotary scan would result in a slowing of the production line, but a linear scanning method would enable inspection at full conveyor line rate with minimal mechanical change. Problems arise regarding the initial sensing of the lid, tracking its edge, and then dynamically changing the non-inspect zones.

Sensing the lid edge as it appears in the camera field of view and adjusting the initial non-inspect area present little problem, but automatically defining the end of the inspect period is more complicated. The problem is not insuperable, and a block diagram of the proposed electronics is shown above. The theory assumes that the camera is adjusted in each case so that the field of view is that of the lid diametere, so that the lid diameter is 1024 elements. We can then state that the enable T_{on} measured in clock pulses from line start will be equal to the clock count a the detection of the lid edge plus the preset margin, and the enable T_{off}, will be equal to 1024 — the clock count at T_{on}. (The preset margin is assumed to be equal at start and finish of scan, and is thus included and defined at T_{on}.)

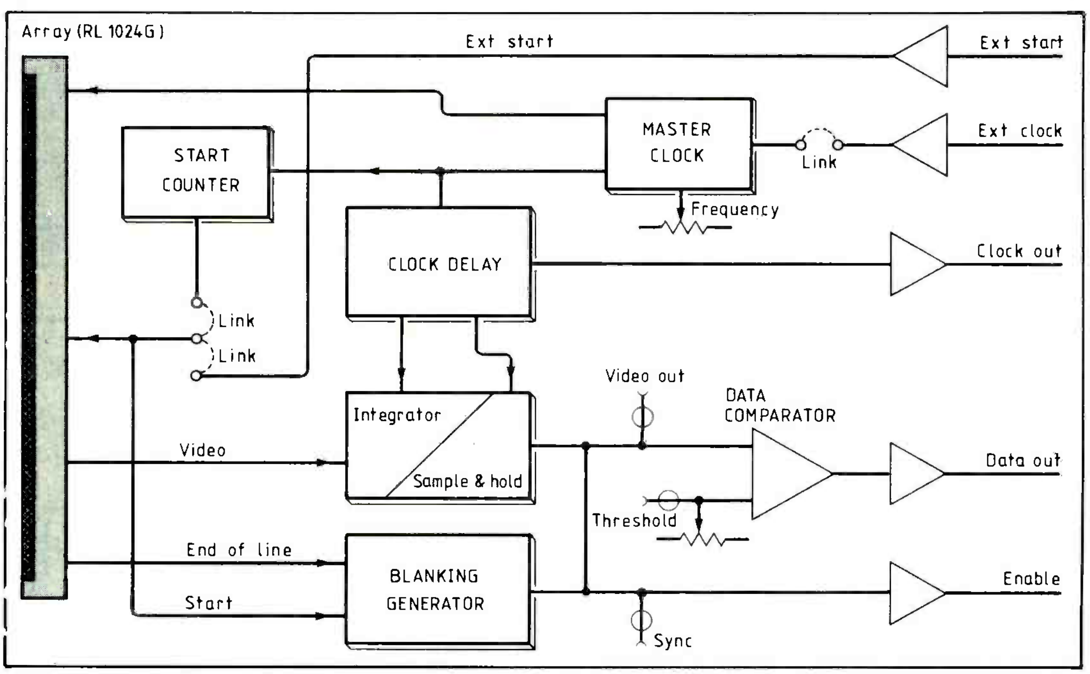
This hardware approach is preferred to a microprocessor application, since the system speed will always be limited only by the camera and not the computer processing time. In fact the hardware required should be about the same or less, and servicing easier.

Clearly other techniques may be necessary to inspect other products. In cases where product speed is slow, inevitable with larger items, a microprocessor approach may be desirable to allow easier parameter change.

A variety of line scan cameras and arrays are advertised in this country and it may seem surprising that such a potentially useful device is not more widely used. One factor is the price. Diode arrays typically cost £500 for a 1024-element device, although some charge-coupled devices made by Fairchild would seem to give similar definition at a lower cost and faster data rate. ■



Inspecting circular objects where the inspect area varies according to diameter and position calls for a more complext digital solution.



Only a simple circuit is required to produce video signal from the diode array. Power requirement is very low compared to vidicon cameras and overall stability much higher.

Continued from page 30

Cable '86

satellite. This is just the situation with d.b.s.

But there was some disagreement on the actual size of the launch failure risk. Chaplin argued that despite recent failures (Shuttle and Ariane), the total launch success rate was 94%. Chaplin added however, that once a satellite was in orbit there was only a low probability of an in-orbit failure. The highest risks are in getting it there in the first place. Space consultant Rodney Buckland challenged Chaplin's launch failure figures saying that the true launch commissioning failure rates for commercial satellites are much higher, nearer 18%.

Bemoaning the fact that different countries in Europe are going their separate ways when it comes to d.b.s. transmission, Chaplin warned that in practice different modes of transmission may end up being used at different orbital locations. The UK and Irish direct broadcast satellites which will be at 31°W may be transmitting on isolation in C-MAC while other European satellites at 19°W and elsewhere will be using D2-MAC.

In a later technical session, Bernard Green, the IBA's satellite broadcasting head, entered the C-MAC v. D2-MAC argument saying that "C-MAC was the best of the MAC family for viewers in the UK, where cable is just not a major consideration."

DTI consultant Bernard Rogers said that B, C, D2-MAC were all good and that MAC provides the path for enhancement to future tv systems. MAC as a transmission system is more 'rugged' than PAL or SECAM, because there are no subcarriers.

Brighton was the cheerful seaside venue for this year's satellite and cable tv exhibition and conference, Cable '86, attracting 5,300 visitors and 72 exhibiting companies. The increases over the last year's figures (4,000 visitors and 50 exhibitors) reflects a growth of interest in an industry which impinges on many others: telecommunications, information technology and broadcasting.

The Cable '86 organisers, Online, are bringing next year's exhibition and conference, CableSat, forward to 2-4 June 1987 to avoid clashing with the start of the European holiday season. With the recently announced launch delays and with rumours circulating that France is considering scrapping its high-powered TDF-1 d.b.s. project altogether in favour of a lower-powered satellite, it's anybody's guess whether there'll be any European d.b.s. in orbit by the time Cable '87 comes round! – *NC* ■

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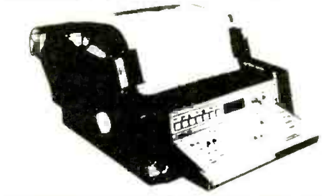

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CIRCLE 52 FOR FURTHER DETAILS

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by J.L. Gordon

8085 development on the BBC Micro

A simple system to introduce 6502 users to another popular processor family

John Gordon is senior lecturer in electronics and microelectronics at Blackburn College.

Memory addresses for the 8085 board. Single bits may be read from memory by loading from either the set or clear addresses.

2716 eprom (firmware)	\$0000 – \$1FFF
2114 ram	\$4000 – \$43FF
8154 p.i.a.	\$8000 – \$80FF
port A	\$8020
port B	\$8021
d.d.r. A	\$8022
d.d.r. B	\$8023
Set bit 0, port A	\$8010
Set bit 1, port A	\$8011
Clear bit 0, port A	\$8000
Clear bit 1, port A	\$8001
Set bit 0, port B	\$8018
Set bit 1, port B	\$8019
Clear bit 0, port B	\$8008
Clear bit 1, port B	\$8009

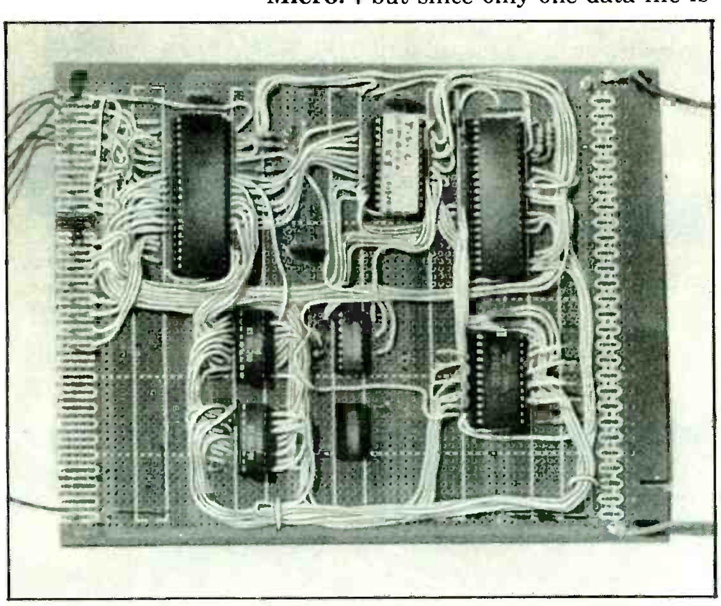
Fig. 2 (opposite). The complete controller. The spare dil device is included for convenience in making connections to the 8085's reset and interrupt inputs.

This article describes hardware, firmware and software which together allow the user of a BBC microcomputer to study and develop stand-alone applications for the 8080 series of microprocessors. For those who have had little microprocessor experience outside the confines of the 6502, the project offers an opportunity to experience a contrasting processor architecture. The 8080, 8085 and Z80 all have similar structures and the newer 16-bit 8086 and 8088 are upward-compatible with the 8080.

The system consists of a simple, almost minimal, 8085 controller board with firmware in a 2716 eprom to handle communications with the BBC Micro. Software includes a simple but effective 8085 assembler written in Basic; a loader, also in Basic; and a communication program, in Basic and machine code, which allows memory transfer between the BBC and the controller. The software is designed for disc-based systems; but since only one data file is open at a time, it will run from tape if cassettes are changed as required.

The 8085 microprocessor is described fully in many textbooks. The book listed as reference 1 is a general electronics text which contains an more than adequate description of 8085 hardware and software.

Fig. 1. Prototype of the 8085 controller board showing leads to the BBC Micro.



Hardware

Construction of the hardware is quite straightforward, Fig. 1. A suitable basis for it is the dip board supplied by Maplin Electronics or RS Components. A spare 14-pin socket has been included with supply connections suitable for a 7400 or 7404. Such a device may be needed later if the reset output or interrupt inputs of the microprocessor are to be used.

The 8085 microprocessor and its associated address bus latch are situated at the right of the board. The latch is an 8212 eight-bit type which is activated by the address latch enable (ALE) line on the microprocessor. This active-high line is high during the first T-clock cycle to indicate that a valid address has been placed on the address/data multiplexed bus (the address is also valid during the trailing edge of ALE). This signal causes the strobe input to the 8212 to latch the lower address byte. The high address byte remains on the address bus for the complete instruction cycle.

On the circuit diagram, Fig. 2, ALE is connected to the 74138 enable line so that chip select does not occur during ALE. This is to prevent ram data from corrupting the valid address. The 2114 ram devices employ the not-write enable line as a read/write signal. This means that the ram is normally set to read (i.e. not-write enable is set high) when software in ram is being accessed and it might otherwise corrupt the address/data bus during address latching. Reference 1 gives an alternative arrrangement.

At the bottom left of the board, two 2114 static rams provide 1K-byte of memory organised as 1K by four bits. Each device handles one half of the data bus.

The system firmware is quite compact and so there is plenty of room in the 2716 eprom to extend the board's capabilities further. The not-read strobe from the 8085 is used to enable the output of the 2716 and the chip select comes from the 74138 three-to-eight line decoder. The eprom must be located at the lowest address, as shown in figure 2, since the reset start location for the 8085 is 0000_{16}.

The i/o device is the 8154 p.i.a. This is useful for applications where the control of single bit i/o is predominant: it has separate address locations to set, clear and read any of the sixteen bits in the two eight-bit ports, as well as address locations for the ports as a whole. Especially useful in a small controller such as this is its 128-byte block of user ram.

The M/IO line on the diagram is connected to A_7 of the address bus and the chip is enabled at 8000_{16} (or its shadows). For this configuration, the port bit address lines will lie between 8000_{16} and 807F; and the addresses from 8080_{16} to 80FF will be user ram. In contrast to the ram i.cs, this device is of the 8000 series and therefore supports the correct not-read and not-write strobe lines.

With the 8085, the not-read and not-write lines require pull up resistors as shown in

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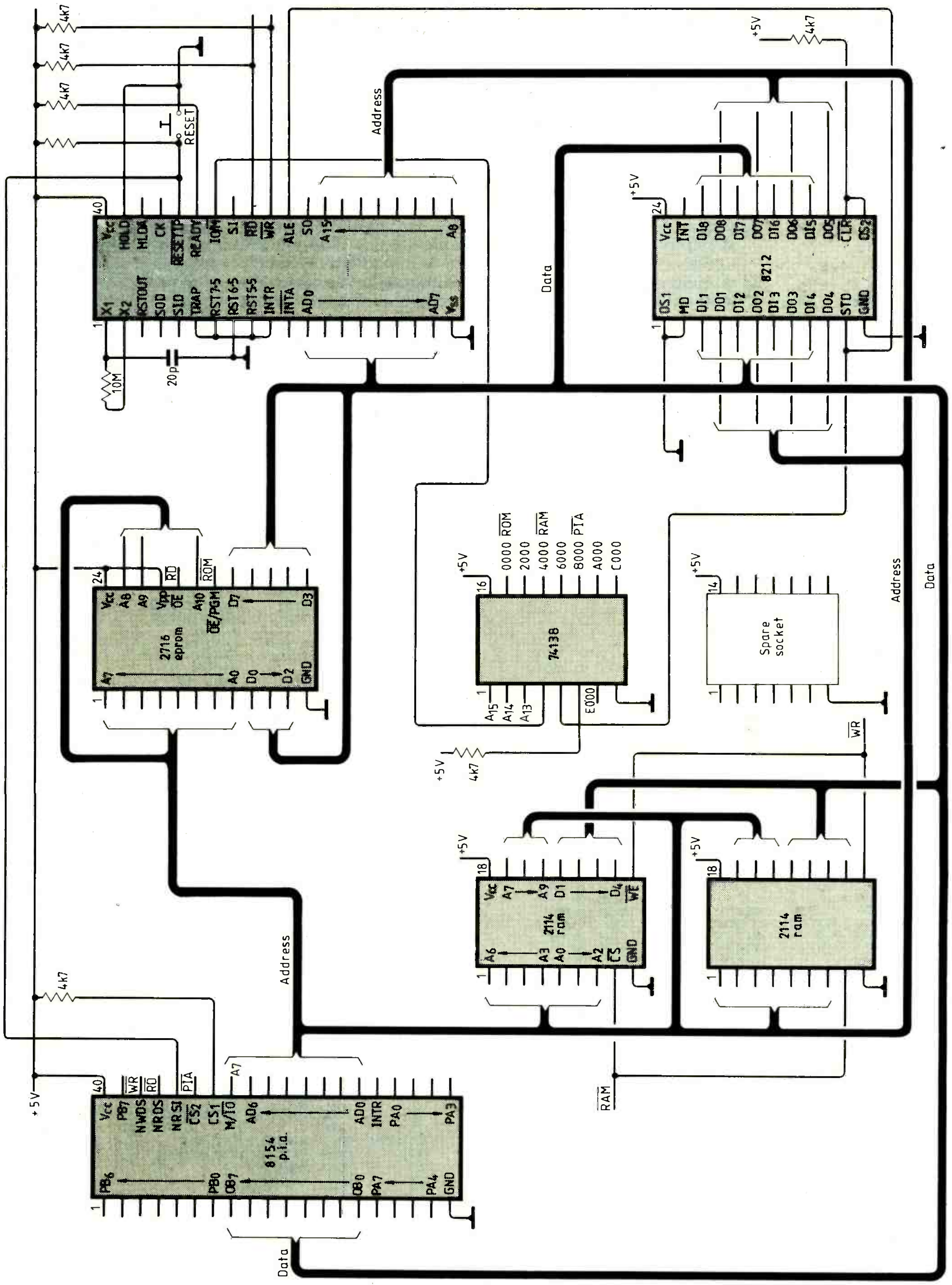

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A kit of parts for this design is available from Microkit Ltd, Blakesley, Northamptonshire NN12 8RB at £39.99 including v.a.t. and postage. Send a stamped, self-addressed envelope for more details.

References

1. The Art of Electronics by Horowitz and Hill. Cambridge University Press.
2. The Advanced User Guide for the BBC Microcomputer by A.C. Bray, A.C. Dickens and M.A. Holmes. Cambridge Microcomputer Centre. 1983.

the circuit diagram. The clock can be generated on the 8085 simply by the addition of a resistor and capacitor at pins 1 and 2, or a 3MHz crystal may be used instead. The values shown given an input frequency of about 3MHz and an output clock frequency of half this value.

Reset is achieved by shorting together two pins at the top of the board, though a small push-to-make switch might be more serviceable. The reset-in line also resets the p.i.a.; but this may be altered so that the reset-out line resets the p.i.a., allowing controlled resetting of the i/o function.

Figure 1 shows eight short wires surrounding the 8212 latch. These wires, the low eight bits of the address bus, were left on the board to allow a logic analyser to be connected but are not needed on the complete board.

Connections to the computer user port are four control or data wires and a common ground. The board must of course be reset before communication takes place.

The interrupt facility of the 8085 has been rendered inactive, but any interrupt line may be used with only slight modification to the board. The interrupt lines have varying priorities and their inputs are active high.

Software for this design will be described in the next article.

Simple pulse generator

Two separate kits are available for B.J. Frost's pulse generator described on page 43 of the August issue. Kit A comprising p.c.b., components and switches, costs £23.50 and Kit B, comprising low-profile case, screen-printed front panel, knobs and BNC connectors, costs £17.40; both prices exclude v.a.t.

The generator is also available built and tested for £78 excluding v.a.t. from the kit suppliers Ver Controls (St Albans) Ltd at Rookery House, Crowes Loke, Little Plumsted, Norwich NR13 5JB, tel. 0603 721215.

```
;COMMUNICATION FIRMWARE FOR THE
;8085 CONTROLLER MODULE
;
;LABELS USED IN FIRMARE
;----------------------
ERROR   =    $8086
BYTE    =    $8080
FB1     =    $8082
FB2     =    $8083
FB3     =    $8084
FB4     =    $8085
ODRB    =    $8023
BIT0    =    $8008
BIT1S   =    $8019
BIT1C   =    $8009
BIT2    =    $800A
BIT3S   =    $801B
BIT3C   =    $800B
        ORG  0        JUMP INST.
        JMP  START    JUMP TO START    0000 C3 EB 02
                      ;
                      PROGRAM
        ORG  $0200    ORIGIN
SNDBIT  PUSH PSW      TO STACK         0200 F5
SL1A    LDA  BIT2     LOAD CTS         0201 3A 0A 80
        CPI  0        COMPARE ZERO     0204 FE 00
        JP   SL1A     BACK TIL -       0206 F2 01 02
        POP  PSW      FROM STACK       0209 F1
        JNC  SZERO    SEND ZERO        020A D2 13 02
        STA  BIT1S    DATA = 1         020D 32 19 80
        JMP  SEND1    SEND A 1         0210 C3 16 02
SZERO   STA  BIT1C    DATA = 0         0213 32 09 80
SEND1   STA  BIT3C    RTS LOW          0216 32 0B 80
SLOOP   LDA  BIT2     GET CTS          0219 3A 0A 80
        CPI  0        COMPARE ZERO     021C FE 00
        JM   SLOOP    BACK IF -        021E FA 19 02
        STA  BIT3S    RTS HIGH         0221 32 1B 80
        RET                            0224 C9
SNDBYT  MVI  A,0      MOVE 0 TO ACC    0225 3E 00
        STA  ERROR    IN ERROR         0227 32 86 80
        MVI  H,8      INIT COUNTER     022A 26 08
SBLOOP  LDA  BYTE     BYTE TO ACC      022C 3A 80 80
        RAR           ROTATE RIGHT     022F 1F
        STA  BYTE     BACK IN BYTE     0230 32 80 80
        CALL SNDBIT   SEND BIT         0233 CD 00 02
        DCR  H        DEC COUNTER      0236 25
        JNZ  SBLOOP   IF NOT ZERO      0237 C2 2C 02
        RET                            023A C9
SETUP   MVI  A.$FA    LOAD FA          023B 3E FA
        STA  ODRB     SET ODR          023D 32 23 80
        STA  BIT3S    RTS HIGH         0240 32 1B 80
        RET                            0243 C9
RECBIT  MVI  H.$FF    SET UP COUNTER   0244 26 FF
RECWAT  LDA  BIT2     GET CTS          0246 3A 0A 80
        CPI  0        COMPARE ZERO     0249 FE 00
        JP   OKGET    ON IF READY      024B F2 55 02
        DCR  H        DEC H REG        024E 25
        JNZ  RECWAT   BACK NOT ZERO    024F C2 46 02
        JMP  FAULT    IF NO BIT FND    0252 C3 8C 02
OKGET   LDA  BIT0     GET DATA BIT     0255 3A 08 80
        RAL           BIT TO CARRY     0258 17
        PUSH PSW      SAVE CARRY       0259 F5
        STA  BIT3C    RTS LOW          025A 32 0B 80
RECL1   LDA  BIT2     GET CTS          025D 3A 0A 80
        CPI  0        COMPARE ZERO     0260 FE 00
        JP   RECL1    WAIT FOR CTS     0262 F2 5D 02
        STA  BIT3S    RTS HIGH         0265 32 1B 80
        POP  PSW      GET CARRY BACK   0268 F1
        RET                            0269 C9
RECEV   MVI  A,0      CLEAR ACC        026A 3E 00
        STA  ERROR    CLEAR ERROR      026C 32 86 80
        MVI  L,8      INIT L REG       026F 2E 08
RECBYT  CALL RECBIT   GET ONE BIT      0271 CD 44 02
        PUSH PSW      SAVE CARRY       0274 F5
        LDA  ERROR    GET ERROR BIT    0275 3A 86 80
        CPI  0        COMP ZERO        0278 FE 00
        JNZ  RECEND   FAIL IF ERROR    027A C2 8A 02
        POP  PSW      GET CARRY        027D F1
        LDA  BYTE     GET BYTE         027E 3A 80 80
        RAR           ROTATE BIT IN    0281 1F
        STA  BYTE     PUT BYTE BACK    0282 32 80 80
        DCR  L        DEC L REG        0285 2D
        JNZ  RECBYT   DO 8 BITS        0286 C2 71 02
        PUSH PSW      CORRECT PULL     0289 F5
RECEND  POP  PSW      RECOVER PSW      028A F1
        RET           RETURN           028B C9
FAULT   MVI  A,$FF    LOAD FF          028C 3E FF
        STA  ERROR    SIGNAL ERROR     028E 32 86 80
        RET           RETURN           0291 C9
SNDADR  LHLD FB2      GET ADDR         0292 2A 83 80
        XCHG          INTO DE          0295 EB
        LDAX D        LOAD ACC         0296 1A
        STA  BYTE     STORE DATA       0297 32 80 80
        CALL SNDBYT   SEND A BYTE      029A CD 25 02
        RET           RETURN           029D C9
RECADR  LHLD FB2      GET ADDRESS      029E 2A 83 80
        XCHG          INTO DE          02A1 EB
        LDA  FB4      GET DATA         02A2 3A 85 80
        STAX D        STORE INDIRECT   02A5 12
        RET           RETURN           02A6 C9
RECFOR  LXI  B,FB1    B&C POINTERS     02A7 01 82 80
RFLOOP  CALL RECEV    GET 1 BYTE       02AA CD 6A 02
        LDA  ERROR    TEST FOR ERROR   02AD 3A 86 80
        CPI  0        COMP ZERO        02B0 FE 00
        JNZ  RFLOOP   AGAIN IF ERROR   02B2 C2 AA 02
        LDA  BYTE     GET DATA         02B5 3A 80 80
        STAX B        STORE INDIRECT   02B8 02
        MVI  A,$86    END OF 4 BITS    02B9 3E 86
        INR  C                         02BB 0C
        CMP  C        TEST END VALUE   02BC B9
        JNZ  RFLOOP   DO 4 BYTES       02BD C2 AA 02
        RET           RETURN           02C0 C9
ACTION  LDA  FB1      GET COMMAND      02C1 3A 82 80
        CPI  1        is it 1          02C4 FE 01
        JNZ  ACT1     CARRY ON         02C6 C2 CD 02
        CALL RECADR   RECEIVE BYTE     02C9 CD 9E 02
        RET                            02CC C9
ACT1    CPI  2        IS IT 2          02CD FE 02
        JNZ  ACT2     CARRY ON         02CF C2 D6 02
        CALL SNDADR   SEND BYTE        02D2 CD 92 02
        RET                            02D5 C9
ACT2    CPI  5        IS IT 5          02D6 FE 05
        JNZ  ACT4     CARRY ON IF NO   02D8 C2 DF 02
        CALL DOPROG   DO PROGRAM       02DB CD FA 02
        RET                            02DE C9
ACT4    MVI  A,$AA    GET AA           02DF 3E AA
        STA  BYTE     REPORT FAULT     02E1 32 80 80
        CALL SNDBYT                    02E4 CD 25 02
        CALL SNDBYT                    02E7 CD 25 02
        RET                            02EA C9
START   LXI  SP,$80FF STACK POINTER    02EB 01 FF 80
        CALL SETUP    SET PORTS        02EE CD 3B 02
MAIN    CALL RECFOR   RECEIVE          02F1 CD A7 02
        CALL ACTION   DO IT            02F4 CD C1 02
        JMP  MAIN                      02F7 C3 F1 02
DOPROG  LHLD FB2      GET START ADDR   02FA 2A 83 80
        PCHL          JUMP IND         02FD E9
; END OF CODE
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What makes a good oscillator?

by K. Lewis
M.I.E.R.E.

Oscillators are sometimes taken for granted. This article discusses the parameters to consider when defining their performance.

Mr Lewis is group leader with responsibility for design and development of frequency synthesizers at Grinaker Electronics in South Africa. Before that he designed v.h.f. synthesizers at Plessey, Ilford.

Function generators have become common place instruments in a typical laboratory and provide a versatile source of signals with square, triangle and sinusoidal waveforms. The source of these signals is usually an astable circuit formed by a closed loop, consisting of an integrator and a hysteresis gate. The hysteresis gate generates the square wave and the integrator generates the triangular wave from which the sine wave is formed by employing a diode shaping circuit. This method can provide reasonably low harmonic distortion.

Casual observation of a typical waveform generated by this method, displayed on an oscilloscope, can be deceptive, as it may not show the frequency or phase jitter generated. Although the performance of some function generators can be reasonable in this respect, closer examination of an inferior generator's waveform near the top end of its frequency range could well reveal observable phase jitter. This is seen at its maximum in the zero cross-over region of the waveform towards the end of the oscilloscope trace.

Phase jitter, together with any amplitude noise which may be present, can be observed and quantified with a spectrum analyser, providing it is within the resolution of the analyser. The displayed spectrum requires careful interpretation because (a) the spectrum analyser has its own limited resolving bandwidth and (b) the local oscillators within the spectrum analyser also exhibit phase jitter and there will be a reciprocal mixing between its internal oscillators and the signal being analysed. In the frequency domain, the ideal oscillator spectrum consists of a single discrete line at the frequency of oscillation. In practice, this ideal spectrum is contaminated by harmonics and noise which appears approximately symmetrical about the oscillator frequency. In r.f. oscillators harmonics may be reduced by filtering. The reduction of oscillator noise, however, is only realistically achieved by careful design.

Whilst astable oscillators perform an important role in the electronics laboratory, the oscillators considered here employ a frequency-selective network, around which is placed an active network that provides the necessary feedback to cause oscillation. This class of oscillator is capable of providing an excellent performance in terms of spectral purity, especially when compared to its astable counterpart.

It is possible to gain considerable insight into the performance of such an oscillator if one analyses the behaviour of a simple linear model. With this model the salient parameters are defined without restricting the oscillator to a particular circuit design. Although linearity is assumed, meaningful results may be obtained, particularly for higher grade oscillators.

The frequency selective network within the oscillator may normally be represented by a second-order bandpass function which, for example, takes the same form as the impedance function of a simple LCR parallel circuit. In general this may be represented by the equation:

$$B(f)=\frac{B_0}{1+jQ(f/f_0-f_0/f)} \qquad (1)$$

In this equation, f_0 is the resonant frequency and B_0 is the gain of the circuit at $f=f_0$. Q is the selectivity of the circuit and defines the 3dB bandwidth given by f_0/Q.

In the block diagram Fig. 1, an amplifier of gain A is shown driving a filter block B(f). The output of this is fed back to the input of the amplifier via a summing point, where an external signal V_1 has been added to investigate the response of the circuit to V_1 as the amplifier gain is varied. Voltage $V_2 = V_1 + V_4$ and therefore the overall feedback is positive, as V_4 is in phase with V_1 at resonance. The combined response of the block diagram illustrated can be simply derived and is the standard feedback equation.

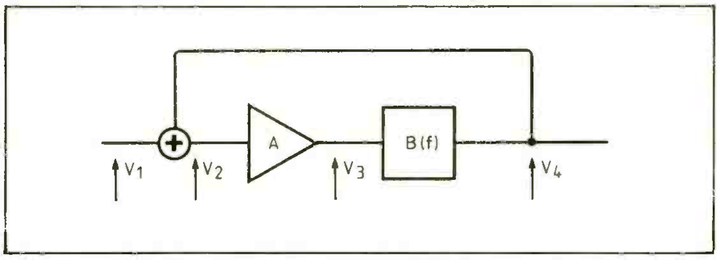
$$V_4/V_1=AB(f)/(1-AB(f)) \qquad (2)$$

Substituting equation (1) into (2) gives

$$\frac{V_4}{V_1}=\frac{AB_0}{(1-AB_0)[1+j(Q/(1-AB_0))(f/f_0-f_0/f)]} \qquad (3)$$

Equation (3) is of fundamental importance in determining the behaviour of an oscillator. This can be appreciated when A is allowed to increase and the product AB_0 approaches unity. At this point the gain goes to infinity. Therefore V_1 can be zero and oscillation is maintained. However, in practice this description is a simplification, because the product AB_0 sus-

Fig. 1. Linear model of an oscillator, which is a frequency-selective network, represented by B(f), an active network to provide gain and feedback.



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tains an average value less than unity. A practical oscillator therefore turns out to be a very high-gain amplifier having a narrow bandwidth, which employs automatic gain control or limiting to define a given output level. The input to this amplifier is noise!

Equation (3) above is of the same form as equation (1) and, by comparison, it can be seen that at frequency f_0 the operational gain has been increased to

$$G_0=V_4/V_1=AB_0/(1-AB_0) \quad (4)$$

The operational Q has been increased to

$$Q_0=Q/(1-AB_0) \quad (5)$$

The 3dB bandwidth has therefore been reduced to

$$f_{3dB}=f_0/Q_0=f_0(1-AB_0)/Q \quad (6)$$

Now let the voltage source V_1 be replaced by a noise source of voltage density V_n r.m.s. volts per $\sqrt{Hz}$. This noise may be regarded as the equivalent voltage noise source of the amplifier. The oscillator output level, determined by the a.g.c. characteristic of the oscillator design, is not of course a function of V_n. Since the closed-loop voltage gain of the oscillator is capable of reaching infinity, the amplifier gain will adjust itself. At this point it is worth noting from equations (4) and (6), that each time the operational gain, G_0, is doubled, i.e. increased by 6dB, the 3dB bandwidth is halved. This reduction in bandwidth alone results in a 3dB reduction in output signal. The net increase in signal is therefore 3dB.

Any white-noise which is subject to narrow band filtering will, when examined on a suitable storage oscilloscope, take on the appearance of a sinusoid. The average r.m.s. value of that sinusoid is simply given by the product of the voltage noise density V_n and the square root of the filter noise bandwidth. The oscillator is an extreme example of the narrow-band filtering of noise.

From this discussion it should be apparent that the output V_4, taken as the r.m.s. value, is the product of V_n times the gain, given by equation (4), times the square root of the noise bandwidth. This may be shown to be the 3dB bandwidth, given by equation (6), multiplied by $\pi/2$[1]. The result of combining these equations is

$$\frac{V_4}{V_n}=\frac{AB_0}{1-AB_0}\sqrt{|f_0\pi(1-AB_0)/(2Q)|} \quad (7)$$

This equation is also fundamental, since it enables the product AB_0 to be qualified and therefore the operating Q, gain and bandwidth to be determined. Equation (3) can now be used to determine the noise spectrum of the oscillator within the limitations of the theorectical model.

Equation (7) cannot be written explicity in terms of the product AB_0, which in practice is very close to unity. Only the difference terms $(1\text{-}AB_0)$ therefore need be considered. In making this approximation equation 7 simplifies to:

$$(1-AB_0)=(V_n/V_4)^2)\pi f_0/2Q \quad (8)$$

Substituting equation (8) into the above equations gives the following results

Operational Q

$$Q_0=2Q^2(v_4/V_n)^2/\pi f_0 \quad (9)$$

Operational gain

$$G_0=2Q(V_4/V_n)^2/\pi f_0 \quad (10)$$

Oscillator gain response,

$$G(f)=\frac{G_0}{1+jQ_0(f_o/f_0-f_0/f)} \quad (11)$$

In oscillators the spectral purity can be measured as the ratio of the carrier amplitude to the noise level measured at some frequency offset Δf from the carrier such as $\Delta f=f-f_0$. Assuming that $|\Delta f|<f_0$, equation (11) may be approximated by

$$G(f)=\frac{G_0}{1+j2Q_0\Delta f/f_0} \quad (12)$$

If practical values are substituted, as is done shortly, it will be noticed that an oscillator's 3dB bandwidth is typically very small. Therefore at practical values of Δf the real term 1, in the denominator of equation (12), may be neglected. This gives a simple expression, after some cancellation, for the magnitude of gain.

$$|G(f)|=f_0/(2Q\Delta f) \quad (13)$$

This remarkably simple result could have been derived directly from equation (3) by equating the product AB_0 to unity in order to obtain the theorectical gain of the oscillator when the input noise is zero. In practice this means that as Δf increases, positively or negatively, the gain of the oscillator rapidly converges on to the ideal gain response and is independent of the output voltage V_4! From this result it is apparent that the carrier-to-noise ratio can be maximized by simply designing the oscillator to provide a large voltage output swing: the accompanyinging noise output being the product of the gain, given by equation (13) and the voltage noise density V_n.

Equation (13) also illustrates a fundamental property of oscillators. This is that the operating gain, and therefore its accompanying noise, is proportional to the oscillator frequency f_0 for a given value of Δf, Q and V_n. Because of this property, even the noise performance of audio oscillators which typically operate with low-Q, frequency-selective networks, can be very good when compared to r.f. oscillators. The basic requirements for a low-noise oscillator are therefore a high value of Q, and low values of V_n and F_0, if this is possible. This may be intuitively obvious; however, equation (13) quantifies their simple relationship.

The frequency stability of an oscillator also relates to its effective operating bandwidth. The oscillator output, which is essentially amplified noise, will be coherent in phase for a time proportional to the reciprocal of the effective bandwidth. It can therefore be appreciated that even with perfectly stable components there will be a random drift in the oscillator's phase.

In general, the oscillator output V_4 exhibits less noise, at larger values of Δf, than the output V_3 because of the filtering action of B(f). Output V_3, assuming that it is available in practical oscillator, is simply equal to V_4, divided by the filter response. At larger values of Δf, the enhancement of gain, due to positive feedback, becomes negligible and the output noise is equal to the product V_nA. Also, any harmonic distortion introduced by the amplifier is reduced at the filter output. This is of particular relevance in the design of low harmonic-distortion audio oscillators.

Take the example of an oscillator operating at 100 MHz. Let the Q of the frequency-selective network be 40, the amplifier noise voltage be $10nV/\sqrt{Hz}$, and the output voltage be 3V r.m.s. From equation (8), $(1\text{-}AB_0) = 4.4\times10^{-11}$. The operating gain, defined by Equation (4), is the reciprocal of this, i.e., $G_0 = 2.3\times10^{10}$. From equation (9) $Q_0 = 9.2\times10^{11}$ and $f_{3dB} = 1.1\times10^{-4}$ Hz. At 10 kHz from the carrier the gain given by equation (13) is 125 and the noise is 1.25×10^{-6} volts per $\sqrt{Hz}$. The carrier-to-noise ratio, 10kHz off, is therefore -128dB. Figure 2 is a graph of the oscillator gain in dB over the frequency span of 40 kHz as defined by equation (11). Figure 3 shows the output level, in dBV as would be displayed by an ideal spectrum analyser employing a true rectangular filter with a noise resolution bandwidth of 1 Hz. In Fig. 4 the frequency span has been reduced to 200 Hz and the flat top of the filter is just visible. The extreme values of gain and Q may appear incredibly high. However, it should be remembered that in the ideal oscillator model both these parameters are infinite.

Consider now the degradation in noise performance of an oscillator which has an amplifier that introduces an arbitrary phase shift θ at the oscillator frequency. If it is assumed that this phase shift is constant over the frequency range of interest the gain of the amplifier may be represented in polar form by $A>\theta$. The oscillator is now forced to operate at a frequency removed from f_0 so that the bandpass filter can offset this phase shift. If equation (3) is rewritten in terms of Δf, and $A\,\Delta\,\theta$ is written in its trigonometric form, the equation becomes:

$$\frac{V_4}{V_1}=\frac{AB_0(\cos\theta+j\sin\theta)}{1-AB_0\cos\theta+j(2Q\Delta f/f_0-AB_0\sin\theta)} \quad (14)$$

This equation will have a maximum value at a frequency which makes the j terms in the denominator zero. This gives the result:

$$\Delta f=(f_0AB_0\sin\theta)/2Q \quad (15)$$

At practical values of Δ f, in

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equation (14) the real part of the denominator may be equated to zero. This results in the equation:

$$\cos\theta = 1/(AB_0) \quad (16)$$

Substituting the AB_0 in equation (15) gives the particular value of Δf which defines the modified operating frequency:

$$\Delta f = (f_0 \tan\theta)/2Q \quad (17)$$

This result may be illustrated by considering a phase shift θ of 45 degrees in the amplifier. Then $\tan 45 = 1$ so that $\Delta f = f_0$ 2Q. This corresponds to the 3dB corner frequency of just the filter where it is generally known the filter phase shift is the corresponding 45 degrees.

To examine the effect of the phase shift on the oscillator noise, it is convenient to redefine the offset frequency as Δf_1 which will now equal the offset from the actual oscillator frequency. If Δf_1 is used in equation (14), the term $AB_0 \sin\theta$ falls away and for practical values of Δf_1, the term $(1 - AB_0 \cos\theta)$ is negligible. Equation (14) then simplifies to

$$\frac{V_4}{V_1} = \frac{AB_0(\cos\theta + j\sin\theta)}{j2Q\Delta f_1/f_0} \quad (18)$$

If from equation (16) AB_0 is substituted by $1/\cos\theta$, the magnitude of the gain simply becomes

$$|G(f)| = f_0/(2Q\Delta f_1 \cos\theta) \quad (19)$$

This expression can be directly, compared to equation (13) from which it can be seen that the gain has been raised by a factor of $1/\cos\theta$. (In practice a small correction is necessary to allow for the fact that f_0 is defined by the filter and is no longer the oscillator frequency.) For the example of $\theta = 45°$ it is apparent that the gain and therefore the oscillator noise will be increased by 3dB.

It may seem surprising that the gain symmetry predicted by equation (19) has been preserved, since the centre frequency of the filter no longer coincides with the oscillator frequency. However, substituting practical values in the more exact equation confirms this symmetry for reasonable values of Q. In contrast the gain V_3/V_1, and therefore the noise, will no longer be symmetrical, as can be demonstrated by dividing equation (19) by the filter response defined by equation (1).

In a practical oscillator it is a simplification to represent the total oscillator noise source by a single white noise generator particularly in r.f. oscillators. Also no allowance has been made for the noise generated by the tuned circuit. However, it should be apparent that this noise source may also be referred to V_n when considering just the output V_4. In practice, the close-in noise determined by equation (12) is ideal and is degraded by a flicker noise and non linearity in the amplifier or tuned circuit. This results in a complex frequency translation of low-frequency amplifier noise which is folded symmetrically about the oscillator frequency.

The principle of injecting a stimulus, such as a sinusoidal source, is an important one. This enables closed-loop responses of oscillators to be analysed. The model depicted in Fig. 1 may readily be extended to represent an actual oscillator circuit to enable a more complete analysis to be carried out employing the approach described.

In the oscillator model discussed, the sideband noise energy is equally divided between phase noise and amplitude noise. However, in practice, the phase noise will normally predominate because of voltage-sensitive capacitances in the amplifier. These, for example, convert power supply noise to phase noise. This is particularly true for Varactor-diode frequency-controlled oscillators. Varactor diodes, in addition to increasing oscillator non-linearity, readily convert externally injected noise into phase noise to the extent that induced phase noise can become totally dominant.

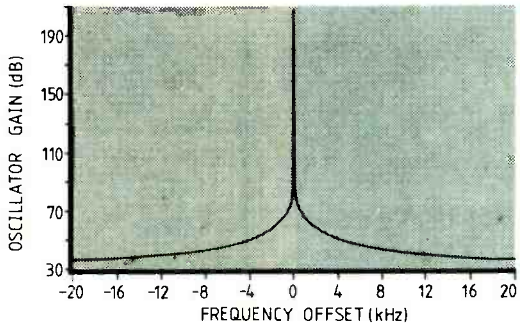

Fig. 2. Oscillator gain over a range of 20kHz either side of carrier: gain defined in equation (11).

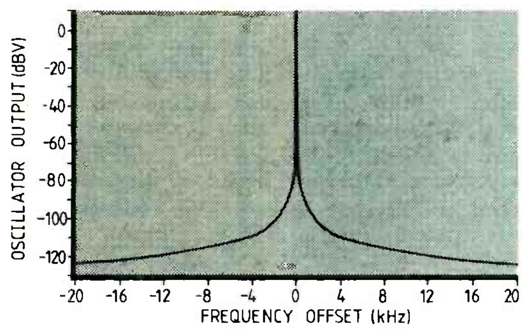

Fig. 3 Oscillator output (in dBV) shown by ideal spectrum analyser.

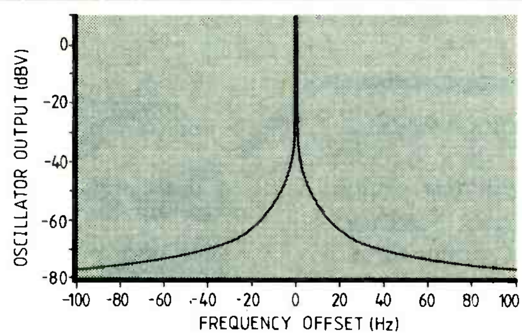

Fig. 4. Fig. 3 graph on 200Hz base, showing flat top of spectrum analyser filter curve.

Reference

1 Transmission Systems for Communications, 4th ed., Bell Telephone Labs, Western Electric Co. Winston-Salem, N.C. ■

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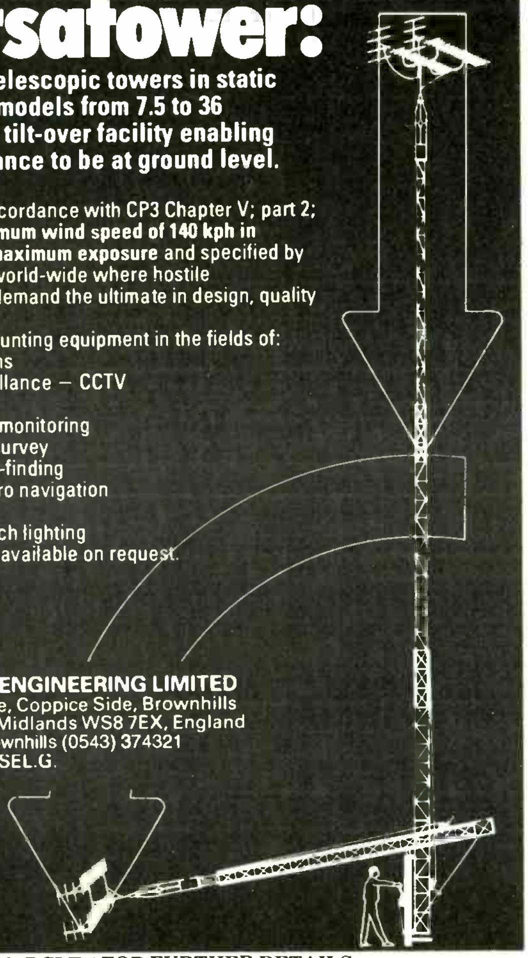

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APPLICATIONS SUMMARY

Ten-channel graphic equalizer

One of numerous application examples in Samsung's audio i.c. data book is this graphic equalizer circuit in which two five-channel i.cs are combined.

The KA2223 consists of an op-amp and five active-filter circuits. Total harmonic distortion for 1V input at 1kHz is 0.02% and noise between 10Hz and 20kHz is 7µV.

Other products in this, the first Samsung audio data book to be made available in the UK, include f.m./a.m. r.f. devices, stereo decoders, pre/power amplifiers and led level meters.
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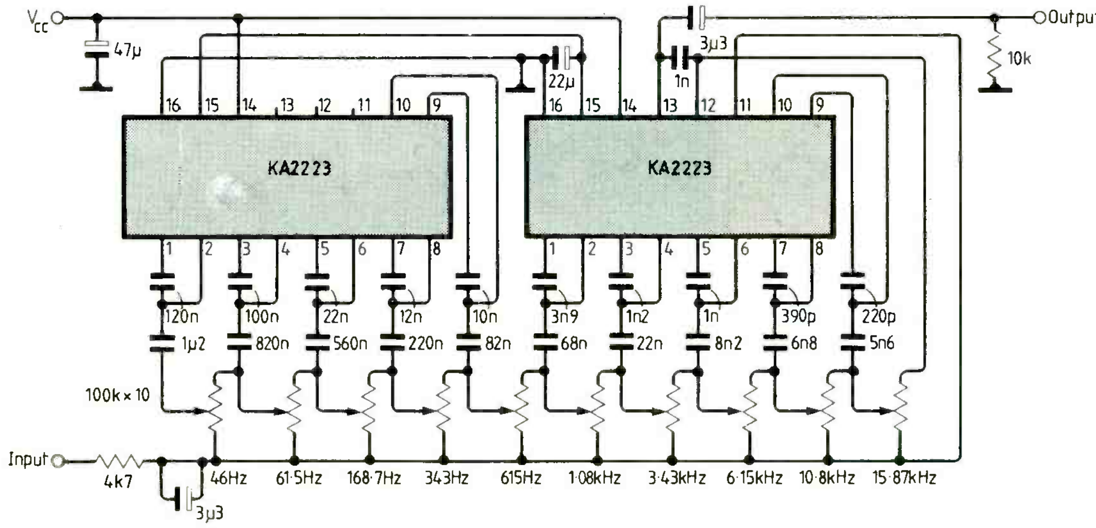

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Dialogue Distribution Ltd
Wicat House
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Surrey GU15 3HL

Samsung (UK) Ltd
6th floor, Victoria House
Southampton Row
London WC1

Supertex, see Maxim

50-240Hz inverter with precision snubber

In switching power converters using more than one power transistor, a delay is usually needed between switching one transistor off and the next one on. Without this delay, transformer ringing would be dissipated in the switching transistors.

In this inverter circuit, one of 29 applications in "Dmos design entries and articles" from Supertex, the 11.25° delay is produced digitally. Output power is increased by connecting more switching transistors in parallel.
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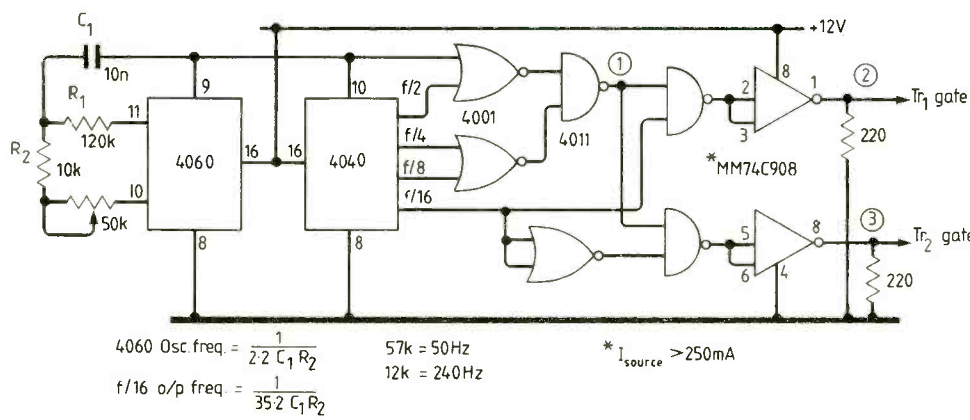

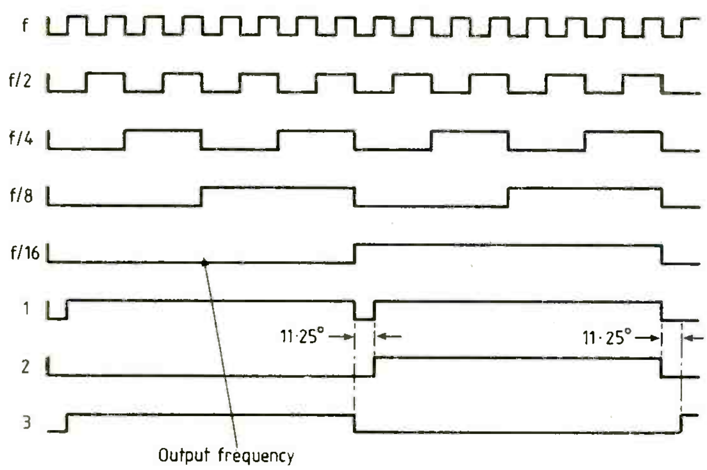

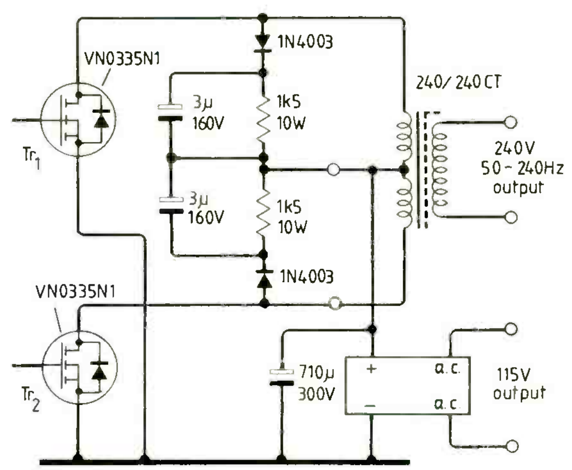

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NEW PRODUCTS

Digital capacitance meter

Capacitance values between 0.1pF and 2mF can be measured on the Levell 7705 capacitance meter. Accuracy on this 3-digit instrument is 0.5%. The test voltage is 3.2V peak with two measurements a second. The unit has an imput protection fuse. £49 (+ tax) from Levell Electronics Ltd, Moxon Street, Barnet, Herts EN5 5SD.
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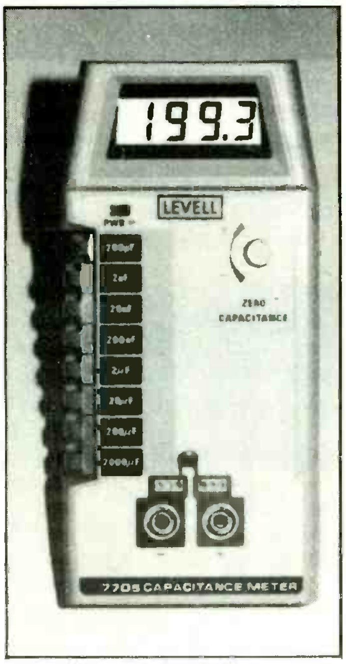

Fast 256K d-ram

Claimed to be the fastest available, the 256K d-ram from Inmos has an access time down to 60ns, more than twice as fast as the usual standard of 150ns. The IMS2800 is suitable for all applications in replacing 64K d-rams in, for example, personal computers or upgrading first-generation 256K d-rams in mainframe applications. It also has an important application with the latest generation of 32-bit processors where, according to Inmos, it is the only dynamic ram that can enable them to work at peak performance. The c-mos devices can operate at up to 30Mbit/s. Inmos International plc, Whitefriars, Lewins Mead, Bristol BS1 2NP.
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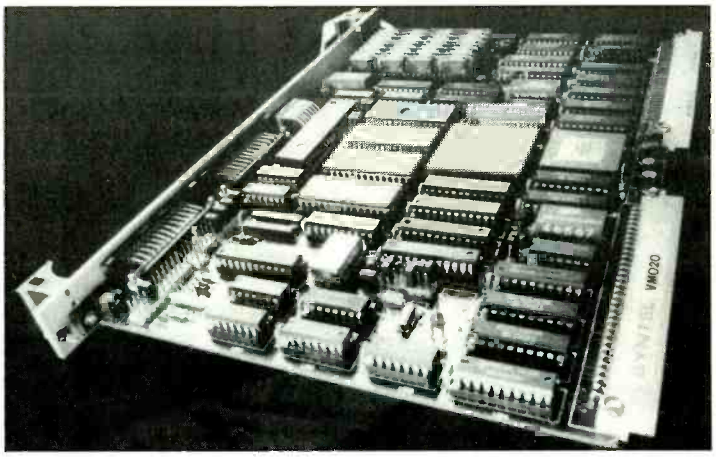


68020 on VME card

The VME processor module from Syntel is claimed to be the first to use the 68020 and the 68881 maths co-processor with a G-64 i/o interface. High-speed maths and graphics are possible. The addition of the G-64 interface allows the user to select from over 300 i/o modules from more than 15 suppliers. Processing power is further enhanced by the 1Mbyte, 32-bit wide on-board memory. Additional memory cards can be added in units of 64 and 256K d-ram.

The processor can operate at 12 or 16MHz and the VME interface offers 16Mbyte, 16-bit wide addressing space with bus access logic and full line buffering in accordance with the VME specification. The G-64 interface allows off-board transfers at 1 or 2MHz within a 1Mbyte memory address space. A separate on-board i/o memory space allows slow devices to be used with the 2MHz clock.

The module includes a real-time calendar/clock and dual RS232/422 ports. It supports the OS9 68000 operating system, providing multi-user, multi-tasking capabilities for both rom and disc-based systems. Syntel Microsystems, Queens Mill Road, Huddersfield, HD1 3PG.
EWW206 on reply card.

Pulse generator

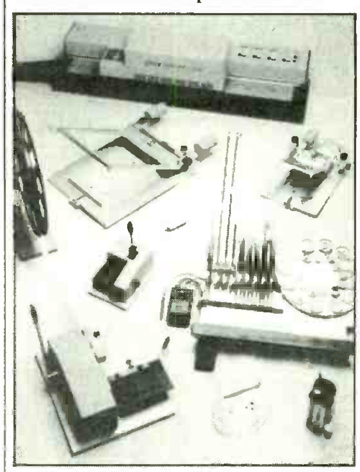
An instrument from Ver Controls is suitable for field or bench work and has sufficient output for direct drive of positive logic families, and is also capable of driving capacitative loads such as power mosfets and small relays. The frequency range extends from 1Hz to over 5MHz and the mark/space ratio can be adjusted as required. Based on the design described in last month's issue (pages 43-47), two complimentary outputs are provided to allow push-pull driving; 30V peak-to-peak and pre-trigger functions. A single shot facility is also included. The generator is powered by a.c. mains and there is also provision for internal rechargeable batteries. Ver Controls (St Albans) Ltd, Rookery House, Crowe's Loke, Little Plumstead, Norwich NR13 5JB.
EWW210 on reply card.

Surface-mount starter kit

Designed to make surface mounting a viable proposition for the smaller company, the Cosy surface mounting starter kit is manufactured by Contact Systems in Switzerland. Hand assembled boards can be produced with the kit which is made up from a screen printer, assembly station, vacuum pick-up pen and a conveyor oven for reflow soldering.

The screen printer offers two sizes of work area; 100 by 120mm and 220 by 300mm. It uses etched or drilled stencils of varying thickness, according to the nature of the circuit. An accurate pin and vacuum positioning system holds the board while the adhesive or solder paste is applied through the screen.

The assembly station can accommodate all of the formats that components are supplied in; stick and tape feeders as well as loose components. An



optional control unit can be programmed to light indicators on each component feeder in the correct sequence for rapid population of the board.

The bench-mounted infra-red conveyor oven features three heating zones and can accept boards up to 108mm wide an up to 34mm high. Typical reflow temperatures are between 180 and 280°C but temperatures above and below this range can be selected for specific applications. All three heating zones and the speed of the conveyor can be adjusted. Sohlberg-Surtech Ltd, Intec 2, Wade Road, Basingstoke, Hants RG24 0NL.
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GEX541 6.50
GJ3M 3.00
GM0378A 1.75
KS100A 0.45

MJE340 0.79
MJE370 0.73
MJE371 1.05
MJE520 0.75
MJ521 0.73
MJE2955 2.25
MJE3055 2.00
MPF103 0.55
MPF104 0.55
MPF105 0.55
MPSA06 0.17
MPSA56 0.17
MPSU01 1.11
MPSU06 1.33
MPSU56 1.71
NE555 0.45
NKT401 4.00
NKT403 3.50
NKT404 4.00
OA5 1.75
OA7 0.75
OA10 0.55
OA47 0.15
OA70 0.22
OA79 0.21
OA81 0.21
OA85 0.21
OA90 0.08
OA91 0.08
OA95 0.08
OA200 0.15
OA202 0.15
OA211 1.00
OAZ200 1.50
OAZ201 1.50
OAZ206 1.50
OAZ207 1.50
OC16 5.00
OC20 6.00
OC22 4.50
OC23 10.00
OC24 3.00
OC25 0.79

OC26 1.50
OC28 5.50
OC29 4.40
OC35 4.00
OC36 4.00
OC41 1.20
OC42 1.50
OC43 1.50
OC44 1.25
OC45 0.85
OC71 0.65
OC72 2.20
OC73 1.45
OC74 1.40
OC75 1.40
OC76 1.60
OC77 2.75
OC81 0.90
OC81Z 4.00
OC82 0.95
OC83 1.40
OC84 1.40
OC122 6.50
OC123 6.50
OC139 12.00
OC140 18.00
OC141 18.00
OC170 4.40
OC171 4.40
OC200 4.00
OC201 5.50
OC202 5.50
OC203 5.50
OC204 7.00
OC205 10.00
OC206 8.50
OC207 18.00
OCP71 2.50
ORP12 2.40
R2008B 1.95
R2009 2.25
R2010B 2.00
TIC44 0.48

TIC226D 1.20
TIL209 0.29
TIP29A 0.35
TIP30A 0.36
TIP31A 0.25
TIP32A 0.25
TIP33A 0.53
TIP34A 0.60
TIP41A 0.38
TIP42A 0.42
TIP110 0.10
TIP117 0.45
TIP125 0.35
TIP130 0.45
TIP131 0.45
TIP132 0.48
TIP135 0.45
TIP137 0.48
TIP140 0.85
TIP141 0.85
TIP142 0.85
TIP2955 0.60
TIP2955T 0.45
TIP3055 0.60
TIP3055T 0.45
ZS140 0.25
ZS170 0.25
ZS178 0.54
ZS272 0.23
ZS278 0.57
ZTX107 0.12
ZTX108 0.12
ZTX109 0.12
ZTX300 0.13
ZTX301 0.14
ZTX302 0.14
ZTX303 0.14
ZTX304 0.14
ZTX311 0.13
ZTX314 0.25
ZTX500 0.14
ZTX501 0.14
ZTX502 0.14

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

2N1893 0.30
2N2147 8.00
2N2148 2.75
2N2218 0.32
2N2219 0.32
2N2220 0.22
2N2221 0.22
2N2222 0.20
2N2223 7.50
2N2368 0.23
2N2369 0.23
2N2384 0.24
2N2646 0.75
2N2904 0.30
2N2904 0.30
2N2905 0.30
2N2906 0.22
2N2907 0.22
2N2924 0.12
2N2925 0.22
2N2926 0.12
2N3053 0.30
2N3054 0.55
2N3055 0.70
2N3440 0.60
2N3441 0.75
2N3442 1.00
2N3641 5.00
2N3702 0.11
2N3703 0.11
2N3704 0.11
2N3705 0.11
2N3706 0.11
2N3707 0.11
2N3708 0.11
2N3709 0.11
2N3710 0.11
2N3711 0.10
2N3771 1.20
2N3772 1.20
2N3773 1.60
2N3819 0.50
2N3820 0.60

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

VALVES

A1834 9.00
A2087 13.50
A2134 17.50
A2293 16.00
A2426 35.00
A2521 25.00
A2900 15.00
A3343 45.00
AZ31 2.75
AZ41 2.60
BK448 114.90
BK484 155.35
BS90 58.00
BS810 60.00
BT5 58.95
BT17 185.00
BT19 44.05
BT29 349.15
BT69 354.80
BT95 129.90
CBL31 4.00
CL33 4.00
CY31 3.00
C1K 20.00
C3A 22.00
C3JA 22.00
DA41 25.00
DA42 18.70
DAF91 1.75
DAF96 1.75
DET22 35.00
DET24 49.00
DF91 1.75
DF96 1.75
DK91 1.75
DK92 2.00
DK96 1.75
DL92 2.00
DL94 1.75
DL96 1.75
DLS10 14.00
DLS15 12.50
DLS16 12.50
DLS19 12.50
DM70 2.00
DM71 2.00
DM160 4.75
DY87 1.50
DY802 1.50
E55L 50.00
E80CC 15.00
E80CF 11.27
E80F 14.19
E80L 13.73
E81CC 8.00
E81L 13.27
E82CC 8.10
E83CC 8.40
E86C 8.25
E88C 8.25
E88C 10.33
E90CC 9.47
E90F 9.90
E91H 6.25
E92CC 8.75
E99F 9.10
E130L 18.50

E180CC 10.50
E180F 12.05
E182CC 13.25
E186F 11.50
E188CC 8.91
E280F 22.51
E283CC 12.00
E288CC 17.50
W810F 35.48
EA52 32.25
EA76 2.50
EABC80 1.25
EAC91 3.50
EAF42 2.50
EAF801 2.00
EB41 4.00
EB91 1.50
EBC33 2.50
EBC41 2.50
EBC81 1.50
EBC90 1.25
EBF80 1.50
EBF83 1.75
EBF89 1.50
EBL31 10.00
EC90 1.25
EC91 8.00
EC92 1.75
EC175 462.00
ECC33 4.50
ECC35 4.50
ECC40 5.50
ECC81 1.75
ECC82 1.75
ECC83 1.75
ECC84 1.75
ECC85 1.75
ECC86 2.50
ECC88 3.50
ECC89 2.00
ECC91 8.93
ECC189 2.10
ECC807 1.75
ECC808 3.00
ECF80 1.50
ECF82 1.50
ECF86 2.50
ECH35 3.00
ECH42 3.50
ECH81 3.00
ECH83 2.50
ECH84 2.50
ECL80 1.50
ECL81 1.75
ECL82 1.50
ECL83 3.00
ECL84 1.50
ECL85 1.50
ECL86 1.75
EF37A 5.00
EF39 2.75
EF40 5.00
EF41 3.50
EF42 4.50
EF50 2.50
EF54 5.00
EF55 3.50
EF80 1.75
EF83 4.00

EF85 1.75
EF86 3.50
EF89 2.50
EF91 2.95
EF92 6.37
EF93 1.50
EF94 2.50
EF95 5.99
EF98 2.00
EF183 2.00
EF184 2.00
EF804S 12.00
EF805S 15.00
EH90 1.75
EK90 1.50
EL32 2.50
E133 4.00
EL34MUI 4.00
EL36 2.50
EL41 2.80
EL42 2.50
EL81 5.25
EL83 6.00
EL84 2.25
EL86 2.75
EL90 3.25
EL91 7.39
EL95 2.00
EL156 30.00
EL360 8.50
EL500 3.00
EL509 10.00
EL821 13.00
EL822 13.97
ELL80 19.00
EM34 8.00
EM80 2.50
EM81 2.50
EM84 2.00
EM85 2.75
EM87 2.50
EN32 25.00
EN91 6.50
EN92 6.96
EY51 2.75
EY81 2.50
EY83 2.50
EY84 9.24
EY86 1.75
EY88 1.75
EY500A 3.00
EY802 1.75
EZ35 1.75
EZ40 2.50
EZ41 2.50
EZ80 1.50
EZ81 1.50
EZ90 3.00
FW4-500 3.50
FW4-800 3.50
GL371K 35.00
G551K 12.00
G180.2M 17.50
G240.2D 12.00
G400.1K 17.50
GN4 9.00
GN4A 9.00
GN4A 9.00
GS16 16.00

GT1C 25.00
GU50 20.00
GU51 20.00
GXU1 15.35
GXU2 30.00
GXU3 25.40
GXU4 44.50
GXU50 20.00
GY501 3.00
GZ32 4.00
GZ33 4.75
GZ34 4.00
GZ37 4.95
KT61 5.00
KT66 15.00
KT77 Gold Lion 12.00
KT88 Gold Lion 20.00
KTW61 2.50
KTW62 2.50
KTW63 2.50
M8079 12.34
M8080 8.25
M8081 9.82
M8082 9.69
M8083 10.25
M8091 10.43
M8096 6.80
M8097 8.10
M8098 8.15
M8099 8.00
M8100 10.30
M8136 11.75
M8137 12.25
M8140 6.00
M8141 6.50
M8142 8.75
M9144 7.50
M8149 6.50
M8161 9.35
M8162 11.75
M8163 8.25
M8190 5.00
M8195 10.85
M8196 7.50
M8204 7.05
M8212 11.37
M8223 6.00
M8224 6.30
M8225 4.50
M8248 14.03
MD2901 115.00
MU14 2.50
MX119 55.00
MX123 76.00
MX145 56.70
MX151 17.25
MX152 131.25
MX161 152.25
MX163 20.25
MX164 25.52
MX166 147.00
MX168 50.00
N78 15.00
OA2 3.25
OA3 2.50
OA4 6.00
OB2 4.35

OB3 2.50
OC2 4.55
OC3 2.50
OD3 2.50
OZ4 3.50
PC86 2.50
PC88 2.50
PC95 1.75
PC97 1.75
PC900 1.75
PCC84 1.50
PCC85 1.50
PCC88 2.00
PCC89 1.75
PCC189 2.50
PCC805 1.60
PCC806 1.60
PCE82 2.00
PCF80 2.00
PCF82 1.50
PCF86 2.50
PCF87 2.00
PCF200 3.25
PCF201 3.25
PCF801 2.50
PCF802 2.50
PCF805 1.70
PCF806 1.70
PCF808 1.70
PCL82 2.00
PCL83 3.00
PCL84 2.00
PCL85 2.50
PCL86 2.50
PCL805/85 2.50
PD500 6.00
PE06-40N 45.00
PFL200 2.50
PL36 2.50
PL81 1.75
PL81A 2.00
PL82 1.50
PL83 2.50
PL84 2.00
PL504 5 2.50
PL508 5.50
PL509 6.00
PL519 6.00
PL801 1.50
PL802 6.00
PY33 2.50
PY81 1.50
PY82 1.50
PY83 1.25
PY88 2.00
PY500A 4.00
PY800 1.50
PY801 1.50
QF451 82.50
QQV02-6 38.00
QQV03-10 26.25
QQV03-20A 48.38
QQV06-40A 46.00
QQZ06-40A 62.20
QU37 12.50
QV03-12 6.80

QV04-7 3.50
QQV07-50 76.65
QV08-100 197.40
QY3-65 63.24
QY3-125 78.48
QY4-250 74.00
QY4-400 87.20
QY5-500 208.00
QY5-3000A 566.80
QZ06-20 46.00
R10 6.00
R17 3.00
R18 3.00
R19 9.24
R20 2.50
RG3-1250 59.50
RG3-250A 32.68
RG3-1250 59.00
RG4-1250 61.60
RG4-3000 99.45
RR3-250 40.00
RR3-1250 45.75
SHE12 65.00
S130 6.00
S130P 6.00
STV280-40 14.00
STV280-80 21.00
SU41 5.00
SU42 10.00
TD03-10 35.00
TD03-10F 35.00
T15 50.00
TT21 37.50
TT22 37.50
TT100 60.00
TY2-125 78.75
TY4-400 88.20
TY4-500 115.50
TY5-500 236.00
TY6-800 231.00
TY66-5000A 540.00
TY6-5000B 395.00
TY6-5000W 446.00
TY7-6000A 579.00
TY7-6000W 597.00
TZ40 25.00
U18.20 3.50
U19 13.75
U25 2.50
U26 2.50
U37 12.00
UABC80 1.25
UAF42 2.50
UB41 3.00
UBC41 2.25
UBF89 1.50
UCC84 1.75
UCC85 1.85
UFC80 2.00
UCH42 2.50
UCH81 2.50
UCL82 1.75

UCL83 2.75
UF41 2.00
UF42 2.10
UF80 1.75
UF85 1.75
UF89 2.00
UL41 5.00
UL84 1.75
UM80 2.00
UY41 2.25
UY81 2.25
VLS631 15.00
XG1-2500 100.00
XG5-500 30.00
XG2-6400 185.00
XR1-1600A 53.75
XR1-3200 110.00
XR1-3200A
XR1-6400 150.00
YD1120 395.00
YD1240 490.00
Z803U 25.00
Z259 25.00
ZM1001 8.00
ZM1020 9.00
ZM1020 9.00
ZM1022 9.00
ZM1023 9.00
ZM1040 19.36
ZM1041 16.66
ZM1042 17.77
IB3GT 3.00
IB24 25.00
IB35A 48.00
IB63 64.00
IR5 1.75
IS5 1.75
IT4 1.75
2AS15 11.50
2C39A 60.00
2C43 70.00
2D21 3.25
2E26 8.25
2J4Z 98.00
2J55 245.00
2J70A 383.00
2J70B 336.00
2K25 125.00
3400Z 115.00
3500Z 100.00
3A5 3.00
3B24 11.00
3B28 15.35
3B29 20.05
3B240M 17.50
3B241M 17.50
3C23 25.00
3C24 12.00
3CX100A 47.00
3E29 45.00
3S4 2.00
3V4 1.75
4-65A 60.00
4-125A 60.00

4-250A 80.00
4-400A 87.00
4B32 20.00
4C35 120.00
4CX250B 58.00
4CX350A 105.00
4X150A 60.00
4X150D 56.00
5B254M 35.00
5B255M 35.00
5C22 160.00
5J180E 1650.00
5R4GY 5.50
5U4G 3.00
5U4GB 2.50
5V4G 2.50
5Y3GT 2.50
5Z3 4.00
5Z4G 2.50
5Z4GT 2.50
6-30L2 1.75
6AB4 1.75
6AB7 3.00
6AC7 3.00
6AF4A 4.25
6AG7 3.00
6AH6 5.00
6AK5 5.99
6AK6 2.50
6AL5 1.50
6AM4 4.00
6AM5 9.69
6AM6 6.02
6AN5 4.75
6AN8A 3.50
2AQ5 3.25
6AS6 8.66
6AS7G 8.75
6AT6 1.25
6AU5GT 5.00
6AU6 2.50
6AV5GA 4.50
6AV6 1.50
6AX5GT 3.00
6B7 3.25
6B8 3.25
6BA6 1.50
6BA7 5.00
6BA8A 4.00
6BC4 4.00
6BR6 1.50
6BH6 2.50
6BJ6 2.25
6BK4 4.50
6BL6 85.00
6BL7GT 4.50
6BM6 115.00
6BN6 2.00
6BQ7A 3.50
6BR7 6.00
6BT8A 3.50
6BS7 6.00
6BW6 6.00
6BW7 1.50
6BX7GT 5.00
6BZ6 2.75
6C4 1.25
6CB6A 2.50
6CD6GA 5.00

6CG7 2.50
6CH6 13.00
6CL 63.75
6CW4 8.00
6D2 1.50
6DK6 3.00
6DQ6B 4.75
4EA8 3.00
6EB8 2.50
6EW6 2.25
6F6 3.00
6F23 1.60
6F28 1.60
6F33 33.50
6H1 14.00
6H3N 2.75
6H6 3.00
6J4 5.50
6J6 8.93
6J7 4.75
6JE6 7.50
6K4N 2.50
6K6GT 2.75
6K7 3.00
6K8 3.00
6KD6 8.00
6L6G 3.00
6I6GA 3.50
6L6GC 5.75
6L6GT 3.00
6L7 2.50
6N2P 2.50
6N3P 2.50
6N7 3.00
6P225 4.00
6Q7 3.75
6K7 3.25
6RHH8 6KN8 10.00
6SA7 3.00
6SC7 2.75
6SF7 2.50
6SH7 3.00
6SJ7 3.25
6SK7 3.50
6SL7GT 3.00
6SN7GT 3.00
6SQ7 3.40
6SR7 4.00
6SS7 2.75
6U5G 3.50
6U8A 2.25
6V6GT 4.25
6X4 3.00
6X5GT 1.75
7B7 2.50
7C3 4.00
7C6 2.50
7H7 4.00
7R7 4.25
7S7 3.50
7Y4 2.25
7Z4 2.00
12AH8 5.00
12AT6 1.50
12AT7 1.75
12AU6 2.50
12AU7 1.75
12AV6 2.50

12AW7 3.50
12AX7 1.75
12AY7A 4.00
12B4A 3.50
12BA6 2.50
12BE6 2.50
12BH7 2.75
12BY7 3.00
13E1 170.00
12E1TTT 28.00
12E14 65.00
12E1 20.00
13E1 170.00
19H5 47.50
24B9 67.25
30C15 2.00
30C17 2.00
30C18 2.00
30F5 1.60
30FL1 2 1.38
30FL12 1.80
30FL14 2.00
30L1 1.50
30L15 2.00
30L17 2.00
30P4 2.50
30P19 2.50
30PL1 3.00
30PL14 1.80
30PL15 1.80
35W4 1.00
50C4 1.50
75B1 6.05
75C1 4.50
85A1 7.50
85A2 6.45
90AG 20.00
90AV 20.00
90C1 6.00
90CG 14.54
90CV 15.45
92AG 20.00
92AV 20.00
95A1 8.45
150BA 6.50
150B3 8.35
150C2 3.25
150C4 6.00
211 35.00
723AB 125.00
803 25.00
805 45.00
807 3.75
811A 18.33
812A 35.00
813 valve 65.00
833A 193.16
866A 20.03
872A 20.00
922 6.00
931A 18.50
1624 4.00
1625 3.50
2050 7.50
4212E 300.00
4212H 300.00
5544 110.00
5545 150.00
5551A 120.00

5552A 155.35
5642 9.00
5654 3.00
5651 4.45
5670 4.50
5675 28.00
5687 6.00
5696 4.50
5718 7.50
5725 5.50
5726 11.37
5727 7.05
5749 2.50
5751 4.00
5763 4.50
5814A 4.00
5840 4.00
5842 12.00
5876A 31.50
5879 5.00
5886 17.50
5963 2.50
5965 3.50
6005 2.25
6021 4.50
6057 12.25
6058 12.34
6059 6.00
6061 6.00
6063 3.75
6064 10.25
6067 11.75
6072 6.00
6080 14.00
6097A 235.00
6097B 200.00
6146A 12.00
6146B 12.00
6159B 19.00
6189 9.50
6201 11.40
6442 20.00
6550 8.00
6883B 12.50
6973 7.50
7025 3.00
7027A 8.00
7551 6.25
7586 15.00
7587 23.00
7609 56.00
7868 6.00
7895 12.00
8068 16.50
8136 2.50
8417 6.00
18042 11.53
18045 10.49
18046 11.53

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

BASES

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

CRTs

2AP1 8.50
2BP1 9.00
3BP1 20.00
3DP1 5.00
3EG1 10.00
3FP7 6.00
3GP1 6.00
3JP1 8.00
3JP2 8.00
3JP7 10.00
3KP1 15.00
3RP1 35.00
3WP1 20.00
5ADP1 55.00
6CP1 10.00

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

CRT sockets
Prices on application

I/C sockets
Texas low profile
8 pin 10p
14 pin 10p
16 pin 10p

INTEGRATED CIRCUITS

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

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

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

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

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

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

TAA570 1.75
TAA630S 1.75
TAA700 3.00
TBA480Q 1.50
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TBA560Q 1.75
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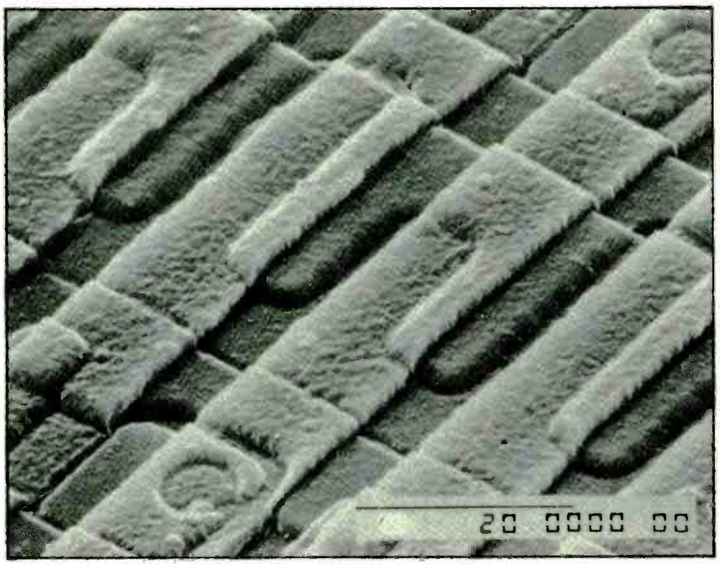
Flat cable goes round

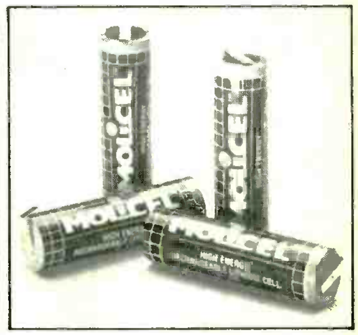
The routing flexibility of round cable is combined with the easy termination of flat ribbon types in the 3M 3659 cable. The flat cable is surrounded by a film foil shield which is in turn covered by a 90% tinned copper braid. This combination offers effective r.f.i. shielding. A flat cable termination area occurs every 20mm along the cable which minimizes cable waste during preparation. The outer p.v.c. insulating sleeve, rated at 80°C, is available in four colours. Connect and Control Systems Ltd, Unit D3, Taylor Industrial Estate, Culcheth, Warrington, Cheshire WA3 6BH.
EWW221 on reply card.

Low-cost scanning microscope

Especially suitable for the inspection of electronic components and microcircuits. The T100 scanning electron microscope costs £1500 which is less than an advanced optical microscope. It offers magnification up to 100 000 times. It comes with a 24-function maintenance checker to help the user to check quickly the operating parameters.

A fast scan facility presents the operator with continuous images up to tv frame frequency and images can be captured by the integral camera. Optimum settings are automatically maintained even when the field-of-view or magnification are altered. With a resolution down to 8nm, the scanning electronic microscope offers several advantages over optical instruments in terms of sharper detail and in electronic circuit testing. Many other facilites, such as X-ray spectroscopy and backscatter electron detection are possible with the system. Jeol UK Ltd, Grove Park, Colindale, London NW9 0JN.
EWW214 on reply card.



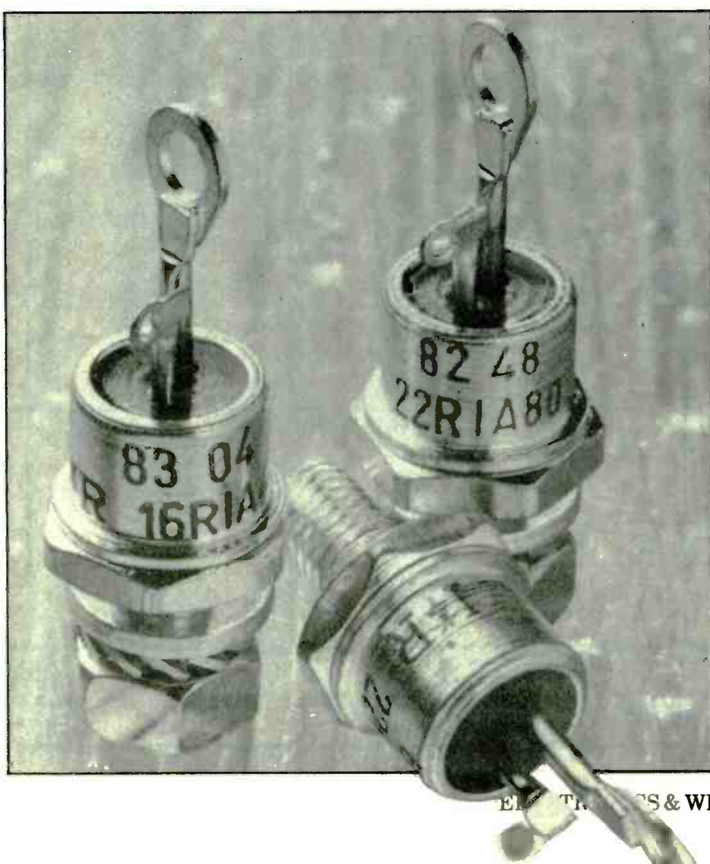


Rechargeable lithium

The Molicell lithium battery has an energy density about twice that of NiCd cells. Self-discharge rates are very low and cycle life is similar to that of other rechargeable batteries. A useful feature of the lithium cells is that relationship between discharge and voltage is almost linear which allows the stored charge to be monitored accurately. Available through All Batteries at Watford and Suvicon Ltd, of Solihull.
EWW216 on reply card.

Thyristors for medium-power applications

Designed for use in general purpose phase-control applications such as converters, lighting circuits, battery chargers, regulated power supplies and temperature or motor speed control circuits, the RIA series of glass-passivated thyristors come from International Rectifier. Features of the devices include, depending on type, a maximum 'on' current of 25 or 35A; and a maximum peak non-repetitive current of 190, 285 or 335A. The maximum repetitive reverse voltage is 100 to 1200V and the typical turn-on time is 0.9μs. Available through Hi-Tek Electronics, Ditton Walk, Cambridge CB5 8QD.
EWW215 on reply card.



Low-distortion audio oscillator

According to Sage Audio, traditional measuring instruments do not match the equipment that they are supposed to measure with the advent of digital audio, compact discs and mosfet amplifiers. The SA1 audio oscillator offers a total harmonic distortion of typically 0.0001% (or 1p.p.m.) at 1kHz. Its four fixed test frequencies of 100 and 400Hz, 1 and 10kHz have a continuously variable output level up to 1V r.m.s. Other frequencies are available to order. The instrument also incorporates a noise test button which removes the test frequency whilst leaving the generator's gain, source impedance and residual noise level as they were. An accurate noise reference can then be established which can be subtracted from the t.h.d.+noise reading to give a more accurate measurement for the system under test. Sage Audio, Construction House, Whitely Street, Bingley, W. Yorks BD16 4JH.
EWW213 on reply card.

www.americanradiohistory.com

The Archer Z80 SBC

The **SDS ARCHER** – The Z80 based single board computer chosen by professionals and OEM users.

★ Top quality board with 4 parallel and 2 serial ports, counter-timers, power-fail interrupt, watchdog timer, EPROM & battery backed RAM.

★ **OPTIONS:** on board power supply, smart case, ROMable BASIC, Debug Monitor, wide range of I/O & memory extension cards.

from £185 + VAT.

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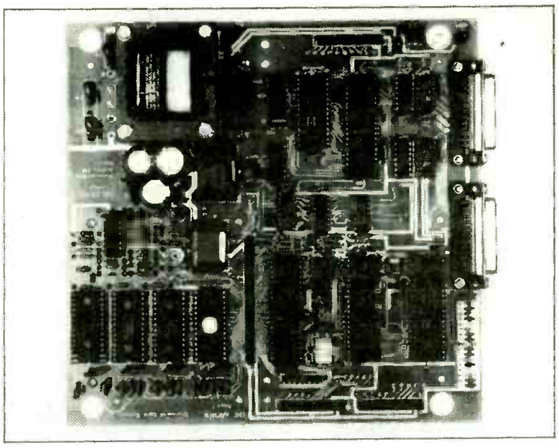


The Bowman 68000 SBC

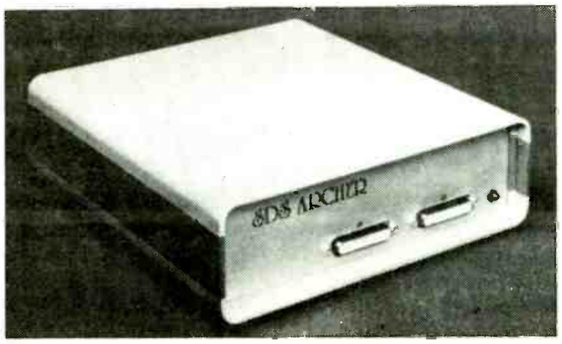
The **SDS BOWMAN** – The 68000 based single board computer for advanced high speed applications.

★ Extended double Eurocard with 2 parallel & 2 serial ports, battery backed CMOS RAM, EPROM, 2 counter-timers, watchdog timer, powerfail interrupt, & an optional zero wait state half megabyte D-RAM.

★ Extended width versions with on board power supply and case.

from £295 + VAT.

CIRCLE 43 FOR FURTHER DETAILS



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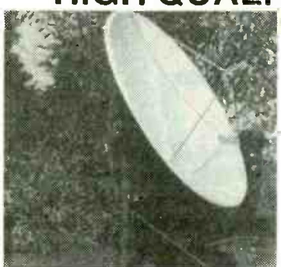

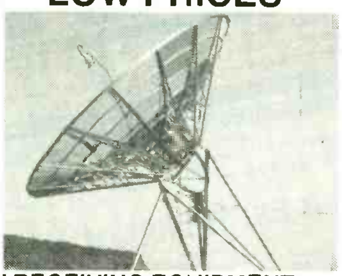

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.2N5634	.2N6083	.2N4431	.2N5102	.2N5918	.2N6084

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Very high quality kit for this recent design featured in 'Wireless World'. Advanced construction system, approved by the Author, uses 3 double sided PCBs in a stacked layout for total stability, ease of construction and minimal wiring. This module will form the AM section of an ultra high quality AM/FM switched bandwidth tuner to match our 300 series amplifiers. Power supply and tuning gang will be included with the FM section.

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HC20 Permalloy Stereo Head. Good quality standard head fitted as original equipment on many decks £5.11
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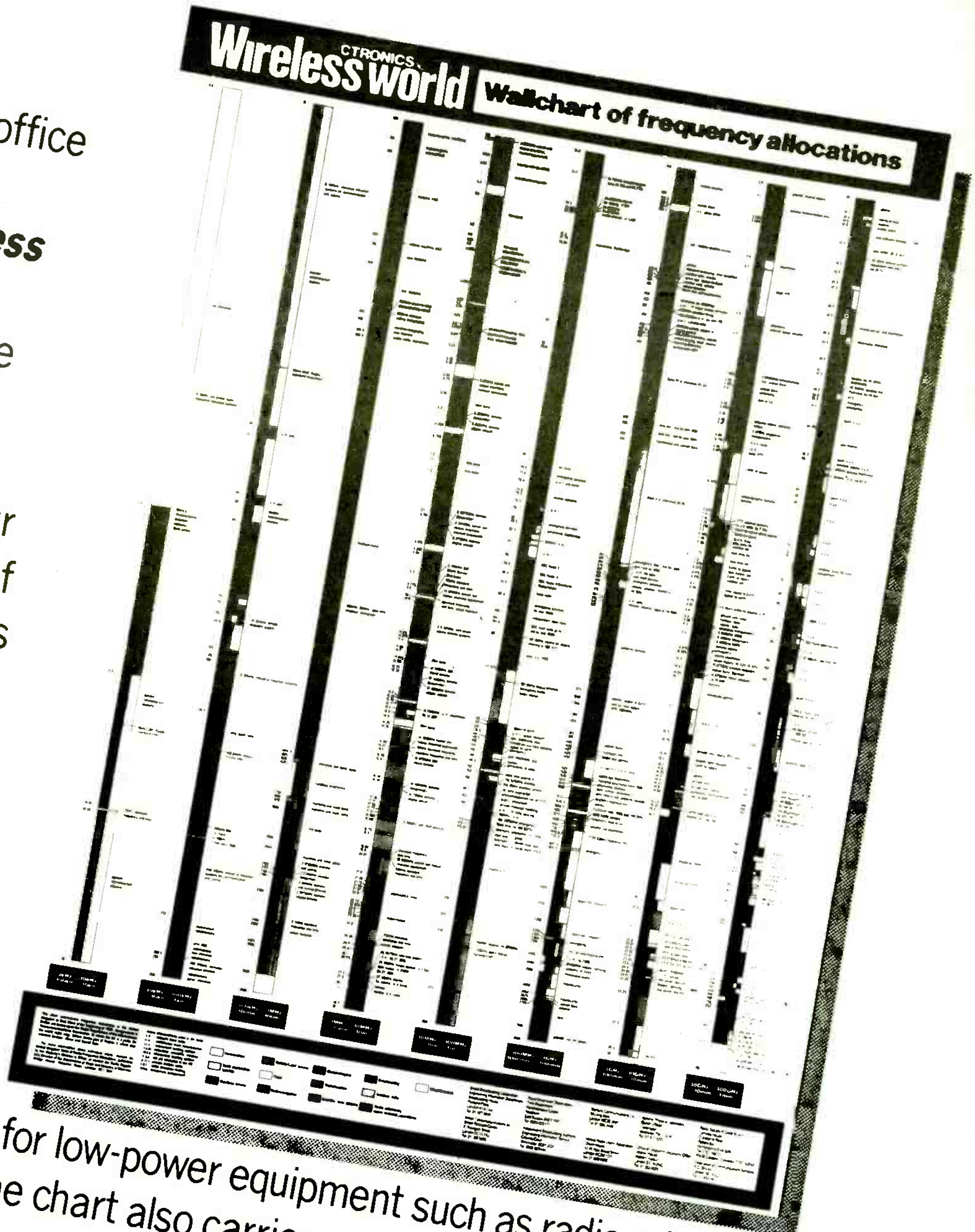

Brighten up your office or lab with a copy of ***Electronics and Wireless World's*** wallchart of frequency allocations. The chart covers frequencies from 3kHz to 300GHz in eight sections, with colour codes to show the uses of each band. Detailed notes mark areas of special interest to the scientist and engineer — such as standard frequency and time signals, radio-astronomy bands, mobile radio, public radiophones and pagers, and assignments for low-power equipment such as radio-microphones and anti-theft devices. The chart also carries a useful list of addresses.

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Computing Posting Ltd,
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Surrey CR4 3HP

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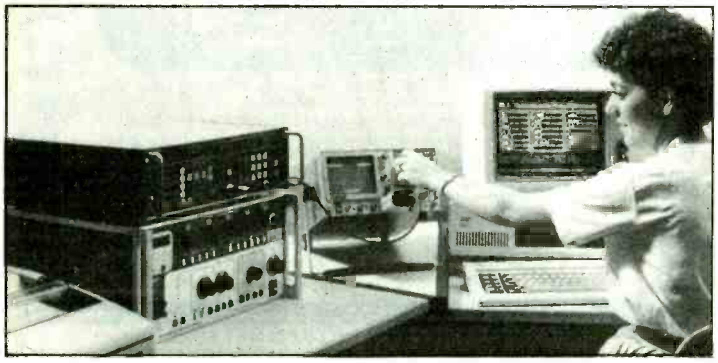
Calibration system

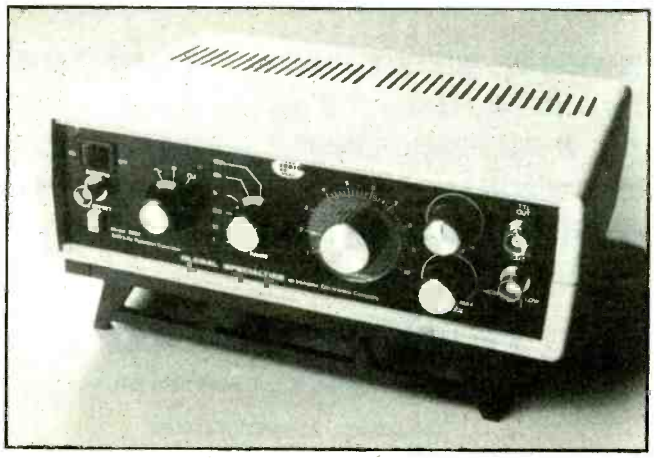
A programmable calibrator can be combined with a personal computer to give an automated, documented calibration system for multiplexers, oscilloscopes, wattmeters and watt-hour meters. The system is aided by menu-driven programmes to enable less-skilled operators to conduct tests and calibrations. Compucal, as it is called, assures quality control by programming the test to be carried out on each instrument. Results before and after the adjustment can be recorded, and a test certificate automatically printed. Storage of an instrument's test history on disc can help in the organizing of test instrument inventory. New test procedures can be entered simply by response to program-generated questions. All tests can be password protected. Control is carried out through an IEEE488 interface.

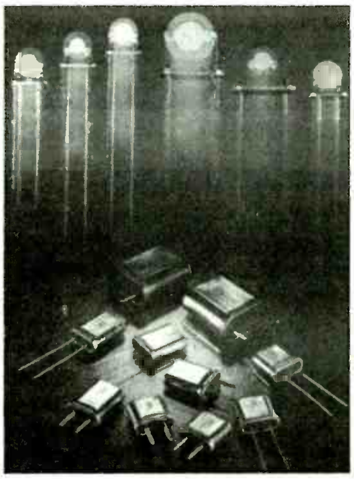
The tests are carried out to certification standard in accordance with BS5750 and can be used by those who previously had to send the equipment to other test laboratories to be certified. PPM Instrumentation Ltd, Hermitage Road, St. Johns, Woking, Surrey GU21 1TZ. EWW212 on reply card.



Function generator

A frequency range from 1Hz to 100kHz with calibrated vernier adjustment is available on Global's 2001 function generator which can also provide frequency sweeps. High and low-level sine, triangle and rectangular outputs are augmented by a separate t.t.l.-level rectangular-wave output which can drive up to 30 standard loads with rise and fall times less than 25ns. Outputs levels are adjustable over a range of more than 40dB. The voltage-controlled sweep oscillator can be set to any range of frequencies, and the sweep input can be within the range of ±10V. Of low weight and easily portable, the instrument is suitable for field servicing and measurement of audio and video equipment and for oscilloscope sweep drives, as well as for general use in the laboratory. Global Specialties Corporation, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ. EWW205 on reply card.





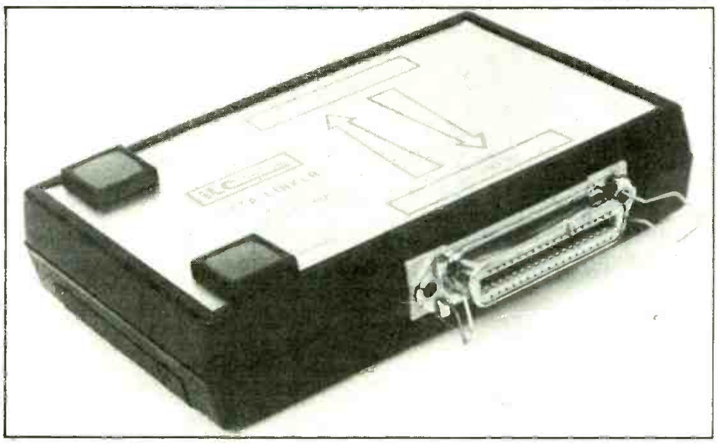
Instant crystals

A service designed to supply quartz crystals in the frequency range 1 to 70MHz on an express made-to-order basis is available from Piezo Products. Their production unit in Hampshire is geared to producing crystals within three days, or even less in an emergency. The crystals are tested for compliance with the relevant standards. They can reproduce a crystal from its type number or specification, or from the equipment type and model number together with the frequency. Piezo Products Ltd, Millstream Trading Estate, Christchurch Road, Ringwood, Hants BH24 3SD.
EWW225 on reply card.

Two-port ram speeds interprocessor access

A dual-port static ram simplifies multiprocessor system design by allowing independent read/write access to the devices' common data bank. The 1K by 8 device, AM2130, has separate i/o ports, addresses and controls, as well as busy and interrupt signal for interfacing with most popular processors. For increased flexibility the device also independent chip-enables for each port control. Automatic power-down circuitry allows the respective sides of the device to remain in standby power mode while it is inactive. On board arbitration circuitry and an internal mailbox prevent clashes between simultaneous access to the same memory location and eases port-to-port communication.

The main function of the device is to offer a data communications memory between two asynchronous processors or controllers. This aids efficient instruction and data transfer between c.p.u. and i/o processor in mini and multiprocessor computers. Advanced Micro Devices (UK) Ltd, Goldsworth Road, Woking, Surrey GU21 1JT. EWW224 on reply card.



Serial/parallel printer buffers/converters

Two versions of the Model B Datalinker serial-to-parallel and parallel-to-serial conversion and either 8 or 32K of printer buffer. The 8K version can be upgraded to 32K at a later stage. Other attributes include selectable page repeat and automatic line-feed generation. Recommended prices for the converters are £120 for the 8K and £180 for the 32K models. Interlink Communications Ltd, 6 Buchanan Units, Gorse Lane Industrial Estate, Clacton-on-Sea, Essex CO15 4XA.

EWW208 on reply card.

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It's also very fast. In fact, one of our customers has compared the speed of the BBC micro with Hewlett-Packards powerful HP64000 development system. He assembled identical software on both machines and was surprised to find the BBC micro running with our 6801XR cross-assembler to be the fastest of the two.

Our software is available for assembling machine code programs for the BBC micro itself (for which our 65C02XR rom is ideally suited) or for any of the other target processors listed below. It is compatible with the models B, B+ and Master 128 and with all DFS, ADFS and Econet filing systems. (Owners of early model B's should ensure that their computer is equipped with Basic 2).

Order Code	Target Processors	Price
6801XR	6800,6801,6802,6301...6301X	£48.00
6805XR	6805,146805,6305	£48.00
6809XR	6809 family	£48.00
8085XR	8085,8080A	£48.00
Z80XR	Z80, HD64180	£48.00
68000XR	68000,68008	£56.00
65C02XR	65C02, 65SC02, 6502	£38.00

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Our replacement video heads fit most models of VHS or Betamax VCR's. Following our replacement guide and with a practical ability, you can do the whole job in your own home with our head replacement kit.

VIDEO HEADS AT LOW LOW PRICES!

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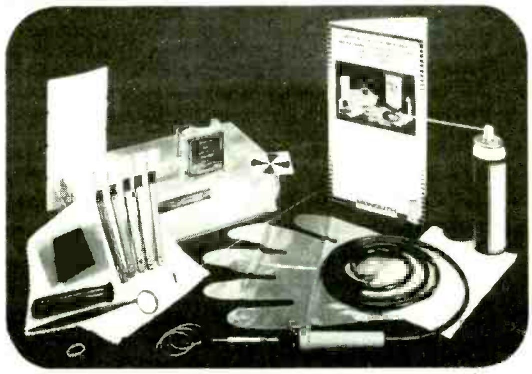

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CIRCLE 19 FOR FURTHER DETAILS

ELECTRONICS & Wireless World

Editorial Feature List

OCTOBER

Oscilloscopes

From high performance to low-cost, the October issue takes a comprehensive look at the array of oscilloscopes available on the UK market.

NOVEMBER

Mobile Radios

With the launch of 900 MHz cellular radio last year and the release of Band III frequencies, mobile radio in the UK is enjoying a period of unprecedented expansion. November's special feature focuses on the systems and the equipment currently available.

For further advertising details please ring Ashley Wallis on: 661 3130

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

Sample stock: Ferranti PC860 IBM-compatible with twin floppy disks and 20MB hard disk, Perfect Filer, Writer & Calc, on-site warranty (used 4 months) – £1,200; Torch ZEP 100 Z80 add-on for BBC Micro with Perfect Software – £150; Data General 10+10MB disk drive subsystems with 3 spare disks, refurbished & tested – £800 + carr.

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Portable data aquisition and control

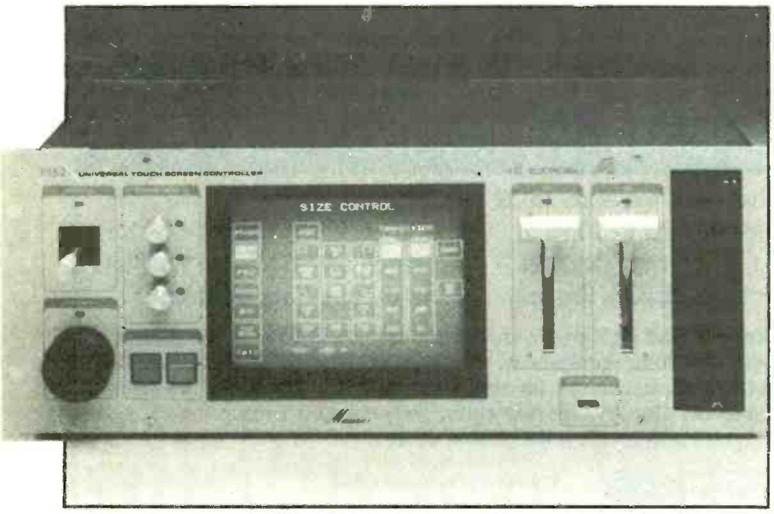
Up to 100 remote measurement channels can be monitored and controlled through the Solartron Impact system. This is designed to work with the same companies' IMP family of isolated measurement pods; rugged remote scanners that can be sited close to the sensors in the plant or test rig. Impact interfaces through a two-wire network link with up to five of the IMP units, each of which has up to 20 measurement channels. The controller comes in a portable case and includes a keyboard, 8-line display, graphic printer and a serial interface for RS232/422 or a 20mA loop. It can be fitted with a mini-disc drive or battery-backed c-mos ram for mass storage. GPIB interfacing is available as an option. The unit is mains or battery powered with an automatic switch-over for protection in case of failure of the supply.

Scanning is performed under the control of an internal clock, setting date, day, hours and seconds as well as the intervals between scans. External triggering is also possible. Results may be stored in several forms: a complete record, alarm conditions or none at all. All remote inputs can be converted into any required units. Alarm limits can be set, including a rate-of-change limit. Solartron Instruments, Victoria Road, Farnborough, Hants GU14 7PW. 217 on reply card.

Video controller with touch screen

Maurice is a touch-screen software based controller that can interface with a wide variety of studio equipment to provide real-time, on-line control of digital effects on one, two or more channels, as well as signal processing and route switching. Digital effects, mostly from v.t.rs, can be added during the post-production cycle and include smooth zooms, slides, flips, folds as well as compressions, montages, coloured borders and key signals.

Menu-driven software allows moves to be planned, with start and stop points, rehearsed and then stored. Nine such moves can be stored at any one time. Many commands are easily accessed through the central flat screen touch sensitive c.r.t. In addition to the joystick, spin wheel, T-bars, and image control knobs, there is a built-in floppy disc drive to download software and store commonly used effects sequences. The controller is at the heart of a modular system of interfaces and frame stores and the system can be expanded for additional channels or extra effects units, picture combiners etc. very easily. CEL Electronics Ltd, Chroma House, Shire Hill, Saffron Walden, Essex. EWW219 on reply card.

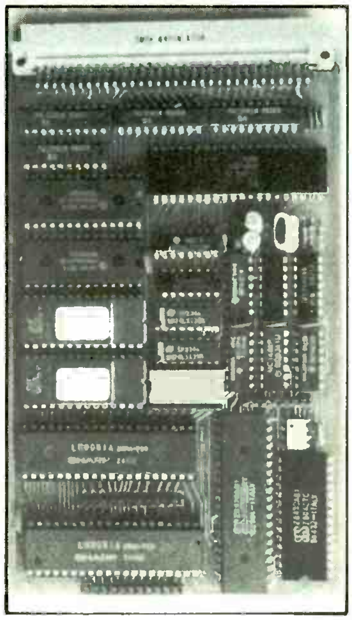


Bus controlled 0.002% multimeter

Keithley's latest 6½-digit six-function multimeter is capable of reading rates up to 1000 readings per second in its 3½-digit mode. For 4½ digits this reduces to 200, and for 5½ digits it makes 20 readings per second. Direct voltage, two and four-wire resistance, decibel measurements, thermocouple and resistance thermometry, and l.f. alternating voltage from 0.1 to 10Hz are the basic functions of model 193. True r.m.s. readings are available (crest factor 3, bandwidth 500kHz) with optional accessories, as are direct current, high voltage and high current ranges. Best 24h accuracy is ±0.007% ±2 counts over a 12 month period. The 6½-digit mode allows a resolution of 100nV on the 200mV range.

The unit contains Keithley's Translator Software which allows the definition of more meaningful terms, for example, 'DC Volts' (*sic*) may be used in place of the typical GPIB alpha numeric command. Long control strings are replaced with short mnemonics, increasing efficiency through bus traffic reduction. And the emulation facility means that a 193 can be substituted into an existing ATE System, with minimal software exchanges.

Other features of the 193 include a 500 point non-volatile memory, data retention during a power loss, and digital calibration from either the front panel or over the bus. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berkshire.
EWW220 on reply card.



CP/M control card

Centred around a Z80 processor is a single-board controller which can also function as the heart of a larger unit. The card contains two peripheral i/o chips; dart, c.t.c. and an array of memory up to 48K with 16K of c-mos ram made non-volatile by the addition of optional Smart sockets. Other features include a watchdog timer and multi-tasking facilities.

The software provided with the card is Mirror, a communications package that reflects the functions of CP/M. Once connected via RS232C to a host computer, the operator has the illusion of CP/M running on the Cardmaster board. Named programs load and run automatically, as they do on the host computer, correctly locating themselves in the new system. GNC Electronics, Little Lodge, Hopton Road, Thelnetham, Diss, Norfolk IP22 1JN. EWW211 on reply card.

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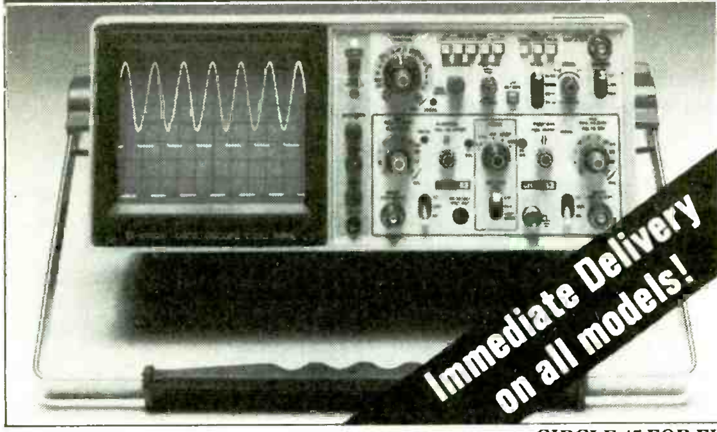
the most competitive prices

from £299 +VAT



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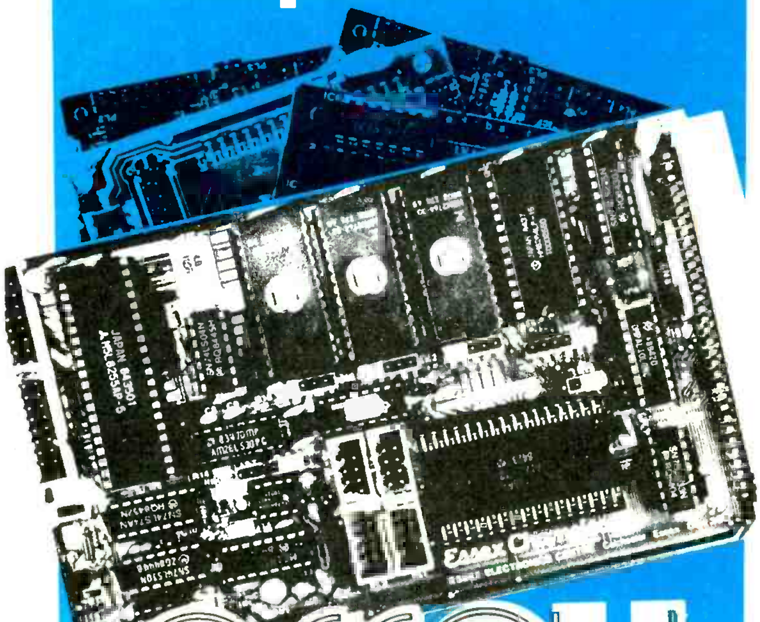

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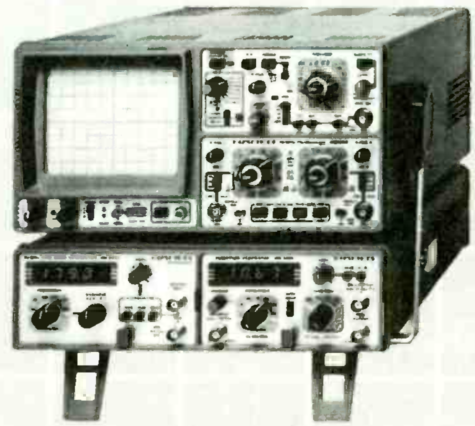

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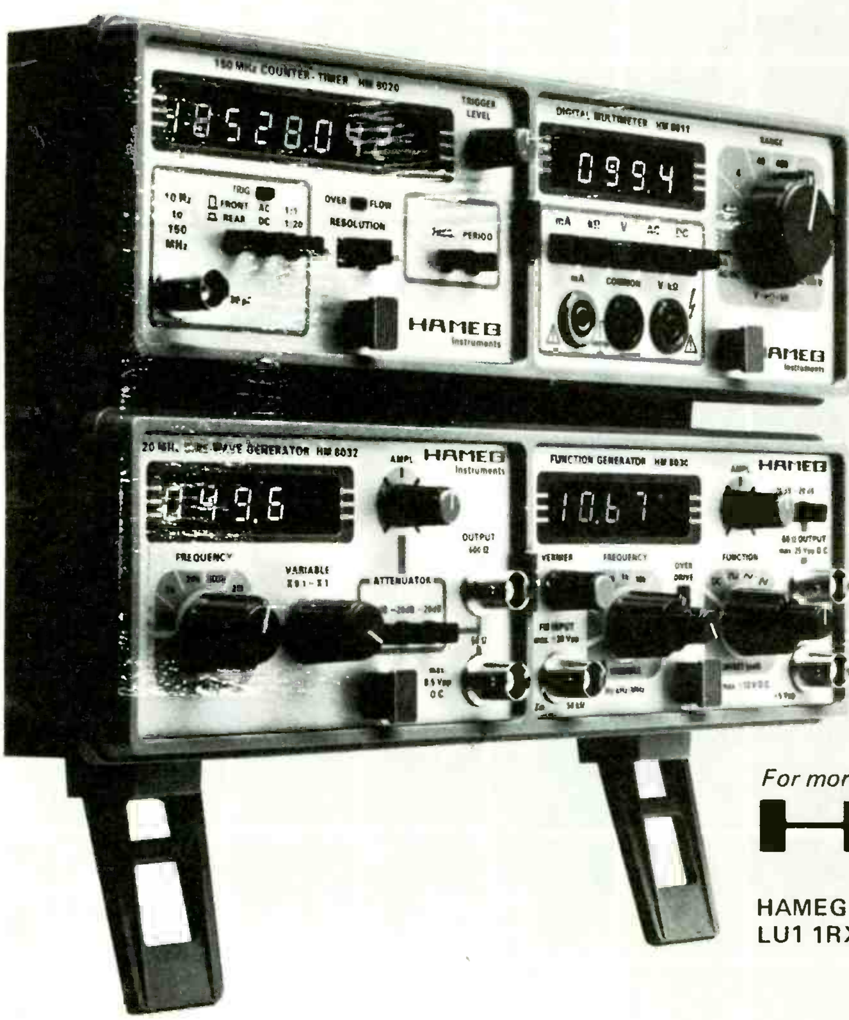

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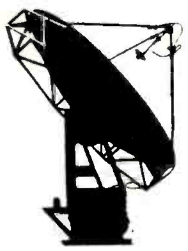

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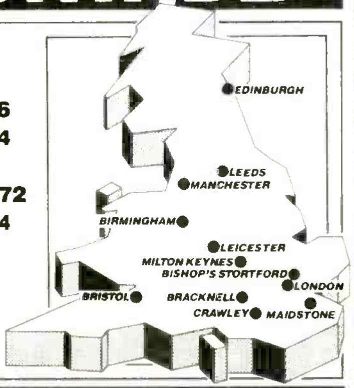

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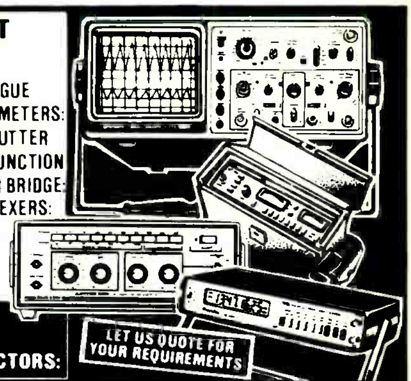

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