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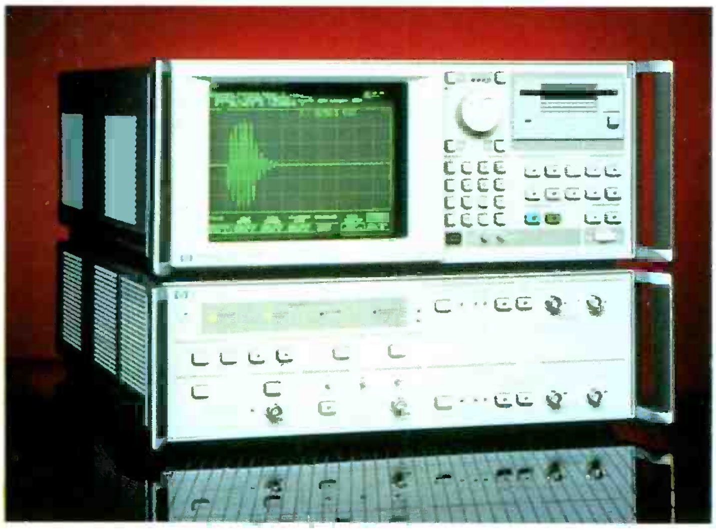

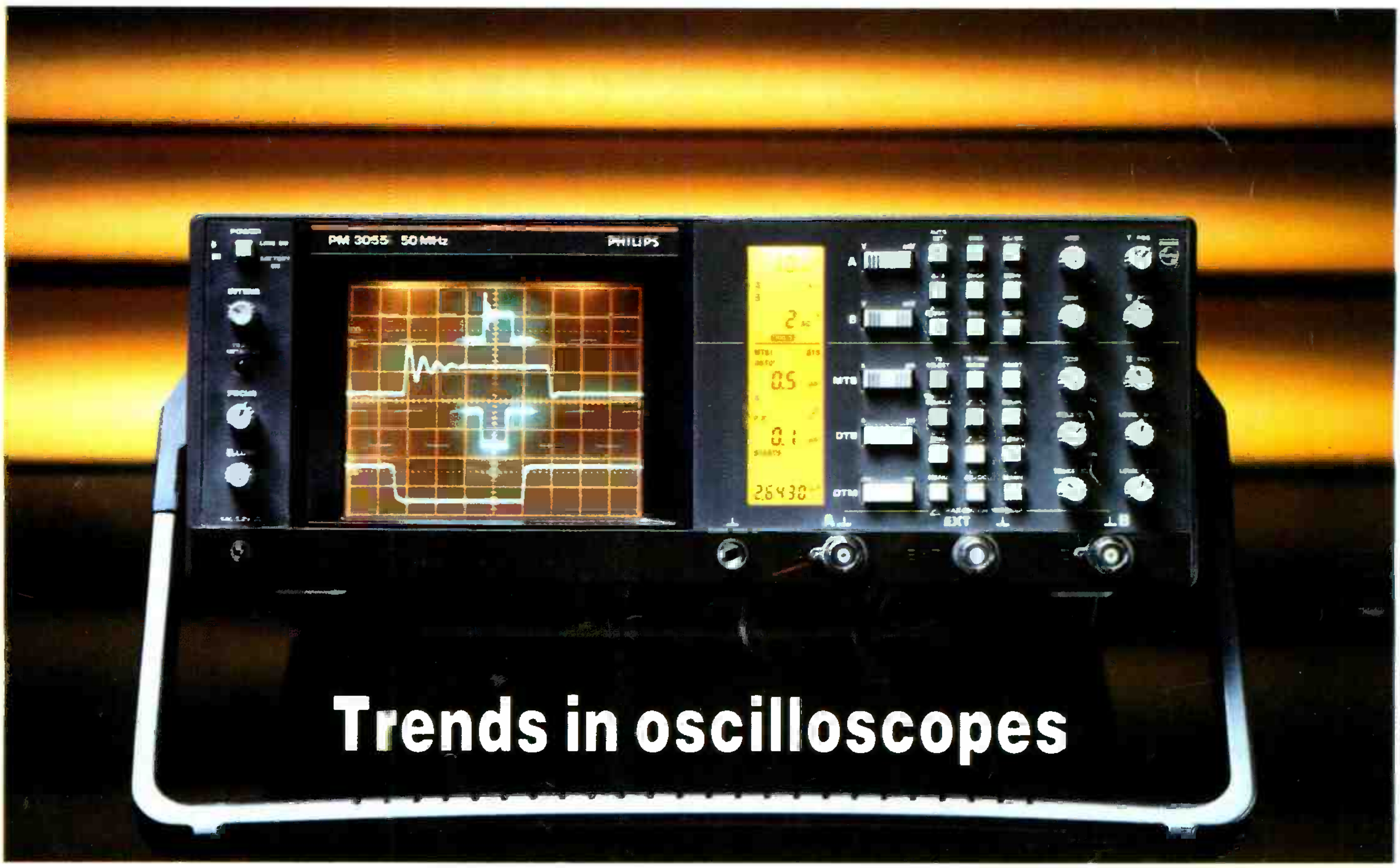

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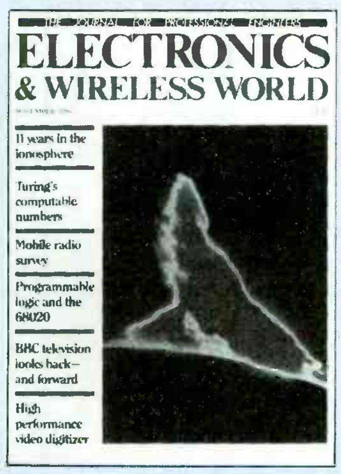

New logo and spine are just part of a new direction for this journal – see page 6

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Electronics & Wireless World is published monthly USPS 687-540

Current issue price £1.25, back issues (if available) £1.06 at Retail and Trade Counter, Units 1&2, Bankside Industrial Centre, Hopton Street, London SE1 Telephone: 01-928 3567.
By post, current issue £1.30, back issues (if available) £1.40. Order and payments to 301 *Electronics and Wireless World*, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Cheques should be payable to Business Press International Ltd.
Editorial & Advertising offices: *EWW* Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Telephones: Editorial 01-661 3614. Advertising 01-661 3130 01-661 8469
Telex: 892084 BISPRS G (EEP)
Facsimile: 01-661 2071 (Groups II & III)
Beeline: 01-661 8978 or 01-661 8986. 300 baud, 7 data bits, even parity, one stop-bit. Send ctrl-Q, then EWW to start; NNNN to sign off.
Subscription rates: 1 year £18 UK and £23 outside UK.
Student rates: 1 year £11.40 UK and £14.10 outside UK.
Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3248.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 04444 59188. Please notify a change of address.
USA: $49.40 surface mail, £102.60 airmail. Business Press International (USA). Subscriptions Office, 205 E. 42nd Street, NY 10117.
Overseas advertising agents:
France and Belgium: Pierre Mussard, 18-20 Place de la Madeleine, Paris 75008.
United States of America: Jay Feinman, Business Press International Ltd, 205 East 42nd Street, New York, NY 10017. Telephone (212) 867-2080 Telex 23827.
USA mailing agents: Expediters of the Printed World Ltd, 515 Madison Avenue, Suite 917, New York, NY 10022, 2nd class postage paid at New York, Postmaster – send address to the above.

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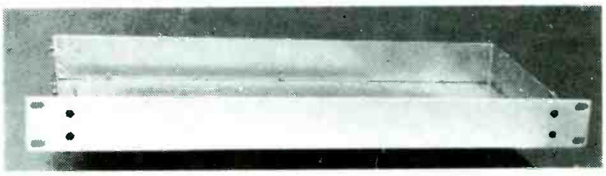

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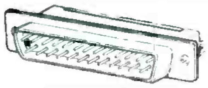

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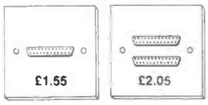

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NEWS COMMENTARY

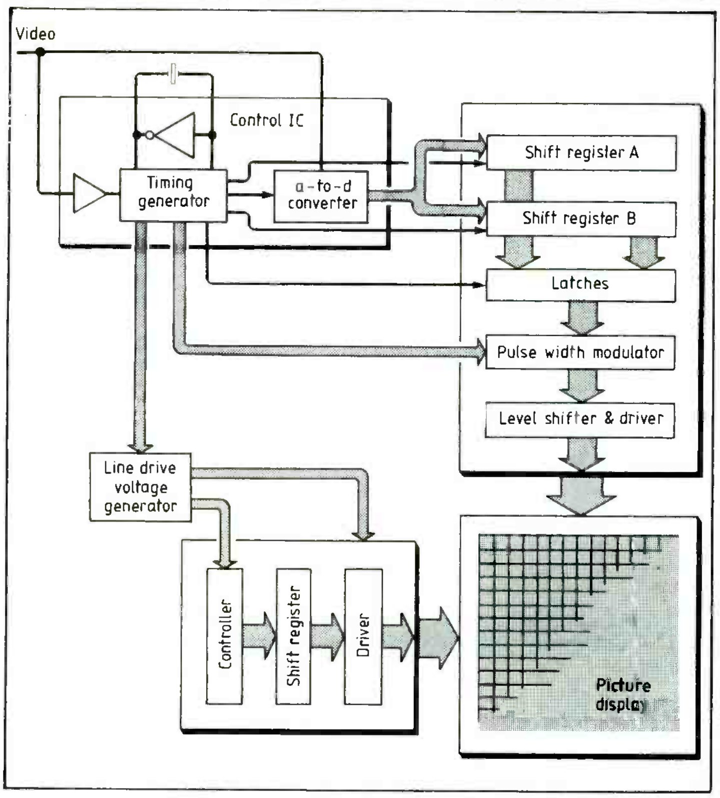
Amateur g.s.o. satellites?

A future project for amateur communications satellites should include the long-term objective of having a chain of geosynchronous satellites in orbit according to Amsat-UK. It may be possible to to use spare capacity on government or commercial satellites or fly amateur-built transponders on such satellites. A 30GHz-up and 20GHz-down link has been offered by NASA to qualified groups of experimenters on the proposed Advanced Communications Technology Satellite (ACTS) to be launched in 1988. But such links are not normally within the amateurs' province and would require gateways. Amsat's technical group points out in a recent discussion paper that microwave experience gained by these experiments would be of great value when it came to building their own geostationary satellite.

NASA are still considering the proposal that ACTS could carry an amateur-built transponder at more familiar frequencies. Some other satellites are also possible carrier vehicles.

Two more satellites in elliptical orbits are planned, PIII-C and D. The main transponders for these are already planned but the UK group could perhaps add digital or microwave transponders, beacons or imaging systems.

These elliptical orbit precess and make the sub-satellite point at apogee change daily. Another orbit, the Molinya, with an inclination of 64.3° would produce a geosynchronous orbit and the two sub-satellite points at apogee would remain the same, on opposite sides of the globe. Stations near the points would see the satellite at near overhead for several hours, each time the satellite comes round. Such a satellite would provide a means of mobile communications, a mode of operation not possible with other orbits. With this in mind, the Science and Engineering Research Council is funding a study of such a mission. Called T-Sat, the study is being undertaken by seven universities and a number of research establishments and due to be published this October. T-Sat is likely to introduce new engineering technologies and support an L-band mobile communication package. Only the feasibility study has been funded so far and although some of the planning is under way, it is unlikely to be launched before 1991.



Already into computer peripherals with what is claimed as the world's thinnest 3½in floppy disc drive, Citizen Watch (UK) expand into consumer electronics with pocket tv, card radio, calculators and watches. Set for introduction early next year is a 2.7in colour tv with l.c.d. of 109 by 480 elements. Currently available is the grey-scale model 06-TA with transmission type display for outdoor use (backlight optional). In the display drive circuits integrated with the l.c.d. panel, the control i.c. generates timing signals to drive the pulse-width modulated segment driver (right), scanning electrode driver (left), and line driver generator.

MSF to close on h.f.

The MSF time and frequency standards service is to be withdrawn from the 2.5, 5 and 10MHz bands. The withdrawal of the short-wave service is partly due to the popularity of the m.f. service according to the National Physics Laboratory; by comparison the h.f. service is little used. The introduction and availability of standard services in other countries removes the need to provide an international service, they say. The 60kHz MSF standard time and frequency service will continue unchanged.

Transmissions began in 1950 with a one-hour daily broadcast on 60kHz. The s.w. frequencies were added in 1953 and were used extensively for some years by aircraft pilots, amateur radio users and astronomers. In 1966 the m.f. service was extended to 24-hours and later the codes that give full year, month, day, hour and minute were provided. The service proved valuable to a wide range of users who operate close time schedule systems.

New direction

This issue is the last in the present format. From November, the appearance outside and in, the content and size all change. *Wireless World's* approach to its subject, ever since it was first published under that name by Lord Iliffe, in 1913, following its acquisition from Marconi's, has been hybrid in the sense that it has appealed both to professional engineers and to those whose involvement is in their spare time. Lately, the 'spare-time' content has become closer to the 'professional', simply because the advance of technology requires a deeper understanding of the subject from anyone who takes part.

From the next issue, we recognize this and devote our content entirely to professionals. Articles on design techniques, advanced designs to illustrate these techniques, theoretical articles, tutorial pieces, the regular columns expanded and augmented by new ones – all will be familiar, but will be written or selected with the interests of the working engineer in mind. Papers on management and social matters closely connected with technology will appear and we will provide a market survey each month, starting with one on mobile radio.

The new design, with its square spine, many pages in colour and fifty per cent more pages, is clearly more costly to produce and this is reflected in the new cover price of £1.95. To offset this, the existing, UK subscription cost of £18 per year is retained and is now, for the first time, cheaper than buying twelve issues from a newsagent. It therefore makes good sense to take out a subscription and save £5.40.

Further, since it appears from conversations with readers that they occasionally experience difficulty in finding *EWW* in newsagents we are offering a year's UK subscription at £11.70 for a limited period. This is equivalent to 98p per issue and makes subscribing even better sense.

RALFE · ELECTRONICS

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CIRCLE 80 FOR FURTHER DETAILS

Computer Appreciation

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SAMURAI Model S16 computer. With twin 8" NEC floppy disc drives (total 2.5Mb), 8086 processor with 128K, monochrome high resolution monitor & MSDOS. Originally cost over £2,000. BRAND NEW (We have very low cost software packages available for this machine for WP, comms etc. Also, we have details of a do it yourself memory upgrade to 512K). BRAND NEW ... £399.00

ITT SCRIBE III WORD PROCESSING SYSTEM. Dual processor (8MHz Z80H & TI 9995) machine with 128K memory, QUME printer interface, & RS232 comms interface. With dual 5¼" floppy disc drives (double density, double sided, 40 track), high resolution monochrome monitor & low profile **keyboard**. Excellent **professional word processing software** with many advanced features including **extensive** help files and **slow scrolling** is **included** together with BASIC. Manufactured 1984 and originally selling at over £5,000. BRAND NEW ... £295.00

ITT SCRIBE III. As above, but with half height 5¼" **MiniScribe Model 3012 10MB WINCHESTER hard disc** drive and single floppy ... £595.00

NEC SPINWRITER Model 7700 daisy wheel printer. 55 c.p.s. printer suitable for use with **SCRIBE III** word processers BRAND NEW ... £680.00

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ITT SCRIBE III PACKAGE. WORD PROCESSOR AS ABOVE WITH 10MB WINCHESTER HARD DISC DRIVE, FULL 256K MEMORY & NEC MODEL 7700 SPINWRITER 55 c.p.s. PRINTER. ALL BRAND NEW & GUARANTEED ... £1200.00

MATMOS PC. Available without disc drives only. 64Kb Z80A (4MHz) based machine with RGB & composite video outputs & UHF modulator. Serial, parallel, cassette (with motor control relay) & peripheral bus interfaces are provided. MICROSOFT BASIC is in ROM, and a further ROM slot accessible to the operator is provided. Keyboard-sized machine with internal power supply & numeric keypad & function keys. Originally selling at £350. BRAND NEW ... £49.00

PYRAMID Model 501 CP/M MICROCOMPUTER SYSTEM. With 4mHz Z80A processor, 64K memory and twin **TEAC** Model FD-55F double sided, double density, 80 track half height 5¼" disc drives (total formatted capacity 1.5mb). With serial **RS232** and parallel **CENTRONICS** interfaces (a second serial interface is available, but may require an additional 8251 ic). Connections to a hard disc controller (WD1001) are provided. These very compact (2¾" high) machines are **S-100** based (with one spare slot), and are software compatible with **NORTH STAR HORIZON**. CP/M Ver. 2.2 is included together with TELEX software. Originally priced at £2,000. BRAND NEW or EX DEMO (Requires terminal) ... £195.00

HITACHI UNCASED MONITORS. We have approx 200 of these BRAND NEW monitors in stock. Connection details are available for most types, and we have circuit diagrams for most types. Colour monitors are mostly available in either TTL (positive V & H sync) or analogue (sync on green) inputs and a horizontal frequency of 24kHz–25kHz. Dot triad spacing is 0.31mm. Prices are as follows:

* 9" monochrome monitor, 12V	£24.00	* 14" colour monitor, high resolution, 240V	£95.00
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* 14" monochrome monitor, 12V	£29.00	* 24" colour monitor, high resolution, 240V	£395.00

HITACHI Model 305S 3" disc drives. With **SHUGGART** compatible interface as for 5¼" drives. Uncased. 125K (single density) or 250K (double density); 40 track; 100 tpi; soft sector, 3ms track to track time; standard 34 way edge connector; 12V & 5V powered (standard connector) with overall 3.7W typical power consumption. These drives have been tested by us on the **BBC with DFS** and on the **AMSTRAD 6128**, and is also known to be suitable for the **AMSTRAD 664** and a second drive for the **AMSTRAD 464.** The same drive is used in the **TATUNG Einstein.** Single sided, 250kb unformatted. BRAND NEW ... £29.95

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RICOH Model GP15 graph plotter. As above, but with 15" paper width, self test **three pens &** other extra features BRAND NEW ... £195.00

TEKTRONIX Model 851 digital tester. "One knob lets you dial 22 functions ... eleven functions measure timing, two register plus & minus peak voltages, three carry out DMM measurements ... and one reads line voltage at the outlet ... the 851 measures its 4 input thresholds to adjust to the logic levels of the equipment being serviced". 5 digit readout, 35mHz frequency/timing, autoranging etc ... £350.00

Please Note: * VAT & Carriage extra for all items
* Visitors by appointment, please

CIRCLE 63 FOR FURTHER DETAILS

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Uses: Security, Education, Industrial, Promotional, Home.

Built-in software makes it the first really useful personal robot, future extensions include improved speech recognition and vision.

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OTHER BOARDS PLANNED

Z80H mod upgrade any Z80 computer (except Sinclair) to 8mhz ... **25.95**

CIRCLE 48 FOR FURTHER DETAILS

COMMUNICATIONS COMMENTARY

The possibility of sending intelligible "speech" over data links at less than 100 bits per second by providing control signals derived from a digital vocoder to a voice synthesizer is already opening the way to new communications systems. Narrow-band systems with speech requiring no more spectrum space than a conventional radio-teleprinter circuit could clearly have a dramatic effect on overcrowded portions of the radio spectrum. The disadvantage, at least with current experimental systems, is that the speech is seldom an individually-recognizable reconstruction of the original. Further development is also needed to overcome the necessity to speak in a 'disconnected' manner more suitable for talking to computers than humans. Apart from spectrum conversation, on-line encipherment is relatively simple, making the technology attractive for military and other secure communications.

Work by the GTE Corporation in the USA has shown that by using artificial-intelligence waveform-recognition matching techniques combined with words stored in a matching dictionary it becomes possible to transmit "speech" via meteor trails.

By sending data in high-speed bursts during the fleeting existence of the many random short-lived (typically 0.2-seconds) ionized trails it has been possible for some 25 years or so to maintain rtty links over distances of about 800 miles on frequencies of the order of 50MHz on a virtually "continuous" basis, although in fact there may be gaps of up to about 2 minutes between usable trails. High-speed bursts enable the throughput to average that of a conventional rtty link.

The GTE work at Westboro, Mass. is the first reported success in adapting a meteor-scatter "burst" link to speech transmission, though snatches of speech have been reported by amateurs on the longer-lasting trails that occur primarily during the meteor-shower periods.

Now modfets

Just as basic gallium arsenide devices such as the mesfet have opened up improved possibilities for 12GHz d.b.s. reception, so a new class of group III devices, the "modulation-doped GaAs/(Al,Ga)As heterojunction field-effect transistor" or modfet, as a form of high electron mobility transistor (h.e.m.t.), seems set to improve dramatically the outlook for millimetric communications. Experimental devices are being reported that offer ever lower low-noise performance at ever-higher frequencies: for example, at room temperatures, under 1dB noise figure up to about 10GHz, under 2dB up to 20GHz, under 3dB well above 30GHz at 300K, and with cooled devices promising to be comparable to the masers which first opened the way to satellite communications in the 1960s but soon tended to be discarded not only on account of high cost but also narrow bandwidth.

A modfet amplifier can have a noise figure of 0.4dB with 14dB gain at 10GHz at 77K and a noise temperature of 3.5K at 3.3GHz with the device cooled to 15K. It has been claimed that these devices are inherently superior to all other fet technologies in terms of achieving higher speeds of operation, lower power dissipation and lower noise. With the concept of modulation doping, which combines features of both mos and mesfet devices, it becomes possible to realise more fully the potential of gallium arsenide in a fet structure. Current work in Europe and the USA on h.e.m.t. devices looks like providing a further improvement not only in microwave and millimetric amplifiers but also as super-high-speed logic.

Cordless outlaws

The Department of Trade & Industry has warned dealers that it will soon be unlawful to manufacture, import, sell or possess unapproved cordless telephones. The maximum penalty for breaches of the Order to be made under the terms of the Telecommunications Act will be a fine of £2000 and the Court can order forfeiture of the equipment.

DTI point out that "A cordless telephone is a radio apparatus which it is unlawful to install or use unless it is of a design approved for connection to the public telecommunications system and marked as such. However, it has not been unlawful to sell such telephones, and they have caused interference to other radio users."

No new legislation is required for such an Order but it has to be laid before Parliament. DTI state this is being done this summer. It is expected to come into force about the beginning of November. It is believed that DTI are also preparing a similar Order relating to unapproved CB amplitude-modulated transceivers.

Parapsychology

Many eminent scientists and engineers have expressed their firm belief or equally strong disbelief in forms of extra-sensory perception in such manifestations as table-turning, clairvoyance, spiritualism, levitation, telepathy or correctly guessing the next or next-but-one card in the pack: Michael Faraday, Sir William Crookes, Sir Oliver Lodge, to name but a few. Indeed for at least 130 years scholars and scientists have carried out serious research and become convinced that they have demonstrated the existence of a 'psychic force' or a supernatural realm occupied by intelligent and superior beings. Current projects aimed at receiving extra-terrestrial intelligence derive at least some of their support from inheritance of the popular Victorian belief that electricity and magnetism were occult forces.

But it must have surprised some readers to find in the usually staid *Proc IEEE* (June 1986) a very long tutorial review and critical appraisal of parapsychology research since the 1850s in an invited paper by Professor Ray Hyman.

He sits firmly on the fence in neither accepting nor rejecting the basic premises of his subject, but shows how both proponents and critics have deviated greatly from the standards of fair-play and rationality that he believes should characterise the best scientific arguments. However, he supports the view that the British mathematician S.G. Goal, who in 1940 produced seemingly incontrovertible evidence in support of the 'displacement effect' in card-guessing games (made popular for psychic research by J.B. Rhine in 1934), was guilty of faking or at least 'massaging' his data. Hyman's main regret seems to be that each generation's best research efforts tend to be cast aside by subsequent generations of parapsychologists, to be replaced by entirely new 'best cases'. He suggests that not only does the evidence so far for psi lack replicability but, unlike that of other sciences, it is non-cumulative. He believes they need to get their own house in order before their experimental evidence ready to be placed b scientific comm judgement. It argued th phenor of a t tr

PINEAPPLE SOFTWARE

Programs for the BBC models 'B' with disc drive with FREE updating service on all software

DIAGRAM

Still the only drawing program available for the BBC micro which gives you the ability to draw really large diagrams and scroll them smoothly around the screen stopping to edit them at any time if required.

Pineapple's unique method of storing the diagram information on disc means that the size of diagrams is limited only by the free space on disc, and not the amount of computer memory you have available. (A blank 80 track disc will allow up to 39 mode 0 screens of diagram).

The superb print routines supplied with the program enable large areas of the diagram to be printed in a single print run in a number of different sizes and rotated through 90 deg. if required. Full use can also be made of printers which have a wider than normal carriage available.

The program is fully compatible with the Marconi Tracker ball described below.

PLEASE STATE 40 or 80 TRACK DISC & WHETHER STANDARD BBC or MASTER VERSION IS REQUIRED

PRICE £25.00 + VAT

DIAGRAM UTILITIES

A suite of six utility programs which add additional features to the 'Diagram' drawing program. The utilities include the saving and loading of areas of diagram to and from disc. The ability to display the whole of your large diagram on the screen at one time (in either 4★4 or 8★8 screen format). The addition of borders and screen indents to diagrams, and the ability to shift a whole diagram in any direction.

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MARCONI TRACKER BALL

This high quality device comes with it's own Icon Artmaster drawing program and utilities to enable it to be used in place of keyboard keys, joysticks, or with your own programs.

PRICE £60.00 + VAT p&p £1.75

PRICE INCLUDING 'DIAGRAM' SOFTWARE £79.00 + VAT p&p £1.75

TRACKER BALL for MASTER series

The Pointer ROM is supplied instead of the Icon Artmaster disc and enables the Tracker ball to work directly with the MASTER series computers. (e.g. to use with TIMPAINT etc.). Prices are the same as for the standard tracker ball.

POINTER

The Pointer Rom is available separately for people already owning tracker balls, and comes with instructions for use with the MASTER computer.

PRICE £12.50 + VAT

PCB

This new release from Pineapple is a printed circuit board draughting aid which is aimed at producing complex double sided PCB's very rapidly using a standard BBC micro and any FX compatible dot-matrix printer.

The program is supplied on EPROM and will run with any 32k BBC micro (including Master series). Also supplied is a disc containing a sample PCB layout to demonstrate the programs features.

By using an EPROM for the program code the maximum amount of RAM is available for storing component location and ASCII identification files etc. (Up to 500 components and 500 ASCII component descriptions may be stored for a given layout). These is no limit to the number of tracks for a given PCB, although the maximum size of board is restricted to 8" ★ 5.6".

Using a mode 1 screen, tracks on the top side of the board are shown in red, while those on the underside are blue. Each side of the board may be shown individually or superimposed. A component placement screen allows component outlines to be drawn for silk screen purposes and component numbers entered on this screen may be displayed during track routing to aid identification of roundels.

The print routines allow separate printouts of each side of the PCB in a very accurate expanded definition 1:1 scale, enabling direct contact printing to be used on resist covered copper clad board.

This program has too many superb features to describe adequately here, so please write or 'phone for more information and sample prinouts.

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Converter leads to enable the Trackerball to run mouse software and the mouse to run trackerball software (inc. DIAGRAM). Please state which way round when ordering.

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CIRCLE 46 FOR FURTHER DETAILS

RFI and planning

A 1985 joint circular from the Department of the Environment (16/85) and the Welsh Office (42/85) relating to Telecommunications Development included, as Annex A on policy, advice to local authorities on dealing with planning applications to erect masts. Amongst its recommendations were:

> (6) Applications for permission for the masts often used by amateur radio operators, radio-taxi firms and many other private and commercial users, present fewer potential planning problems in terms of size and visual impact over a wide area. Such applicants will generally have less scope for using alternative sites or for sharing sites, and masts will often need to be located on the premises.
> (7) All users of radio equipment are required by the terms of wireless telegraphy legislation to avoid creating undue radio interference with other radio users, including domestic television sets and their equipment must be designed to minimise it. In most situations, therefore, questions of potential interference are of no relevance to the determination of planning applications for the masts or antennas needed to operate a transmitter. Other controls should be assumed to deal with any radio interference problems. But in some cases significant interference can arise lawfully and unavoidably for various technical reasons. The Secretaries of State take the view that where there is firm evidence that significant and irremedial radio interference with other electrical equipment of any kind is a probability, or a certainty, or is already happening, as a consequence of any development that is a material planning consideration, to be weighed with all other considerations in the determination of an application. Planning authorities should not, however, attempt to explore, seek out or anticipate potential problems or radio interference, or be influenced in their approach by the clear evidence that significant radio interference will arise, or will probably arise, and that no practical remedy is available, will there be any justification for taking it into account in reaching a decision. Significant interference would be any which materially impaired the normal use, effectiveness, or enjoyment of electrical apparatus in other premises on a regular or continuing basis.

The Policy statement also makes it clear that except in the most exceptional circumstances, planning authorities should not take into account "health and safety" factors concerning the radiated power output as these are subject to international standards.

It is also pointed out that many of the smallest antenna systems, including citizens' band antenna systems and also others which are very small in scale, are normally covered by the principle of "de minimis" or not considered sufficiently substantial in relation to the size of the building to have any material effect on the external appearance. Most conventional television antennas, their mountings and poles are treated in this way and the local authorities are recommended to continue this approach. There is however evidence that some planning applications from radio amateurs are refused or delayed by fears of radio-frequency interference.

GCHQ

The appearance of a new book "GCHQ – the secret wireless war 1900-86" by Nigel West (pen-name of Rupert Allason), following in the wake of "The Puzzle Palace" and the many revelations of signals intelligence in *The New Stateman* tempts one to misquote Dr Samuel Johnson "it is like a dog's walking on his hind legs. It is not done well; but you are surprised to find it done at all."

It is not many years since the linking by a retired diplomat of Cheltenham when codebreaking was regarded as a front-page news sensation. Later the IBA found it prudent to have an interview outside the gates of GCHQ removed from a programme.

Yet it can be argued that excessive secrecy breeds inefficiency and sometimes conceals corruption. For many years, successive governments refused to acknowledge even the existence in peacetime of the Special (secret) Intelligence Service and the intelligence-gathering activities of GCHQ with its many radio intercept facilities – though the communications and computer industries had little doubt as to the purposes for which so much equipment was acquired. When *The Times* printed a story about the planned erection of a large satellite terminal near Bude, Cornwall the official Foreign & Commonwealth Office line was that this was required for its diplomatic wireless service, a cover it has often used for the GCHQ staff manning listening posts in overseas embassies.

In his book Nigel West outlines the story first of Room 40, then of the Government Code & Cipher School (later GCHQ) and its move to its wartime home in and around Bletchley, known as "BP" or more formally as Station X.

Since GC&CS was not funded by the Secret Vote (although it answered to but was not directed by "C", the head of SIS) Nigel West has been able to unearth details of its between-the-wars "establishment" salaries etc. from the Public Records Office. He has apparently relied largely on the multitude of books on the Enigma/Ultra/Pearl operations that have appeared since the original Polish and French books such as Gustave Bertrand's "Enigma" appeared in the early 1970s. Bertrand played a major role in sigint throughout the 1930s and 1940s, yet his book has never been translated or published in the UK despite this country's debt to his work in collaboration with the Poles. Nigel West has attempted, with only partial success, to flesh this out with an account of the special intercept service (Radio Security Service set up as part of MI5, but later under SIS control as MI8c) with its "voluntary interceptors", largely recruited from pre-war radio amateurs by Lord Sundhurst, drawing on the research of Paul Wright, G3SEM who inspired a BBC East tv programme The Secret Listeners and the surviving papers held by the present Lord Sandhurst.

As in his previous books on MI5 and MI6, Nigel West presents a mass of detail that reads most convincingly – except for those parts of the story of which the reader may have personal knowledge or can recognise the source. It is then that large numbers of minor and some major errors are apparent. Perhaps this book was written in a hurry, was poorly proof-read, depends too much on fallible memories, or on the need not to upset the D-Notice Committee. It could also be argued that the author is unduly prejudiced in favour of the Security Service, RSS and GCHQ, while against the wartime SIS (MI6) which is presented as a grossly inefficient organization; its disasters emphasised, its successes (and there were some) largely ignored. But the book may well succeed in enlightening the general public on the importance of signals intelligence and the emergence of its supremacy in wartime intelligence-gathering, even though "humint" or the old-fashioned human spy remains important, as recent events have underlined.

In brief

Although the DTI raised fees for most of the licences issued under the Wireless Telegraphy Acts during July, the charges for amateur radio and CB licences remain unchanged.

The FCC has issued a Notice of Proposed Rule Making that will give American Novice licensees more operating privileges including the use of s.s.b. phone at up to 200 watts power between 28,300 and 28,500kHz, plus access to the 220MHz and 1.25GHz bands. This follows requests by the ARRL who have become concerned that there are now 10,000 less novice licences than three years ago, with about as many dropping out of the hobby as upgrading to the higher grades of licence. Novices are currently restricted to morse operation on segments of some h.f. bands, after taking a 5 words per minute morse test and simple technical examination.

It seems likely that the next edition of the Highway Code will contain a specific recommendation that drivers should not use handheld microphones while in motion.

PAT HAWKER

FEEDBACK

HEAT TRANSFER

I was very interested to read the article on heat transfer in the August 1986 issue. Whilst Dr Smith covered the subject from the viewpoint of transistor failure, my interest in the subject lies in reducing temperature-generated distortion (t.g.d.) in audio amplifiers. Temperature-generated distortion occurs when the gain or base-emitter voltage of a transistor varies as a result of instantaneous changes in its junction temperature. When a transistor is handling a large audio signal, its instantaneous heat dissipation is equal to the instantaneous product of current times voltage. The variation in power dissipation causes the junction temperature of the transistor to rise and fall in relation to its ability to dissipate the heat generated.

I was surprised to note from Dr Smith's article that a TO220 transistor has a much lower thermal resistance from junction to case than a TO202. This is an area that I had been intending to research and a check through a manufacturer's catalogue yielded the information that the thermal resistance of different transistors reduced as the power rating increased. One exception was a transistor which had a much higher F_t and this had a thermal resistance about 10 times those of similar power rating. As a practical test, I replaced a pair of TO126 transistors rated at 12.5 watts with a pair of TO220 rated over 50 watts in part of an audio amplifier circuit in which the power consumption was 60 milliwatts per device. The difference in sound quality due to lower temperature generated distortion was easily audible.

Graham Nalty
Borrowash
Derby

FREQUENCY ALLOCATIONS

Following Mr H.D. Ford's letter (August, 1986) I felt it would be worth explaining the current situation regarding frequency changes to the long-wave broadcast band.

At the World Administrative Radio Conference (WARC) held in Geneva in 1979 it was decided to bring all long-wave broadcast frequencies on to multiples of 9 kHz. In effect this means decreasing all long-wave broadcast frequencies by 2 kHz. The reason for making this change is to help to reduce the effect of interference that can result from the harmonics or intermodulation of two or more broadcast signals. Any product formed in the receiver by these processes will, if all the carriers are located at multiples of 9 kHz, fall on a carrier frequency. This causes considerably less objectionable interference than if the product were to fall at say 2 kHz from the carrier as it could with the present situation. Locating carriers at 9 kHz multiples also simplifies the design of receivers that use synthesized local oscillators to cover both the long and medium-wave bands.

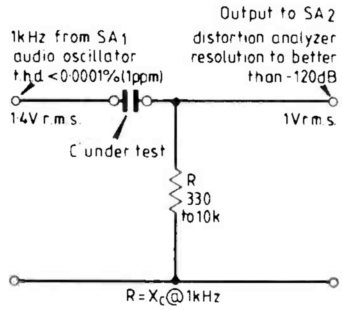
All long-wave transmitters in Europe and Africa (Region 1) operating between 200 kHz and 236 kHz are due to change frequency on 1 February 1988. The BBC's Radio 4 long-wave network will change from 200 to 198 kHz on that date.

Obviously, this change is going to cause difficulty for some people who use 200 kHz as a frequency standard. This point was considered at the WARC, but since the long-wave signals involved are actually broadcast transmissions, and not specifically intended for time or frequency standards, it was felt that the needs of broadcasting must take precedence. It would, of course, have been impossible in any case for the UK to keep using 200 kHz when the rest of the world changed to 9 kHz multiples.

Henry Price
Engineering Information Department
BBC
London

ELECTROLYTIC CAPACITORS

I would like to join in the great capacitor sound debate as after a great deal of practical work I generally have to agree with most of Mr Self's opinions. From purely static harmonic distortion tests, using an SA1 and SA2 oscillator and distortion meter, I have found that all modern types of polyester, box or humbug type (C280), polypropylene, polycarbonate and Mylar capacitors when connected to the circuit of Fig. 1 do not exhibit any measurable distortion down to my limits of 0.0001% (1ppm). However when using some, but not all, types of ceramic discs



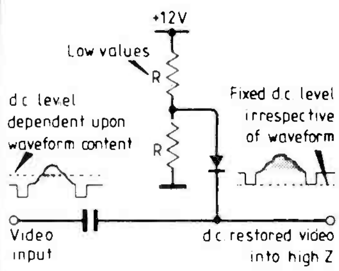
they can have up to 100ppm distortion irrespective of value, types unknown. Also all the miniature ceramic multilayer types and many surface mount types also have between 10 and 100ppm distortion. The distortion is always third-harmonic, indicating a symmetrical distortion of both halves of the sinewave.

It is also interesting to note that virtually all the humbug style capacitors I could find of over 10 years old also have this mysterious up to 100ppm third harmonic. The maximum distortion occurring when $X_c = R$. A very surprising result perhaps is that electrolytics do not exhibit any distortion without bias or with positive bias but show increasing signs of second harmonic with at least 2V d.c. reverse. This was only tried on a small sample of 0.47μ. One point on which I would like to disagree with Mr Self is that of old plugs and sockets having distortion. This is also true; those with oxidized, tarnished contacts exhibit third-harmonic distortion from zero to around 50ppm, dependent upon movement and contact efficiency, the effect improving as the contacts are moved repeatedly, presumably due to cleaning. From a practical point of view, it seems reasonable that any contact will have some resistance and a poor dirty contact will have a resistance which can be partly voltage dependent. This would be symmetrical, therefore giving rise to third harmonic distortion. Also very tarnished i.cs fitted into i.c. holders exhibit distortion, as does an oxidized p.c.b. inserted into an edge connector.

One explanation of the 'old' polyester capacitors having relatively high distortion is that over the years moisture has entered via the leadouts, oxidizing the metal foil and contacts. Scraping and tinning the leads has no effect.

On the subject of d.c. component, I must again agree with Mr Self in that any signal shape coming from a source such as a cartridge, microphone, tape, tuner, etc. cannot have a d.c. component even though the positive and negative peak values are widely different, the average will still be zero. If signals did somehow receive a net d.c. offset dependent upon wave shape, then clearly there would be an overall increase in the low-frequency spectrum giving a very muddled sound.

However, has no one in the audio field ever heard of d.c. restoration? This is the technique used by video engineers to restore the d.c. level lost from a picture in the path from transmitter through a tuner and i.f. to the output stage. Most low cost black and white tvs have simple a.c. coupling throughout, thereby losing any d.c. present at the source. This explains why the contrast level on a black and white tv often varies with picture content. This is totally unacceptable for a colour tv and so d.c. restoration is used. This consists in its simplest form of a black-level clamp potential formed by R_1, R_2 and a



diode D_1 (Fig. 2). The capacitor stores the most negative peak; the whole signal then stands upon this, thereby finding an artificial d.c. level. It is, in fact, peak rectifying without further smoothing. The capacitor is forced to change its change on the negative cycle due to the low impedance diode but meets a high impedance on the positive cycle.

This circuit when fed with a steady state sinewave does not, as would be expected, clip the negative side, but simply changes its d.c. level. The steady-state distortion is then very low as measured after a short period of time. The first few cycles are severely clipped until d.c. restoration is complete. Clearly then, if an amplifier has a non-linear input inpedance, such as a simple common-emitter stage, d.c. shift will occur, dependent upon the music waveform giving rise to an increased l.f. signal spectrum. It is therefore important to design preamplifiers with a constant open loop input impedance, which is fortunately easy with modern ics.

The problem comes with power amplifiers. It is widely accepted that the power-amplifier stages often clip on transients: these can be positive or negative and therefore, if a.c. coupled, will rise to d.c. changes with a corresponding recovery time. In the the seventies it was fashionable to drive an amplifier into clipping with a sinewave for several cycles then remove the drive and measure the recovery time. This, being symmetrical, does not normally give significant d.c. offsets unless the amplifier really is sick, but the same technique should be used with a signal with a larger peak on one half cycle than the other. At the point of clipping since the feedback loop is broken the input impedance drops, giving the effect of d.c. restoration. Amplifiers with low feedback will therefore sound better giving less d.c. and low-frequency spectra when asymmetrical clipping occurs.

The complete answer is obviously not to a.c.-couple the input or feedback networks to the power amplifier and then any amount of asymmetrical clipping can occur without generating any extra l.f. components.

Preamps do not normally clip and therefore can be a.c.-coupled safely, provided their input impedance remains constant over the whole operating range and also that the feedback factor is also constant.

L.Sage
Sage Audio
Bingley
West Yorkshire

SHOOT THAT POSTULATE

A scientific hypothesis or postulate is a peculiar beastie. It seems to be born of a synthesis of experimental data combined with an extremely variable amount of intuitive leaps in the dark; the mix will probably always defy attempts at a precise definition. Once introduced, however, we are on safer ground with it as we can verify its "truth" by the severe test of comparison with experiment, and although no amount of corroboratory evidence will ever prove it true, it requires only one properly established, repeatable bit of evidence to disprove it. *There is no other scientific basis upon which we can say it is wrong.* Nor can any flat statement be accepted for a single moment, no matter what the 'authority' of its author, without the factual evidence to support it, either for or against.

For more years than I care to admit, and no doubt in common with many others, I have sought such evidence to disprove Einstein's "second postulate", but I must confess failure. I have seen much that corroborates it, but not one single, positive fact to contradict it. I am glad to see that this evidence has now become available, otherwise some of your correspondents (vide, for example, Mr Winterflood, Feedback, August, 1986) could not possibly make the totally unequivocal statements that they have done. It is unfortunate that none of them has actually bothered to quote the experimental evidence or any published reference to it, probably because they think that it is better-known than it in fact is. May I ask that they remedy the omission and give us chapter and verse?

Alan Watson
Pollenca
Mallorca

SYNCHRODYNES

I was delighted to read the series of articles by J.L. Linsley Hood on the synchrodyne a.m. receiver earlier this year. They were long overdue.

I have followed with interest the progress of the synchrodyne from the date of its first announcement by D.G. Tucker shortly after World War II. It was (predictably) instantly rejected by the commercial radio manufacturers, wedded as they were to the mass-produced superhet, but later rescued from oblivion (again rather typically) by the amateur radio community under the pseudonym of "direct-conversion receiver".

The amateurs, with no commercial axe to grind, came to recognise its special virtues as an efficient receiver of shortwave a.m. signals, needing no expensive or sophisticated components and easily constructed with the minimum of test equipment.

My only reservation about the Linsley Hood circuitry is that it is rather complex and, in view of the rarity of practical references to the synchrodyne system in the pages of *WW*, may cause some readers to conclude that *all* synchrodyne receivers are *necessarily* complex.

The word rarity is not misplaced. If we ignore block schematics referred to in passing, readers of *WW* whose loyalty is exclusive have had to wait (I think) since August 1948 to see a diagram of a practical synchrodyne circuit.

As the astute Cathode Ray was quick to point out, the two broadcast bands (for which the recent circuitry was designed) are used almost universally for reception of a few powerful stations and the needs of knob-twiddlers are hardly worth catering for. So half a dozen pre-set capacitors and as many switches can, in practice, make all muting circuitry redundant.

The same goes for circuitry designed to extend the receiver's pull-in range, a great help when hand-tuning. Given a switched-station design with an oscillator employing silicon semiconductors and fed from a voltage regulator device, the frequency drift in a domestic environment will be only a small fraction of the normal pull-in range. In practice, whistles caused by drift just don't occur.

Along such lines a fairly simple synchrodyne is possible, perfectly adequate to demonstrate the system's special advantages of low distortion and ease of construction, and above all its unique feature of post-detection selectivity control.

Such a design in the pages of *WW* could well represent an attractive introduction to synchrodyne construction and perhaps act as a stepping-stone to the more ambitious continuous-tuned receivers as exemplified in Mr Linsley Hood's contribution.

D.B. Pitt
Nottingham

ENGINEERING COUNCIL EXAMINATION

During the academic year 1985/6 I gave a course of lectures to two classes for Courses 241 (Fields and Circuits) of the Engineering Council Part 2 Examination. The full course (all 6 papers) is very troublesome for most students and I would like to make some comments based on my experience.

The purpose of the Part 2 Examination is to provide a means for technicians and technician engineers to obtain the academic qualification for professional engineering status. Before a student can take Part 2 he must have passed Part 1 or its equivalent. But this does *not* mean that a topping-up operation is adequate. From the format of the questions on the papers I would say that the real purpose of the examination is to test the roundedness and completeness of a technician's information. He could make heroic efforts collecting and studying course information but still be unable to pass an actual paper. For example text books, which are the normal source of information, do not usually provide answers to specific examination questions. A student intending to pass Part 2 must search around the various topics and acquire a proper understanding of the principles. His answers will reflect his understanding and overall command of the subject. This is very different from the techniques required to pass Part 1. Essentially the Part 2 probes for an understanding of fundamental principles and to assess a student's ability to manipulate those ideas. I am not criticizing the examination, but trying to point out the requirements that a student must satisfy for a successful result.

I would consider my only serious problem to be that classes must sit an examination which is set and corrected by another person(s). I could spend considerable time on a number of topics that might not appear on the paper. This happened with one of the classes because only a limited amount of time was available and the full course could not be covered. The papers can surprise lecturers as well as students. I have no criticism of the syllabus, which compares very well with a degree course at a university or technical college.

I never sat the examination and consequently cannot comment from a student's viewpoint. However, I noticed that most students rarely tired of having examination questions explained and answers thrashed out. I used approximately two-thirds of the lecture time doing questions, but I cannot say that this approach improves a student's chances of getting through over any other method.

The full examination consists of six papers. For a student to pass all six papers at the same sitting is a considerable achievement. Under the present rules he must take three or more at the first sitting and I would favour taking three or four. Failure in any paper brings disappointment and frustration but I would always recommend a second attempt to a serious student.

These are purely personal comments. I would welcome the views of lecturers and students.

Brian P. McArdle
Dundalk
Co Louth
Eire

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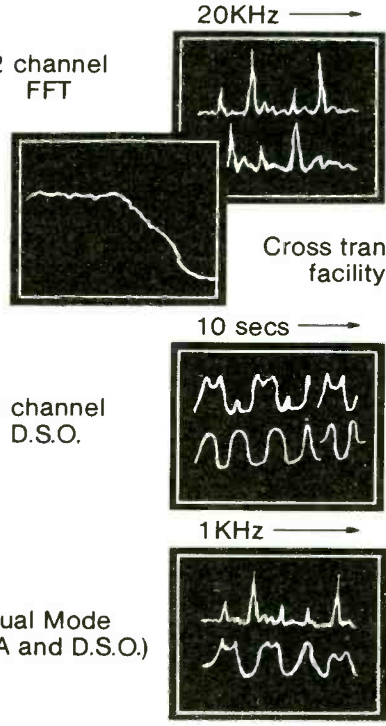

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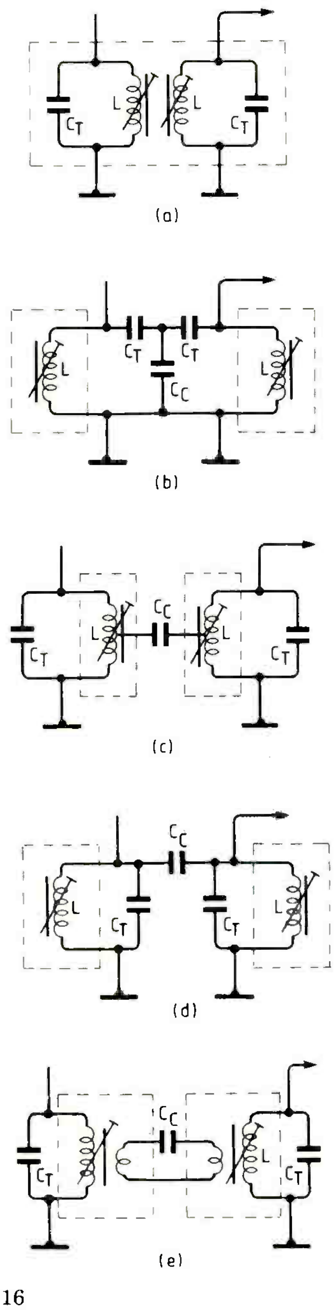
CIRCLE 78 FOR FURTHER DETAILS

by J.L. Linsley Hood
M.I.E.E.
Robins Electronics

Putting the quality back into a.m. radio

This unusual design attempts to match the much sought after sound quality of the post-war five-valve radio designs.

Fig.1. I.f. transformer at (a) used in valve receivers. Alternatives shown (b) to (e) also provide band-pass response.



It is perhaps a rather off-hand commercial attitude to a.m. radio, rather than simple nostalgia or an affection for things using valves that has resulted in the relatively high prices paid for late pre-war or immediately post-war 'table' radio sets.

The reason for this is that these sets were built at a time when a.m. radio reception was the only kind there was, and considerable efforts were made by their manufacturers to achieve the highest practicable quality in the final output signal, and this is normally vastly better than that given by their contemporary equivalents.

There is, therefore, a temptation to the circuit designer to look at the possibilities in this field, and to see how to use some of the good electronic components now available, to put together a contemporary receiver design which would be at least as good as its valve-operated forerunners, without being excessively elaborate or expensive in its construction.

The circuit construction employed for these classic radio sets was invariably of the superhet form. This technique, as it was then employed, allowed the necessary selectivity to be obtained without undue curtailment of the wanted a.f. sidebands by the use of at least two pairs of bandpass-coupled tuned circuits.

These were typically of the form shown in Fig.1(a) where the required inter-circuit coupling is obtained by positioning the coils side by side within the common screening can, so that there is the required degree of mutual inductance.

In the average modern transistor radio, the a.m. i.f. transformers are most commonly of the single-tuned circuit type, which does not give a very good compromise between selectivity and bandwidth, and this appears to be true regardless of whether these circuits are built from discrete transistors, or, more typically nowadays, with some single i.c. that combines the function of local oscillator, frequency changer, i.f. amplifier and demodulator on a single chip.

The fields in which improvement should therefore be sought are in the band-pass characteristics of the i.f. stages to give an optimum compromise between selectivity and bandwidth, in sensitivity, in the distortion introduced by the demodulator stage and in the quality of the subsequent audio amplification.

I.f. transformer design

Starting with the first of these, an immediate problem is that the majority of the small commercial i.f. transformers, designed for use with transistor radios, are of single-coil construction. Those of the type shown in Fig.1(a), though available, are not often used, and are therefore expensive and not very easy to come by. Fortunately, there are a number of alternative methods of achieving a band-pass characteristic, of which I have shown the more practicable structures in Figs 1(b) – 1(e).

Most of the common i.f. coils have taps on their windings, or small secondary coils, to match the desired high dynamic impedance of the tuned circuit to the input impedance of the junction transistor, which would allow the use of the forms shown in Fig.1(c) or (e), and because the size of the coupling capacitor (C_c) required for this layout (in the range 100-1000pF) is a lot larger than the likely stray capacitances, and the signal voltages are relatively low, these forms would lend themselves well to circuits in which the coupling capacitor value was altered, by switching, to give a choice of selectivities.

The layout of Fig.1(b) would be particularly well suited to a switched-selectivity i.f. amplifier, since the value of C_c for critical coupling could be of the order of a hundred times greater than that of the tuning capacitors (C_t), (C_c=0.1μF if C_t is 1000pF), and the r.f. voltage developed across C_c would be proportionately low, since one end would be returned to the chassis line.

For a fixed-selectivity i.f. amplifer, the layout shown in Fig.1(d) is probably the simplest answer, since it works equally well with a wide range of coils, whether or not these have tapped primaries or secondary windings.

The variety of amplitude response curves which are given by coupled tuned transformers of this type is shown in Fig.2, in which Fig. 2(a) shows the transmission/frequency characteristics of an under-coupled pair of tuned circuits (similar to that which would be given by two such tuned circuits in cascade), and 2(e) shows the effect of over-coupling two such tuned circuits. In practice, the coupling factor, k, would be chosen to give a response curve close to that shown in (c) called 'critical coupling', though some excursions on either side of this value could allow bandwidth alteration without too great a degree of departure from the desired flat-topped curve.

A comprehensive analysis of the design of band-pass coupled i.f. transformers is given

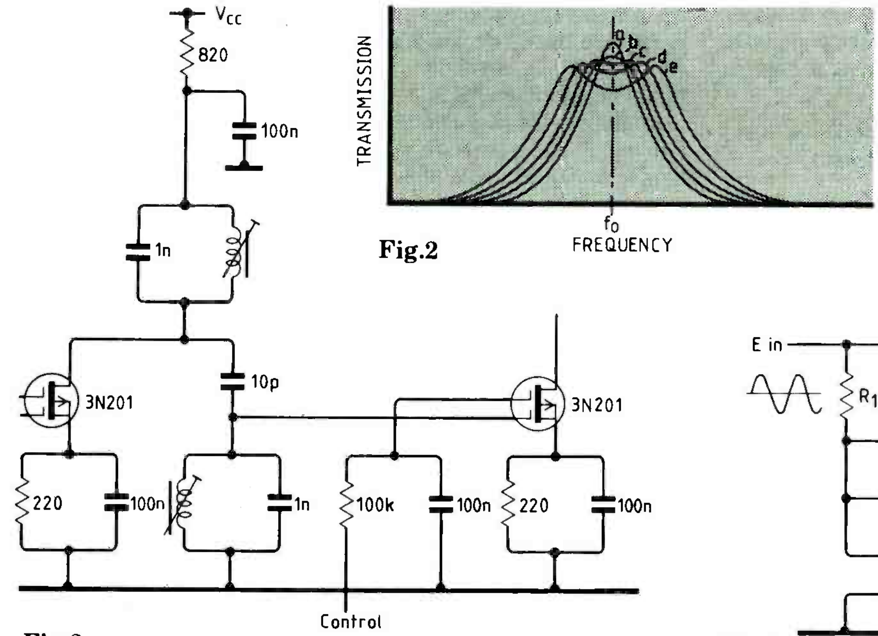


Fig.3

Fig.2

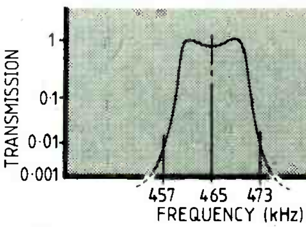


Fig.4

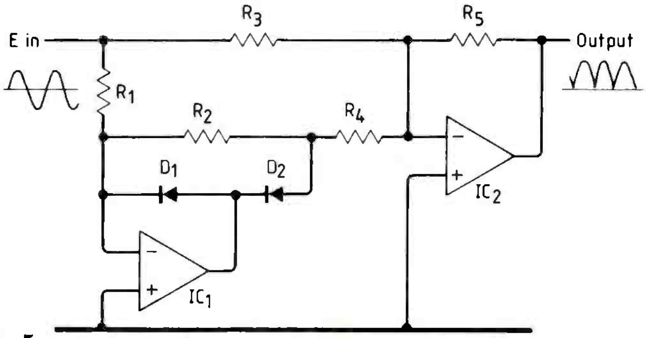


Fig.5

by Sandel*, and a summary of the design data for the type of circuit shown in Fig.1(d) is that for critical coupling the coupling factor (k) should be the reciprocal of the mean Q value for the two coils. If these have a Q of 100, a fairly typical value, then the coupling capacitor (C_c) should be C_t.k, where k=0.01. If the tuning capacitors, (C_t), are 1000pF, then the coupling capacitor value should be 10pF.

Having tested a number of miniature i.f. coils, the great majority intended for use as a single tuned circuit were found to tune over the range 450-470kHz with a 1000pF capacitor, and under these conditions, had a working Q value of about 100. These coils would therefore be very suitable for this particular application.

Those with an internal tuning capacitor, usually housed in larger cans, are normally of higher quality, and have a higher L/C ratio, which leads to the use of a smaller value capacitor and also to a higher working Q value. The circuit layouts of Fig.1(c), or 1(e), would be more appropriate in these cases. Unless the secondary coil or tap ratio can be determined, it is impracticable to calculate the required value of C_c, but this may easily be determined by experiment and will usually lie in the range 100-800pF.

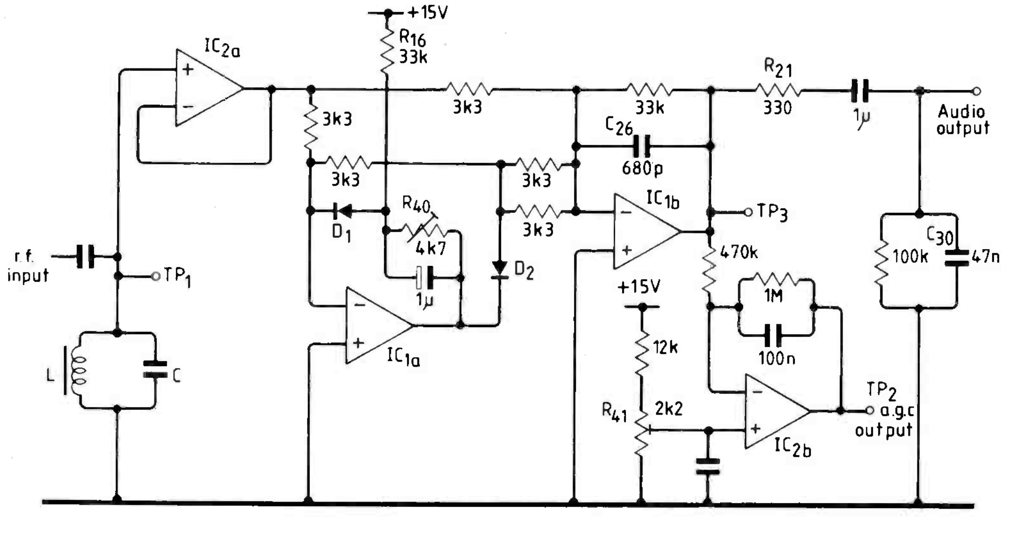
Too high a Q value for the i.f. transformer tuned circuits is not very desirable where a series of these are to be operated in cascade; the effect of this is multiplicative in the steepness of attenuation of the skirt of the pass band. For example, with three such band-pass pairs, as might be used in a high quality receiver design, a Q value for each coil of 100 will give a pass band of about 12kHz at -6dB, and 20kHz at -60dB. A Q of 200 at each stage would reduce the useful pass-band from 12 to 6kHz. For this reason I was quite happy to discover that the inexpensive miniature i.f. coils were in the required Q range.

Sensitivity

To give the type of performance needed to match the old-style 'table' radio set, an aerial sensitivity of at least 10μV is needed, for 6dB s/n ratio. Two i.f. gain stages using dual-gate mosfets will easily attain this value at the input to the i.f., assuming a 'detector' (demodulator) signal level of 100mV, and two such i.f. stages will allow an adequate range of gain control by means of a signal-derived a.g.c. voltage, without the need to apply such a control voltage to the frequency changer, which might

Response curves provided by tuned circuits at Fig.1 depending on degree of coupling, Fig.2. I.f. stage using circuit at Fig.1(d), with a.g.c. applied to fet amplifier rather than to frequency changer, Fig.3, and its response, Fig.4. Op-amp demodulator, Fig.5.

Fig.6. Practical circuit based on demodulator of Fig.5.



*Sandel. B., Radio Designers Handbook, R. Lanford-Smith (Ed.), 4th Edition, (2), Chapter 26. Iliffe Ltd.

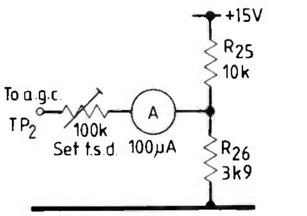


Fig.7. Signal-strength meter uses a.g.c. voltage from TP2.

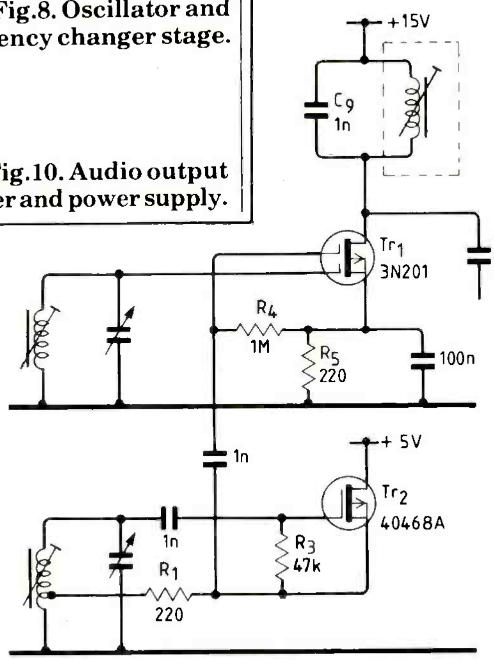


Fig.8. Oscillator and frequency changer stage.

cause oscillator frequency drift. I have shown a suitable i.f. stage layout in Fig.3. When the coils are correctly aligned, the pass-band is as shown in Fig.4.

Demodulator distortion

The normal diode envelope detector used in the average a.m. receiver does not have a very good performance, with introduced harmonic distortion levels lying anywhere in the range 0.5 to 20%.

However, there is a useful op-amp configuration in which the gain of the op-amp is used to remove the diode dead-band and provide a precision full-wave a.c. rectifier, Fig.5.

Its method of operation is as follows. For the positive-going half of an input cycle, the output of IC_1 will drive the cathode of D_2 negative, until the potential at the junction of D_2 and R_2 is equal, and opposite to that applied to the input. In this mode, IC_1 acts as a unity-gain inverting amplifier, and a negative-going current input is applied to the 'virtual earth' point at the inverting input of IC_2.

For a negative-going half cycle applied to the rectifier input, the output of IC_1 will be positive, which will drive D_1 into conduction, and D_2 will be open-circuit. As the inverting input of IC_1 also forms a 'virtual earth', there is no potential across R_2 and R_4, and the current input to IC_2 is simply that which flows from the source through R_3.

On both halves of the input cycle, therefore, a negative-going current input is applied to the inverting input of IC_2, which causes an equal, but opposite current to flow from IC_2 output, through R_5, to preserve the necessary voltage node at the inverting input. Resistor R_4 must have a value equal to half that of R_3 so that there will be the required negative-going total current flow to IC_2, on the positive-going input half cycle, when current is flowing through both R_4 and R_3.

I have shown a practical form of this circuit in Fig.6, in which two dual op-amps provide a low distortion demodulator and a.g.c. amplifier.

In this, IC_{2a} is a unity-gain impedance converting buffer stage to provide the desired low impedance drive to the precision rectifier without loading the secondary coil of the final i.f. band-pass circuit, and a small forward bias is applied to the diodes D_1 and D_2, by means of R_{16} and R_{40}, to assist the circuit to operate in a nearly ideal manner.

It is easy to set this up. With no input to IC_{2a}, (TP1 shorted to the 0V line), the output of IC_{1b} should also be zero. As R_{40} is gradually increased in value, current is fed through D_1, which causes the output of IC_{1a} to move negatively until D_2 just begins to conduct. When this happens, the output of IC_{1b} starts to go positive, as measured at TP3. The correct setting for R_{40} is at the threshold of this output voltage excursion.

Since one is only interested in the l.f. component of the output, the capacitor C_{26} re-

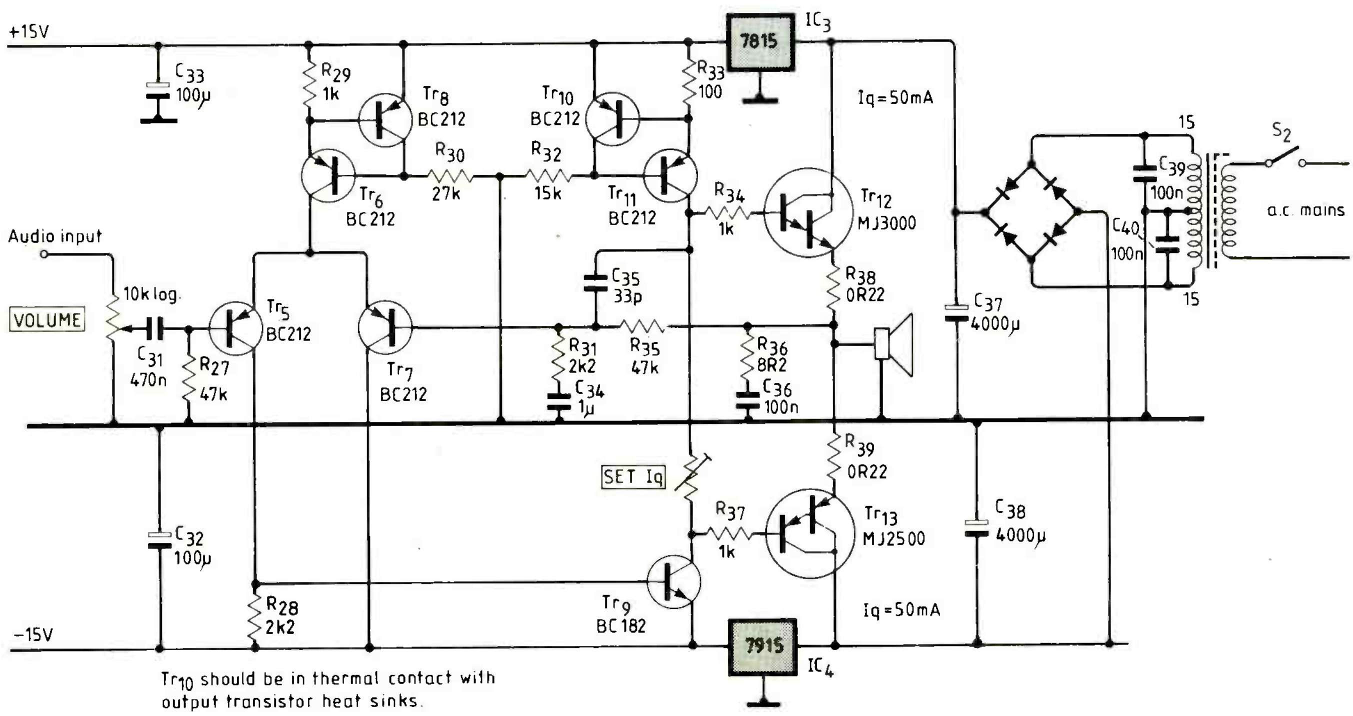


Fig.10. Audio output amplifier and power supply.

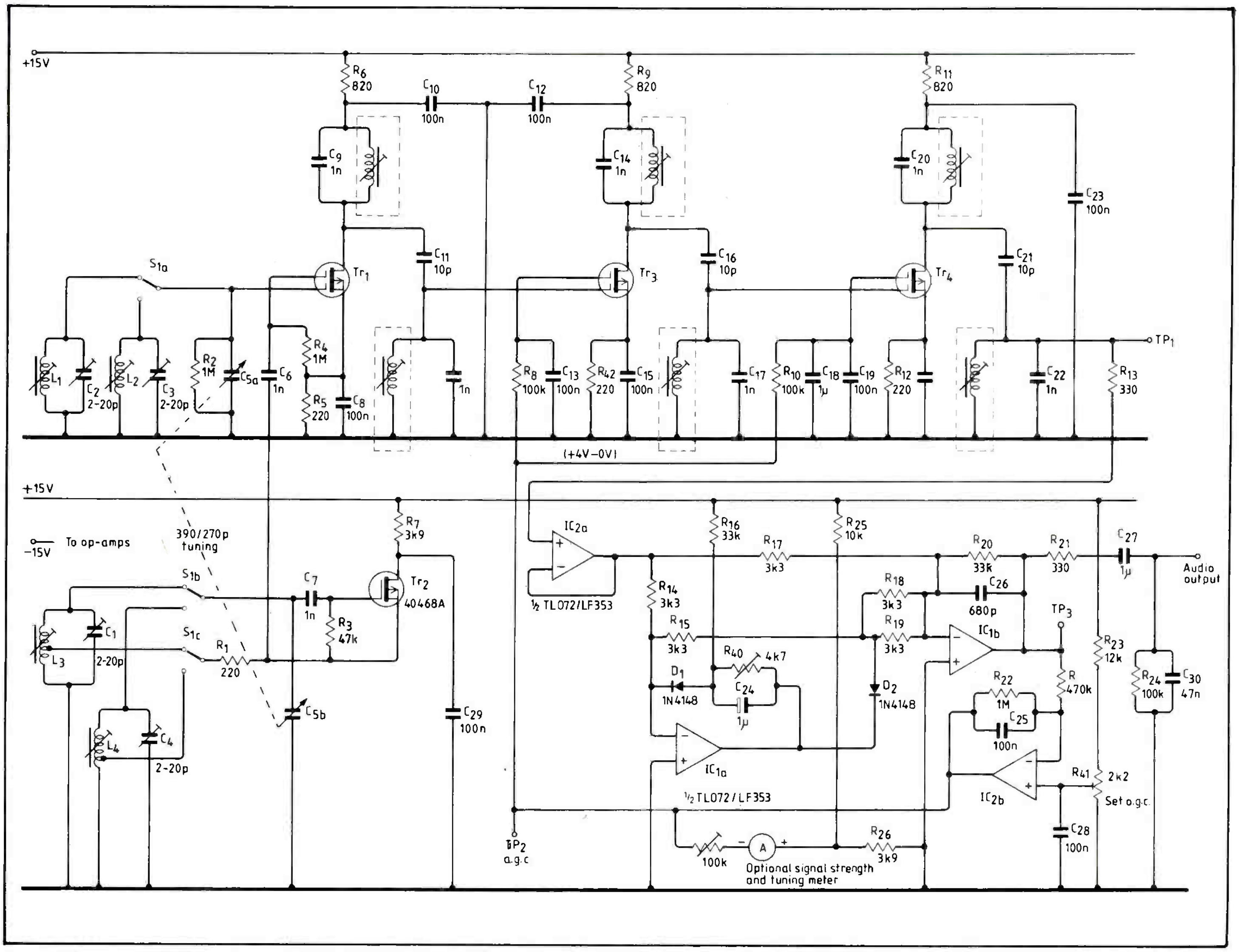


Fig.9. Circuit diagram of receiver for long and medium waves. Additional coils and switching can be used to obtain h.f. coverage, but second-channel interference will be inevitable, though no more than in valve-operated receivers.

duces the h.f. gain of IC_{1b}, to leave only the modulation voltage. It is prudent to ensure that this part of the circuit is well screened from the aerial input, or otherwise there will be a spurious signal at twice the i.f., 930kHz, which is within the medium waveband. Components R_{21} and C_{30} also help to remove the 930kHz component from the audio output line.

In practice, the incoming i.f. signal generates a mean positive potential at the output of IC_{1b} that is proportional to the signal strength. This is amplified and inverted by IC_{2b} to give an a.g.c. potential which becomes progressively more negative as the signal strength increases. Variable R_{41} sets the a.g.c. potential, in the absence of an incoming signal (TP1 shorted to the 0V line), to +4V which is a suitable value for the second gate of the dual-gate mosfets. TP2 can also be used as a source of potential to operate a signal strength or tuning meter, as shown in Fig.7.

This provides an effective and fast-acting a.g.c. system, which holds the audio output substantially constant over a range of input signal strengths from $5\mu V$ – 5mV. The inevitable penalty for such a sensitive receiver is that there is a considerable increase in aerial and other noise when the set is tuned between signals.

Oscillator and frequency changer

This is a conventional circuit layout, as shown in Fig.8, in which a single-gate depletion mosfet is used as a source-coupled oscillator, with the drive to the frequency changer being taken from the low impedance source electrode. The inclusion of R_1 converts the drive waveform into a rounded square wave, of about 800mV pk-pk amplitude, which gives good conversion efficiency in the frequency changer.

Although r.f. mosfets are somewhat dearer than bipolar junction transistors, their use in the oscillator, frequency changer and i.f. stages is amply justified by the performance advantages which they confer: high mutual conductance, high input impedance, and a relatively high output impedance, which lessens the extent of damping of the tuned circuits and removes the need for tapped coils.

Also, in the i.f. stages, the very low feedback capacitance of the dual-gate mosfet avoids problems of r.f. instability. In the frequency changer stage, the mosfet offers a second input electrode, unconnected to the signal gate, for local oscillator injection, and as an oscillator, the mosfet offers a superior performance in terms of output and frequency stability to any other transistor type.

Continued on page 29

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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
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18 pin	60p	—
20 pin	75p	—
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

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by Nigel Gardener

Mains communication without tears

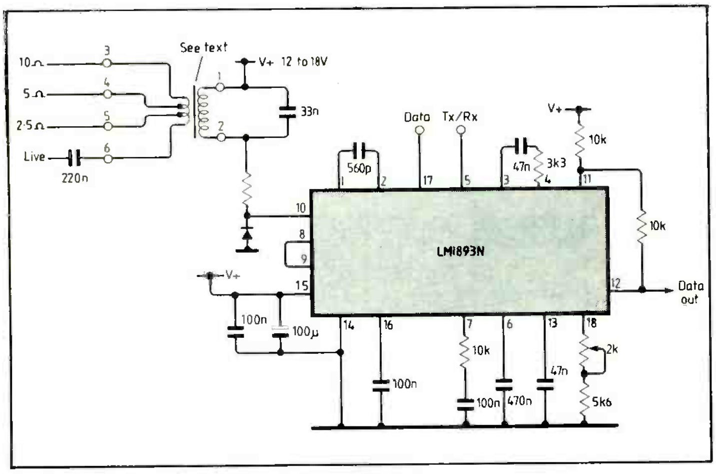
How to interface with the mains supply for data communication and expand into a cost-effective paging system

Nigel Gardner is consumer, automotive and packaging product marketing manager with National Semiconductor, Swindon. Prototype work by Mike Meakin.

A number of articles have been published in the past showing 'simple' methods of communication over the domestic mains. The general circuitry is simple enough for the data formatting prior to transmission, but the bugbear seems to be in the method of interfacing to the mains. One of the methods has been to inject the carrier signal between the neutral and earth. This suffers from one major drawback when the neutral and earth are bonded together at the electricity supply entry point.

The circuitry required for general interfacing tends to include a handful of transistors, regulators and passive components. Most of these components can be replaced by a single LM1893 circuit called a Biline™ carrier current transceiver. This circuit is a special type of f.s.k. modulator/demodulator specifically designed for mains communications.

Fig. 1. Basic mains modem interface uses minimal components for complete digital interface.



Frequency allocation proposed in draft British Standard

Band A	40 to 90kHz	Reserved for electricity supply authorities
Band B	110 to 125kHz	Continuously available channels for occasional transmission
Band C	125 to 140kHz	Time-shared or burst mode, not continuous
Band D	140 to 150kHz	Fire and security equipment

Power levels: 116dB(µV) quasi-peak into 50 ohms, except band D which is 134dB(µV).

Circuit basics

With the impending release of a standard by BSI for communicating over the mains, there must be flexibility with the circuit design to enable the user to align the modem centre frequency within the allotted band. Table 1 shows the proposed frequency allocation. This may change when the specification is finally published, so any commercial user of this method of communication should check when the BS spec is published. The specification mentioned in the reference section was the only one available at the time of printing. However other countries will eventually produce their own specifications as this method of communication increases in popularity. Information about interference limits and test methods is contained in the Draft BS Spec listed at the end of this article. The LM1893 was designed to produce a sinusoidal output for minimum out of band harmonics.

The basic circuit for interfacing to the mains is shown in Fig.1. The transformer is either a Toko or Vacuumschelze type (see page 25) or a hand-wound design as shown in Fig.2. The Toko design can withstand about 2kV; the Vacuumschmelze and home-brew types should withstand about 4kV.

An alternative method of isolation is shown in Fig.3. This idea, originally published by Maplin in their Sept 1985 magazine, is a novel method of isolation. With slight modification to the mains transformer to include a dual secondary, a supply for the non-isolated circuit can be accommodated. Protection diode D_5 is a transient absorber to prevent damage to the LM1893 by erroneous spikes on the mains and is an essential part of the protection circuitry for designs.

Simple control system

If a one-way control system is required, then Figs 4 and 5 could be a cost effective solution. The transmit circuit, Fig.4, is based around the 74C922 keyboard encoder, MM53200 garage door opener and the LM1893.

Operation is straightforward enough. The user depresses a key which is then decoded by the 74C922. The four-bit output is presented to four of the 12 input data lines on the MM53200. The remaining eight bits of input data are used as a 'house code' so that a number of controllers and

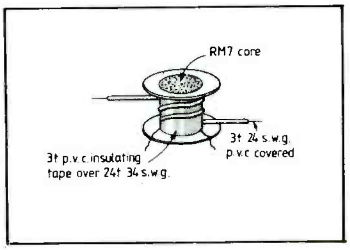


Fig.2. Winding details for coupling transformer. Commercially available components are available – see not on page 25.

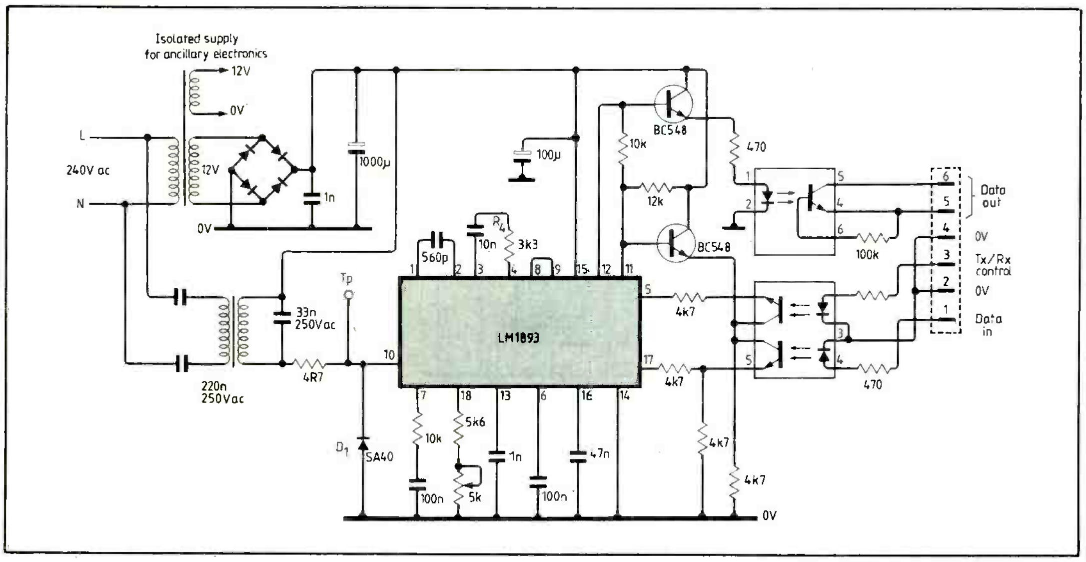


Fig.3. Novel method of isolation using opto-isolators.

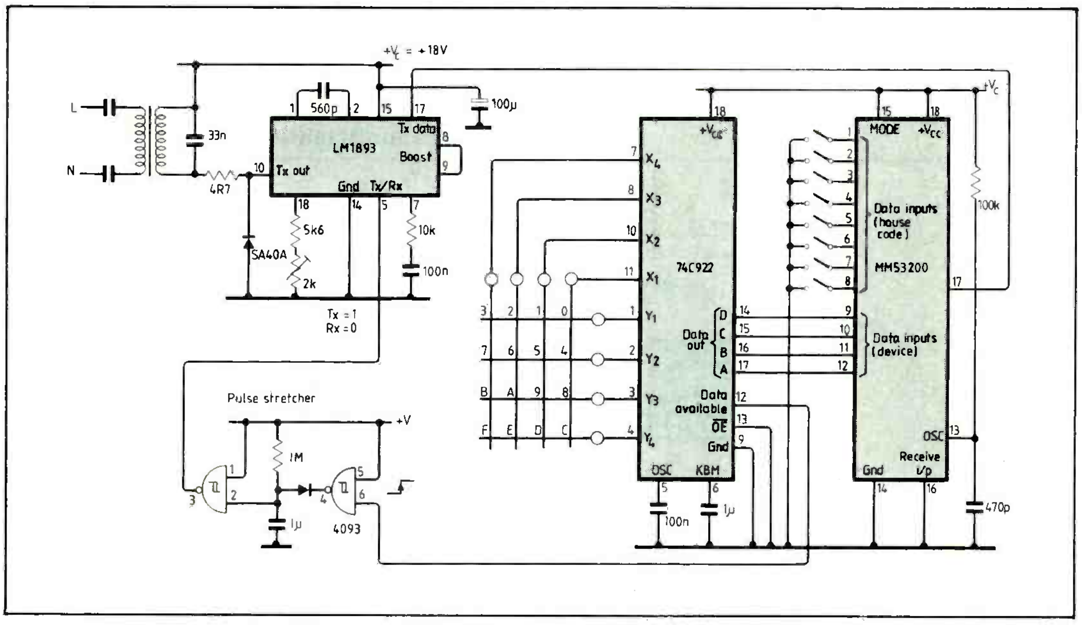


Fig.4. Basic mains control. Circuit diagram of keyboard encoder, parallel to serial pulse width modulator LM1893 wired for transmit mode only.

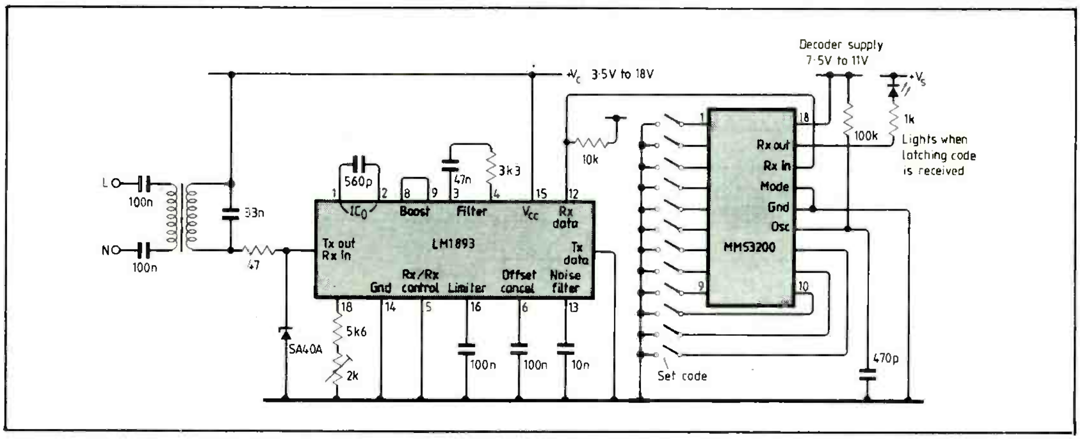


Fig.5. Receiver for simple mains control. LM1893 wired for receive mode only driving the MM53200 digital decoder.

slaves can work on the same system.

During a key depression, the data available pin (12) of the 74C922 goes high. As the output pattern from the MM53200 is of a continuous nature in this configuration, the LM1893 is used to gate the data stream onto the main by controlling its tx/rx pin. The drive for this pin is derived from a pulse stretcher made up from two gates of a CD4093 quad Schmitt circuit. The control input for this gating is obtained from the data available pin of the 74C922.

At the slave end, Fig.5, the LM1893 is used in the receive mode only. Again this can even further reduce the circuitry to around eight components. The data recovered from pin 12 of LM1893 is then passed directly to the MM53200 configured in the receive mode, i.e. pin 15 low. When four consecutive correct code sequences are received from the master, the output line is switched low. This can be used to drive an led or with the addition of a transistor, any other load. The code for both master and slave must be the same, so the eight-bit 'house code' needs to be the set with switches.

These two units form the basic circuitry for simple mains control. With some modification an answerback signal can be sent and received to indicate the required slave has switched successfully – see Fig.6.

When a key is depressed at the master end, the transmission sequence is sent via the LM1893; when released, the master reverts to the receive mode. At the slave end, data received and demodulated by the LM1893 is fed to the MM53200. When transmission from master to slave is finished, a valid ouput from the data output line triggers the monostable into echoing the selected slave address. At the end of the transmission, FF2 is clocked. This has two functions, one to switch the ouput load on and the other to toggle the D0 address bit of the MM53200. This allows the n+1 number to turn off the slave by changing the least significant data bit. The FF2

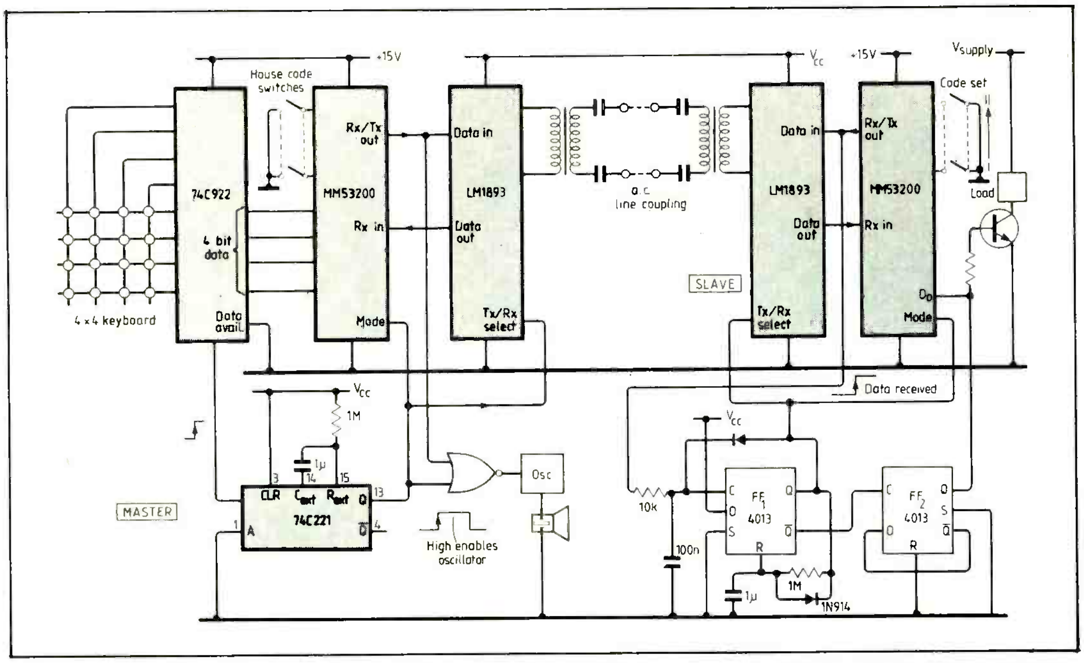


Fig.6. Mains control transmitter/receiver with hand shake. This enhancement of the basic system gives confirmation of correct reception.

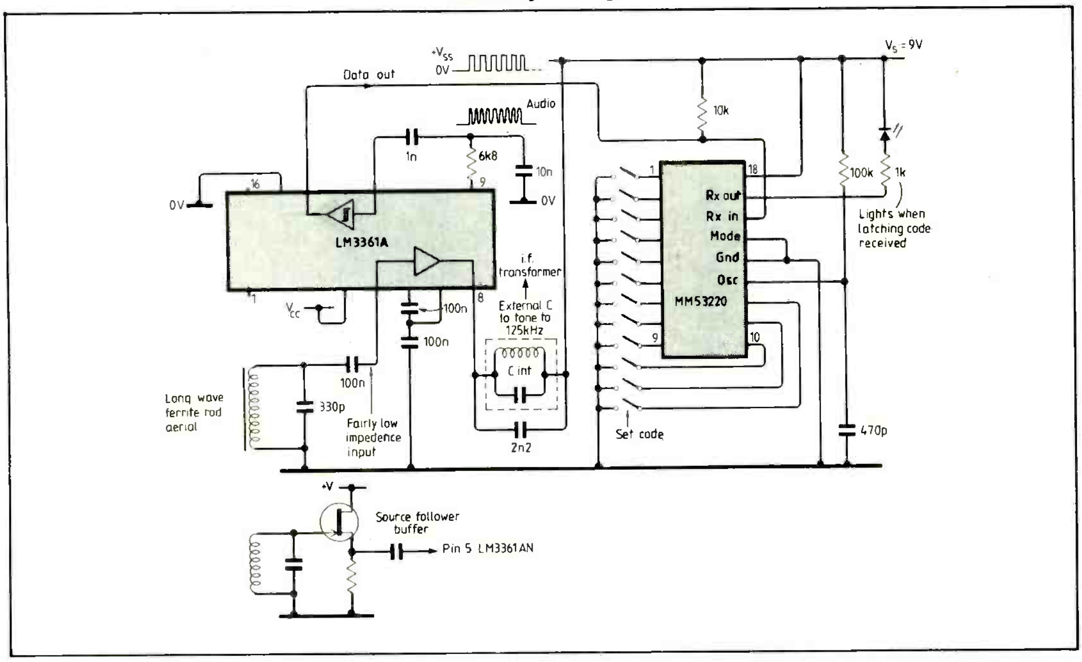


Fig.7. Induction loop receiver using LM3361 and MM53200 digital decoder.

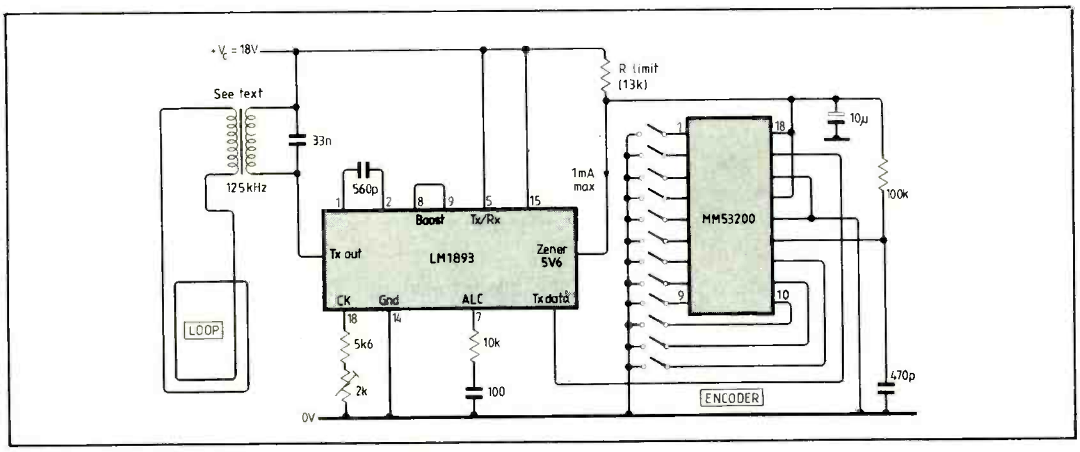


Fig.8. Using the LM1893 as an induction loop driver for use as a paging system.

circuitry can also be used on the simple set up of Fig.5.

When the slave address is echoed to the master, the transmitted and received patterns are compared and, if correct, the user receives an audible or visual signal confirming that the correct action has been taken by the slave.

And now for something completely different

Once the basic interface has been mastered, the expansion of the system is endless. On the master unit, for example, if mains connections from the Toko transformer are replaced with an inductive loop then the circuitry forms the basis for a very cost-effective paging system together with a suitable receiver, as shown in Fig.7 and 8. In this receiver, the signal is picked up by a ferrite rod aerial and fed to an LM3361 narrow band f.m. circuit. This device works to a low voltage with low power consumption. The output tuning is at the carrier frequency of 125kHz, achieved by padding out a 455kHz i.f. coil with a 2200pF capacitor. Recovered data is fed through the internal Schmitt of the LM3361 to provide clean data to the MM53200.

An alternative power supply and interface is shown in Fig.9. This transformerless circuit is intended for applications that do not have any connections exposed to the outside world. Care in the choice of components is essential to ensure a margin of safety.

The LM1893 as it stands will work to 4800 baud, but if error checking is introduced the effective rate is reduced accordingly. For data transmission in areas where the background noise on the power lines could effect overall performance a digital filter, like that shown in Fig.10, could be employed. This circuitry is currently being used on a commercial energy management system and has enabled the system to run at 2300 baud, with 144 bit data strings and a re-transmission error rate of 0.01% over 1 million transmissions per day.

And finally

These circuits for connection to the mains are intended to re-

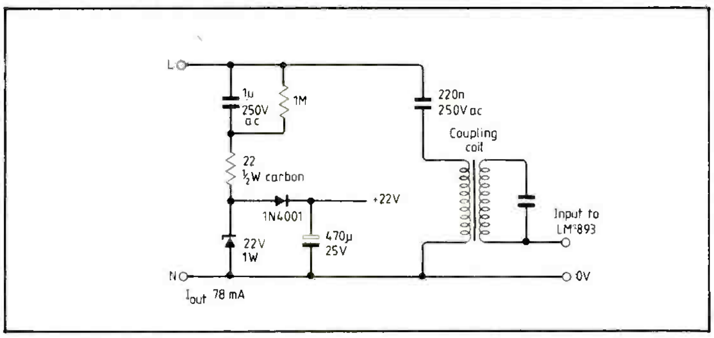


Fig.9. Transformerless power supply for applications needing only minimal current and no isolation.

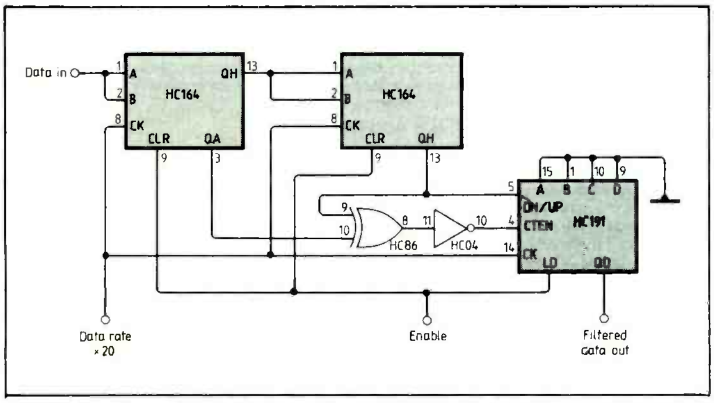


Fig.10. Digital noise filter for clean recovery of signals from noisy mains.

move some of the pain associated with the transmission of data and control signals. The solutions given here are intended to give the interested engineer some ideas as to methods of interface. The medium for transmission is shown to be the domestic mains but the circuits will work just as well on a pair of wires dedicated as a networking bus. There will be less erroneous noise on a separate pair of wires and a reduction in transmission errors.

Further applications based on the simple interface with intelligence are intended, one being transmission of RS232 data from computers to one of a number of printers, another for interfacing a computer RS232 port to master control, which in turn controls up to 256 slaves. This is finished and will be published in the near future.

Each slave has four input, output and i/o lines for general interfacing to the outside world and forms the heart of an industrial or domestic control systems.

Watch this space for further details... ■

Further reading

Biline Carrier Current Networking Systems, National Semiconductor publication number 570075.
Carrier current protocol using an active repeater for consumer and industrial applications, Rob Lytle and Steve Strom. National Semiconductor.
Mains tx/rx module, Electronics (Maplin Magazine) September 1985.
Draft standard for communication and interference limits and measurements for mains signalling equipment, British Standards Institute Draft Spec. No. 85/28596.
LM1893 data sheet – linear supplement 1984, National Semiconductor.
Survey of mains signalling systems in the UK, ERA Technology, Leatherhead.

Suitable transformers are type ZKB490/228-80-W insulated to 4kV made by Vacuumschmelze of Hanau D-6450, Germany and imported by Rolfe Industries (see advertisement), and Toko's 707VX-A0242YUK, insulated to 2kV and available from Cirkit Distribution.

Microcontroller chip integrates peripherals

by
Mike Catherwood

More features of a specially-programmed controller for evaluation and education.

Peripheral functions and memory within the S2 single-chip microcomputer allow the device to be programmed to perform many tasks with very few components.

Last month's article described internal working of the chip and introduced a mask-programmed multi-function version made available only to readers of this journal. This S2 chip includes a monitor which can be driven by a terminal through a serial link, and routines for using the device as a pulse-burst generator, frequency meter and audio communication link using very little extra hardware.

Further routines are included for evaluating the data converter and watchdog time. This article describes using these and the speech-quality communication link.

Audio communication link

The internal eight-bit a-to-d converter and serial interface are used to digitize an audio signal and transfer the data between two S2 processors through a full-duplex serial link. Audio quality is surprisingly good, considering the limitations. Although this demonstration is of limited practical use because the serial interface is intended for local communications only, it forms a useful tool for illustrating some of the theoretical relationships commonly encountered in data communications.

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Mike Catherwood is microprocessor applications section manager at Motorola's semiconductor products division, East Kilbride.

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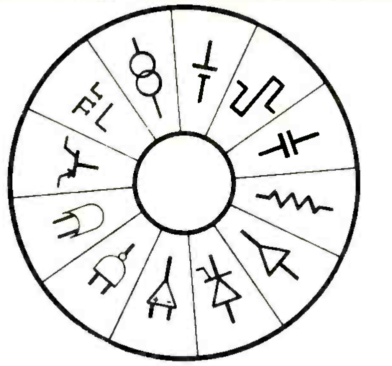

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criteria may be investigated by varying the low-pass filter cut-off points, or the effect on the signal-to-quantization-noise ratio may be observed by reducing converter accuracy through lowering the reference voltage. Relationships such as the Hartley-Shannon theory, which equates channel capacity to bandwidth and s-to-n ratio, may also be confirmed.

Software samples the a-to-d converter at 7.7kHz and the serial-interface clock is set to operate at 100Kbit/s (for a 4MHz m.c.u. clock). Information is therefore passed at a rate equal to eight times the a-to-d converter sampling rate which is 6Kbit/s. This is lower than the channel capacity of the serial interface and consequently the converter sampling rate is the communications-bandwidth limiting factor.

Two S2 demonstration devices are required for this application, one configured as a master (serial interface clock generator) and the other as a slave, Fig. 1. The serial interface is configured for three-wire (receiver, transmit and clock) full duplex operation.

One byte of data is exchanged between the devices every 131 machine cycles; received data is placed on port A which then drives a low-cost MC1408L8 d-to-a converter Both input and output filters should have a cut-off frequency of less than half that of the a-to-d converter sampling rate, i.e. 3.8kHz for a 4MHz c.p.u. clock.

Switched-capacitor filters are easy to use and form effective low-pass filters. The c-mos MC145414 shown uses switched capacitors to form a dual fifth-order elliptic filter for low-pass operation. Two uncommitted op-amps are also included in the device.

Band limiting frequency of each filter is directly proportional to the input clock. For example, an input clock of 128kHz provides a band-limiting frequency of 3.6kHz; halving the clock rate halves the band-limiting frequency.

Each filter is functionally identical except that one provides 18dB of gain within the passband and the other provides unity gain. In Fig. 1, an MC1455P1 timer is used in astable mode to generate a clock signal that can be varied between 70 and 180kHz.

Hardware for the audio communication demonstration was developed by Olivier Pilloud at Motorola's Geneva design centre.

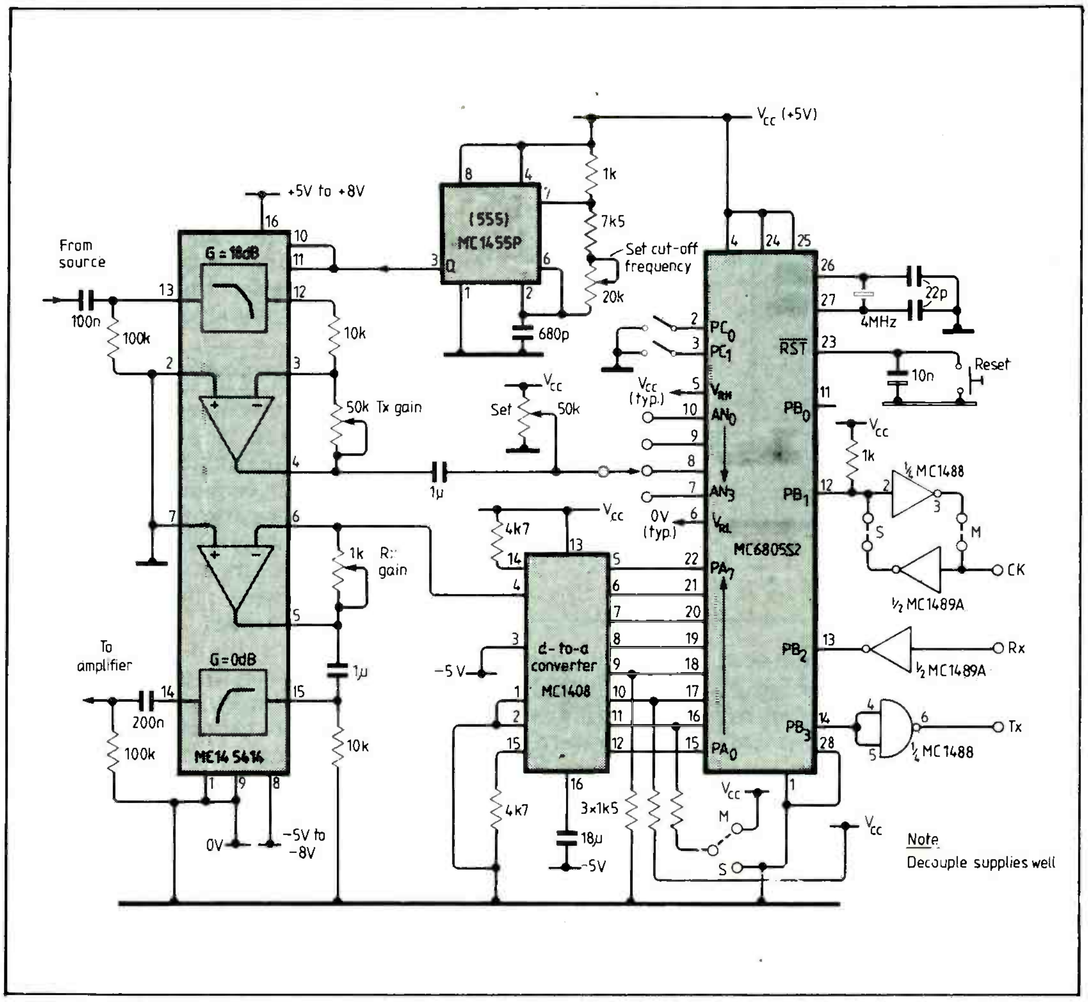


Fig. 1. One side of the S2 audio communication link. Lines $C_{0,1}$ select the converter channel as in Table 2. Line B_5 reads low internally. The d.c. 'Set' potentiometer is set to provide an average converter input d.c. signal level of about half way between V_{RL} and V_{RH}. For maximum converter accuracy, V_{RH} is tied to V_{cc} and V_{RL} to ground. Adding an expander and compressor would improve s-to-n ratio.

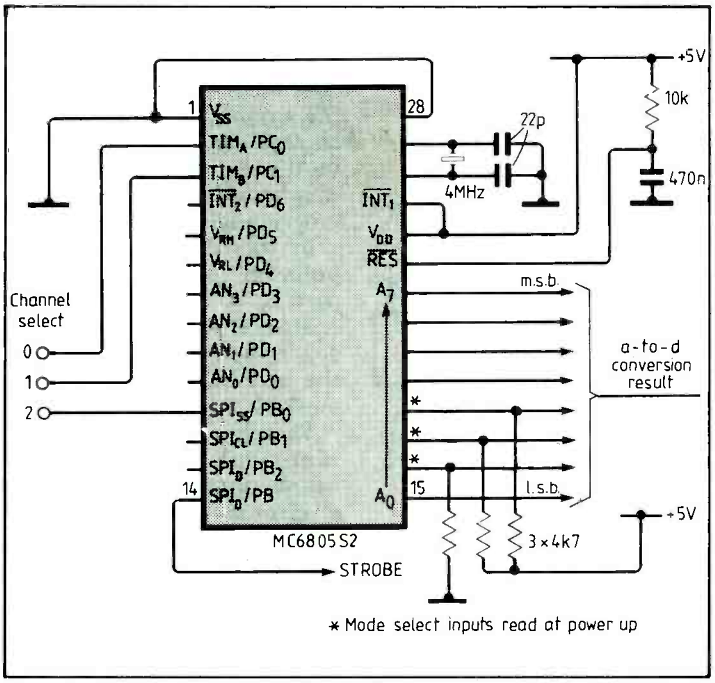


Fig. 2. Analogue-to-digital converter evaluation. Three-bit digital code selects one of four channels or internal calibration voltages. For port B_1 connections, see text.

A-to-d converter evaluation

This program allows you to directly exercise the analogue-to-digital converter in the MC6805S2 and to accurately evaluate its performance in the intended environment.

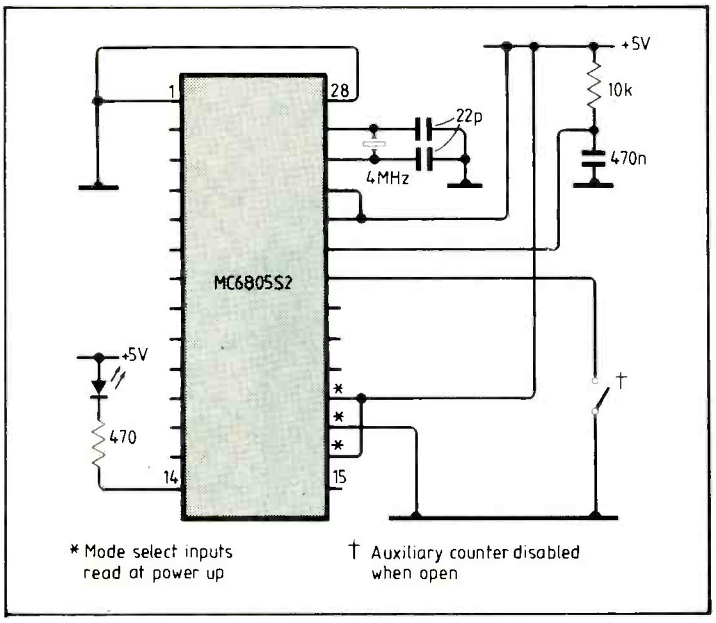


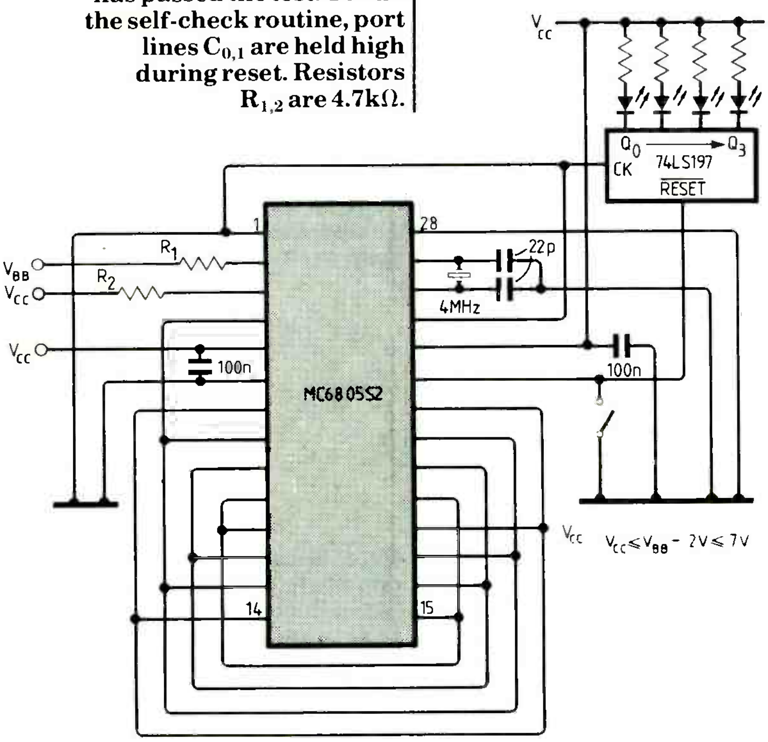
Fig. 3. Using the auxiliary counter as a watchdog allows the processor to regain control after noise has caused erroneous operation.

Figure 2 shows how a typical test board could be configured. The analogue channel is selected by setting inputs, port lines $C_{0,1}$ and B_0 to states corresponding to a-to-d converter control register bits 0 to 2, as defined in Table 1.

After initialization, conversion of the selected analogue input is continuous. The channel selected may, however, be changed without resetting the processor since the program reads the channel code inputs before each conversion. The conversion result placed on port A bits 0 to 7 may either be the value after each conversion (port $B_1=0$) or a value averaged over four conversions (port $B_1=1$).

A data-valid strobe is also generated on port B to indicate when another conversion result has been output. It will rise and remain high during the period that the value on port A is stable.

Fig. 4. Results of the S2 self-check routine are shown on four leds (see Table 2). When the leds blink, the device has passed the test. To run the self-check routine, port lines $C_{0,1}$ are held high during reset. Resistors $R_{1,2}$ are 4.7kΩ.



Auxiliary counter demonstration

The auxiliary or watchdog counter is a ten-bit fixed-modulus counter which may be used in conjunction with some simple software to help ensure reliable processor operation in environments which would otherwise encourage erratic behaviour. For example, should high-energy spikes appear on the power supply the m.c.u. may loose control and start to execute data patterns, causing a catastrophic system runaway.

A program using the auxiliary counter to avoid this regularly presets the auxiliary counter to its maximum value by inverting miscellaneous register bit 5. Provided that this is done more frequently than the auxiliary counter time-out period, then a forced reset will not occur.

So if a program runaway does occur it is probable that the auxiliary counter will not be regularly preset, resulting in the m.c.u. being reset at counter overflow and the user program being restarted.

In this demonstration the program simply increments port B. A hard-wired option enables or disables the watchdog option by manipulating the auxiliary counter reset-mask bit.

Therefore by operating two identical demonstration boards in the same adverse environment but with the watchdog enabled in only one, a direct evaluation of watchdog effectiveness can be made. Wiring is shown in Fig. 3.

The auxiliary counter may alternatively be used as fixed-interval polled timer, provided that the auxiliary counter reset-mask bit is set. Even though the instantaneous counter value cannot be read by the processor, this feature may still be very useful in applications requiring long time-outs.

Table 1. Control codes for analogue channel selection.

Port B_0	C_1	C_0	Input
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}*
1	0	1	V_{RL}*
1	1	0	$V_{RH}/4$*
1	1	1	$V_{RH}/2$*

*Internal levels for calibration.

Table 2. S2 self-test indications

Counter bit 2	1	0	Indication
0	0	0	Bad i/o or INT_1
0	0	1	Bad ram
0	1	0	Bad rom
0	1	1	Bad a-to-d converter
1	0	0	Bad timer A
1	0	1	Bad interrupt timer A
1	1	0	Bad INT_2 or aux. counter
1	1	1	Bad interrupt timer B
Flashing			No fault

Selftest and bootstrap loader

Applying a voltage slightly in excess of $V_{cc}+2V$ to port line C_0 during reset causes the device to select an alternative of vector on reset release, Fig.5.

The new reset vector points to the self-test program area. Within this space, a bootstrap loader program also exists which allows you to copy small amounts of test code from an external eprom into S2 ram and then execute it. The level of port line C_1 immediately after reset is released determines whether the self-test routine or bootstrap loader is executed.

Self-test involves execution of a sequence of subroutines for testing rom, ram, timers, i/o, a-to-d converter and interrupts on a cyclic basis. Many of the routines may be called by the user. Leds display the result of the test, Table 2.

The bootstrap loader program continuously copies data from an external eprom at address zero onwards into S2 ram at address 40 to 7F until port line C_1 is pulled high. It then executes a JSR 40 intruction and runs the loaded program. The most significant eprom address lines may then be incremented and the pro-

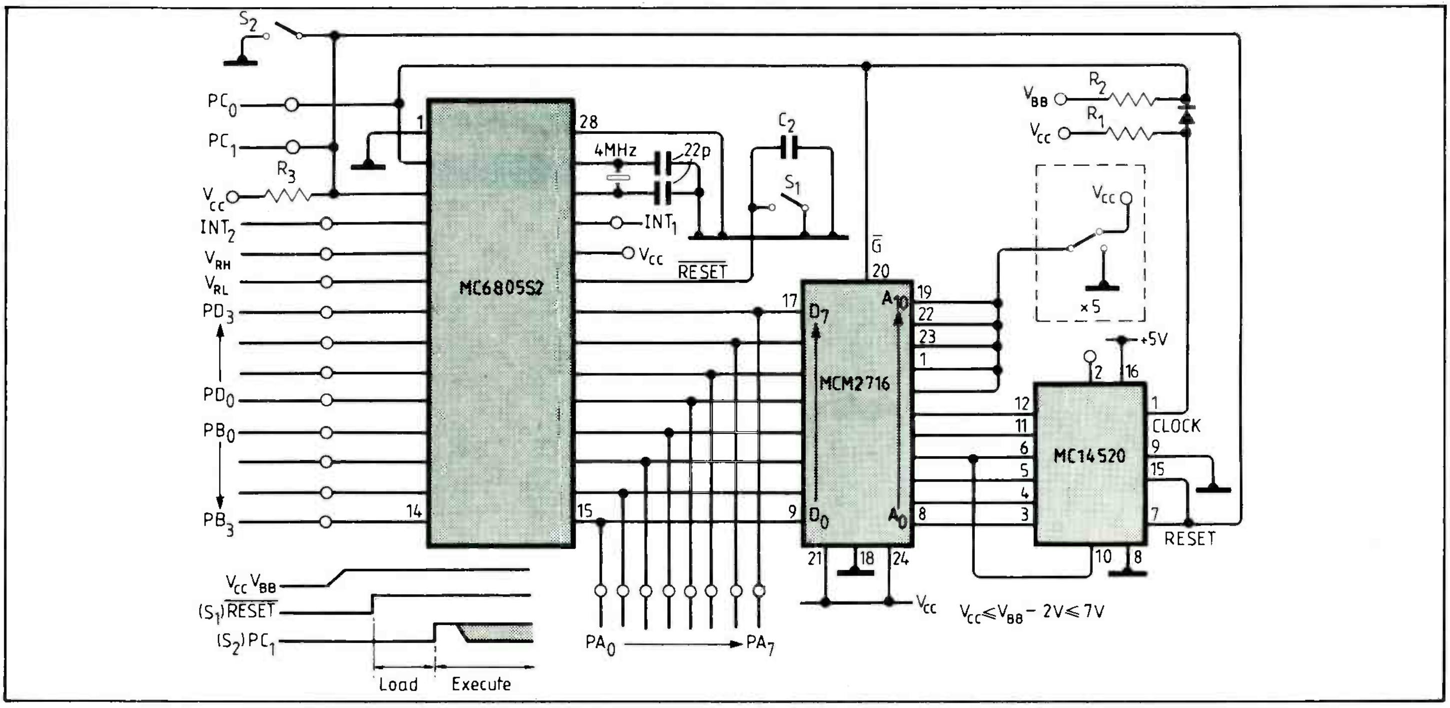


Fig. 5. Small user programs in eprom can be loaded into the S2 using this configuration. At reset, port line C_0 is held high and directly after reset line C_1 must be low. User code is executed when line C_1 goes high. Resistors $R_{1,2,3}$ are 4.7kΩ.

cess repeated with another user test routine.

Test results may be displayed on any of the spare ports. This test procedure is obviously more flexible, but requires more hardware. Input/output related tests are also difficult to realize properly.

Useful monitor subroutines

Figure 6 of last month's article shows hardware required for communicating with the S2's internal monitor through a serial link at either 300 or 1200 baud. Note that the 300/1200 baud switch is only sensed at reset.

Being in standard 6805 code, sub routines within the monitor and many of those used for the special functions will be useful to software writers. A full assembly-language listing is available.*

Routines include low-level functions, such as writing/reading a character to/from the terminal, and higher-level routines for reading and writing hexadecimal numbers for example.

Error conditions are usually indicated by the C bit being set on return from the subroutine. Table 3 is a list of the more useful subroutines and a short description of what they do. Any questions about how a particular subroutine works can probably best be answered by inspecting the source code.

In general, the subroutines shown in Table 3 try to preserve the registers that they do not use. Note that most of the routines expect to be able to use locations 56_{16} to $5B_{16}$ in ram. As the interrupt vector jump table resides 50 and 55, ram locations 50 to 5B should not be used.

Locations 40 to 4F are standby ram and are accessible if the ram is powered through port line D_6. ■

Table 3. Useful subroutines within the S2 monitor.

Label	Subroutine	Address
OUT3HS	Print address	B94
OUT2HS	Print byte pointed to by GET	B9C
PUTBYT	Print accummulator in hexadecimal	BAF
PUTNYB	Print lower 4 bits of A in hexadecimal	BBC
CRLF	Print carriage-return, line feed	BCE
PUTS	Print a space	BE7
GETBYT	Read hexadecimal byte	BF0
GETNYB	Read hexadecimal nibble	C01
GETC	Read a char. into accummulator	C1D
PUTC	Print character in accummulator	C44

***Assembly-language listings cost £2.50 from the editorial office. Please mark your A4 envelope 'S2'.**

In Fig. 8 of the September article, pins 17 and 18 should have been shown wired to 0V; the V_{cc} supply connects to pin 16 and pin 7. ■

Quality radio

continued from page 19

Incidentally, if a single gate mosfet is not available, a dual-gate device, such as the 3N201, can be used with the two gates joined together.

The complete receiver

I have shown the circuit of the complete a.m. receiver in Fig. 9, which includes provision for switching between the l.w. and m.w. bands, (150-300kHz and 550-1600kHz).

Audio stage

I decided on a target performance of 3 watts into a 3 ohm load – a typical 'table radio' output power figure – at not more than 0.05% t.h.d. with good reactive load behaviour, and with all crossover products being substantially less than 0.01%.

The circuit I eventually chose for the audio amplifier, which fully met this specification, is shown in Fig. 10, as is also that used for the power supplies.

The final performance of the unit has proved very satisfactory, both in respect of its ability to recover very weak signals at good entertainment quality – completely unseen by my domestic 'trannies' – and in respect of its frequency stability and tonal characteristics. ■

Slow-scan television in software

by Giuseppe Cameroni I2CAB and Giancarla Morellato I2AED

Direct transmission and reception of pictures by radio or telephone, using only a Commodore 64 computer.

Giuseppe Cameroni and his XYL Giancarla Morellato graduated in commerce and chemistry and both got their amateur radio licences at about the same time, having met via the radio. Software and hardware experts, their knowledge of computing embraces all of the main languages together with the hardware of most personal computers on the market.

Slow-scan television is a way of transmitting pictures over an audio channel. The method is greatly used these days allowing us to transmit and receive pictures all over the world both by telephone and by radio.

The signal transmitted is frequency modulated as follows

1200 Hz sync pulse
1500 Hz black
2300 Hz white

and frequencies from 1500 to 2300Hz represent levels of grey. A picture is completed in about eight seconds, consisting of 128 lines each 66ms long. Sync pulses are 5ms long (horizontal) and 30ms long (vertical).

Considering the interest shown by our correspondents when we tell them our s.s.tv transmission was simply directly generated by a Commodore 64 using just software, we are sure our program will please lots of enthusiasts. These notes should fill a large gap in the literature: we often read about the use of computers for communication in rtty and c.w. but as far as we know, never has an important magazine published complete programs for using a computer with s.s.tv. Through this program the user of a C64 will be able to transmit the full character set of the computer in s.s.tv.

To load the program type the list, verify and save it before the RUN. On RUN we open a window on the screen capable of containing eight characters by seven lines. The cursor has full movement in it; transmission can be actuated by pressing the 'left arrow'. After a few seconds for the basic version of the program the loudspeaker will give out the characteristic s.s.tv sound.

We have also written a version of the program in machine code which allows the text to be transmitted instantaneously.

To stop transmission or modify text hold the key RETURN pressed; during vertical sync (which can be found acoustically as a constant tone about every eight seconds) a routine scans the keyboard and if the RETURN key is found pressed, stops the transmission.

Even if the list is quite long, those who load it will have the satisfaction to have something really complete and which is not, at the moment, on the software market. The program will free s.s.tv enthusiasts from the restrictions of special pens and flying spot scanners.

We succeeded in writing this program to receive s.s.tv via a Commodore 64 directly, without any dedicated interface, by just connecting the receiver a.f. output to the C64 user port. We combined s.s.tv RX and machine code TX in the same program so we now have a program which puts s.s.tv immediately in your hands and eyes. F1 actuates the exchange rx/tx, F7 suppresses interrupts, allowing excellent clear pictures to be received. If you wish do contact us by s.s.tv.

Program description

1000-1130 load routines in machine code.

1320-1520 load video location from the keyboard.

1550 SYS20224 ($4F00) routine fills all memory locations to be transmitted with black ($FD).

1560-1590 gets characters from the screen.

1580 stores in 20479 ($4FFF) the progressive number of the character picked up.

1610-1690 gets eight bytes from rom character and stores them serially from $4000.

1700 SYS20736 routine in machine code finds starting address of s.s.tv characters, loads in memory bits contained in eight bytes from $4000.

1750-1770 load horizontal sync grill.

1780 load vertical sync.

1790 SYS20480 routine transmits in s.s.tv, recognizing the memory location content. Every vertical sync verifies if a key is pressed – if positive, transmission is stopped and the program prepares itself to receive new text, otherwise transmission is repeated.

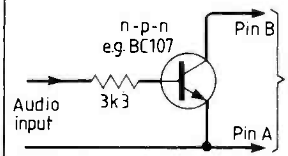
The sequence of operations to access the character rom are

1 – remove interrupt
2 – select character rom
3 – get the desired character
4 – remove character rom
5 – restore interrupt.

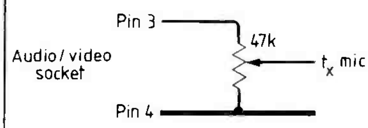
The character rom and register are both located from $D000 and $DFFF; it is so required to select one of them depending on needs. First interrupt must be suspended by, in Basic, POKE 56334, peek (56334) AND 254, and in machine code by

```
LDA #$FE
AND $DC0E
STA $DC0E.
```

The memory bank containing the character rom is selected by setting to 0 bit 2 in the control port, which is in location $01. Remember, AND with 0 set to zero, AND with 1 leave unchanged; OR with 1 set, OR with 0 leave unchanged. This



Though the receiver's audio output can be directly connected to pin B this circuit will give some input protection. The BC107 or 2N2222 circuit needs the a.f.gain set high; an op-amp allows a lower gain setting.



Even though it is possible to transmit s.s.tv pictures simply by placing the tx microphone to the tv monitor loudspeaker, we suggest you connect, using shielded cable, pin 3 in the audio/video connector to the mike input of your transmitter via a potentiometer.

Copies of the complete machine language program containing both transmission and reception in s.s.tv (RXT SSTV) are available on disc or cassette directly from the authors for £15 (L30,000) (two sheets of instructions are included) at via Damiano Chiesa 26, 27029 Vigevano, Italy. Cost is reduced to £10 by sending a floppy disc. Basic listings that accompany this description are available from the editorial office.

is the instruction in Basic:

```
POKE 1, PEEK (1) AND 251
```

and in machine code:

```
LDA #$FB
AND $01
STA $01.
```

The character rom is now at our disposal. Characters are stored from $D000 eight locations per character depend on their screen code. Each bit of the eight bytes corresponds to a point on the screen which could be put off if zero or on if the bit value 1.

Capital letter A has got a screen value 1, so it is memorized from D008 to D00F and the content of progressive memory locations is $18 3C 66 7E 66 66 66 00, see example:

Byte	Bits	Picture
$18	00011000	...**...
$30	00111100	..****..
$66	01100110	.**..**.
$7E	01111110	.******.
$66	01100110	.**..**.
$66	01100110	.**..**.
$66	01100110	.**..**.
$00	00000000	....

Obviously capital B with, screen code 2 is situated from D010 and $D017 and so on for all other characters.

Now position the i/o bank with the Basic message

```
POKE 1, PEEK (1) OR 4
```

or in machine code,

```
LDA #$04
ORA $01
STA $01.
```

Restore interrupt from Basic

```
POKE 56334, PEEK (56334)
OR 1
```

In machine code:

```
LDA #$01
ORA $DC0E
STA $DC0E.
```

Location $4FFF contains the progressive number of the character drawn on the screen locations; doubling this value and adding it to the base location ($4E00) in the address table gives the starting location of a certain character. In eight locations starting from $4000 there are bytes obtained from the character rom, and it is necessary to translate these bytes into bits and store them with the memory locations to be transmitted.

We did that by using the instruction ROL (rotate left) through which carry is loaded with the left-most bit of the byte considered. This instruction is followed by BCC (branch carry clear) which verifies the state of the bit, following the routine store $00 if the bit is on or $FD if the value of the bit is off.

Loading example

Suppose the letter A is in the first position of the screen, the starting location to load the s.s.tv character is found from the table $4E00, and is $6200.

From the rom character the letter A means $18 $3C $66 etc. which will be arranged this way:

```
$6200 00 00 00 FD FD 00 00 00
$6240 00 00 00 FD FD 00 00 00
$6280 00 00 FD FD FD FD 00 00
$62C0 00 00 FD FD FD FD 00 00
$6300 00 FD FD 00 00 FD FD 00
```

and so on over the character and all the text.

Picture transmission

Every line of video consists of 64 memory locations, the content of which actuates the transmission as follows

$00 ≡ white; frequency of 2300Hz is transmitted for the length of a point (0.93 ms)
$FD ≡ black; frequency of 1500Hz is transmitted for the length of a point (0.93 ms)
$FE ≡ horizontal sync; frequency of 1200Hz is transmitted for 5 ms
$FF ≡ vertical sync; frequency of 1200Hz is transmitted for 30 ms

A different memory content is not recognized by the program just now. The content from $00 to $FD would be suitable as transmit values for grey in some future expansion of the program.

The frame transmitted consists of seven text lines containing eight characters each. Every character is constituted by a matrix of 8 by 8 points; so the image definition will be

horizontal: 63 points: 8 by 8 – horizontal sync.
vertical: 128 points: 7 by 8 by 2 (every line is loaded twice) + 16 lines of buffer.

I inserted these 16 lines (eight supper and eight lower) to get the picture received easily with a substandard monitor.

Direct picture reception

At the beginning we initialize the area of memory concerning the position of colour, actuate a 'clear' in all locations that will contain picture information, qualify the bit map and the multicolour mode; all these operations are necessary to present a memory location as a point with different levels of grey.

It is required to know accurately the frequency presented to the input (user port) of our computer to let it do all the operations concerning the composition of the picture; colour a point, actuate horizontal or vertical reset. This sampling of the input frequency must be done continuously in a very short time, by rewriting the NMI (mon-maskable interrupt) routine which is normally situated starting at $FE47 and modify for a new allocation by changing the content of the pointers $0318 (NMI l.s.b.) and $0319 (MNI m.s.b.)

The c.p.u. of the Commodore 64 has various jobs to carry out which, even if requiring very short time, continuously distract it causing holes in the sampling. To obviate this it is necessary of concentrate the attention of the c.p.u.; this is the function of key F7 which removes and restores video interrupts (bit 4 in location $D011). Through this, exceptionally clear reception is achieved.

If the audio frequency gain in the receiver is kept high to saturate the input port our program directly presents s.s.tv pictures on the screen. It is only necessary to connect the a.f. output to the pin B of the C64 (see diagram).

We merged the program for transmission and this one for reception into a single machine-code version. So this way of communication is immediate and completely accessible to the Commodore 64 owners; readers who desire this program (RTX SSTV) do please contact us. The program allows, among other things, the direct reception of pictures transmitted from space during space shuttle flights.

The program is entirely written in machine code and is presented in Basic just for easy loading; we suggest that once you have typed it to save it, verify it and RUN, when the reception of s.s.tv pictures is immediately available to you.■

"The ancient Greeks had pipped us at the post. Star magnitudes differ by 4dB."

exactly one decibel attenuation. Thus the number of decibels of attenuation in any system where the input power P_1 and output power P_2 is known is

$$A(dB) = 10\log_{10}\frac{P_1}{P_2}.$$

If the system resistance was to remain constant, then $P_1 = I_1^2R$ and $P_2 = I_2^2R$ so that

$$A(dB) = 10\log_{10}\frac{I_1^2R}{I_1^2R}$$

$$= 10\log_{10}\frac{I_1^2}{I_2^2} + 10\log_{10}\frac{R}{R}$$
$$=0$$

$$= 20\log_{10}\frac{I_1}{I_2}.$$

But if the resistance levels are not the same, then the current ratio (or the voltage ratio) cannot be used to yield a meaningful dB figure. This is an error often seen now, with little thought by the student (and sometimes even by his teacher...).

Power gain or voltage gain?

As an example, consider an operational amplifier used as a voltage follower, whose output impedence is 50 ohms with input impedence 1 megohm, then the voltage gain is very nearly unity. Therefore the gain in dB is

$$20\log_{10}\frac{V_0}{V_i} = 0dB.$$

. . . and (as some beginning students often ask) what's the use of no gain? But the power input at the terminals of this amplifier is $V_i^2/10^6$ watts, and the output power is $V_0^2/50$ watts. Therefore the gain is

$$10\log_{10}\frac{10^6}{50} = 43dB.$$

So how can an amplifier have no gain and 43 dB gain at the same time? The answer is that the first result is meaningless: decibels compare power levels – not voltages or currents.

One further example might drive the point home. What is the gain of a transformer with a step-up ratio of 25: 1? V_0 will be 25 times V_i, therefore obviously the gain is

$$20\log_{10}\frac{25}{1} = 28dB.$$

But we are told that the transformer is 89% efficient, so 100 watts in will deliver 89 out. The other 11 watts warm up the device. This gives a power *loss* of just over 0.5 dB.

Therefore the use of dB's with anything other than power levels should be treated with great care.

Rootless wanderings

I have actually seen written somewhere on an advertisement "... the power output is 50 dB..." I wondered if this could mean that the power level was "relative to one wingbeat of a housefly", in which case there might be very little power available from the amplifier! Decibels can never indicate absolute power levels – only relative levels. Once again the telephone engineers in earlier times chose a standard reference level of one milliwatt in 600 ohms. This way of stating absolute powers is written as so many dBm. But even this notation was viewed with suspicion by august bodies like the IEEE, who stated[2] that "They did not recognise any letters attached to 'dB' as meaningful...".

Other standards were established relative to this 1mW level. In 1940, H.A. Chinn and colleagues[3] reported on the standard then adopted by broadcasting groups in the USA regarding the calibration and meaning of what was to be called the 'volume unit' (VU). This was referenced to the 1 mW level in 600 ohms. The VU meters subsequently based on the standard became numerous in studios, and much more recently in home entertainment equipment.

Power referenced to one watt is also commonly met. Radio Amateurs now become familiar with transmitter power outputs as so many "dBW". Non-mathematical RAE candidates or people confused already with decibels find this formidable. One approach (also useful for rather more advanced engineers...) notes that 3 dB is a doubling of power. Thus 6 dB means a doubling of the doubling, 9 dB a further doubling and so on. Therefore when we learn that top band carrier levels must be not greater than 9 dBW, we reason: "first doubling, two watts second doubling, four watts the third takes us to eight watts".

The maximum peak envelope power on the main h.f. bands is 26dBW, which means eight doublings (i.e. 24dB watts. The further 2dB takes this to around 400 watts.

Another point to notice is that 10 dB is exactly ten times. So another way of reasoning is to take, for example, the 26dBW as two lots of 10dB and a further two doublings (that is, 6 dB more). This is reasoned as "Ten dB on a watt is ten watts, a further ten dB takes us to one hundred watts, double, then double again – i.e. 400 watts exactly.

M.N. Lustgarten stirred up a small hornet's nest about the uses and misuses of dBs when he wrote a letter[4] in the *IEEE Proceedings,* November 1971. The problem really was to do with the loose terminology that had crept in regarding units attached to the number in the argument of the logarithm[5]. Mathematically such numbers must be "pure", i.e. they must not be *quantities* with units in any of these transcendental functions. For instance if

$$y = \log_e(P\ \text{watts})$$

$$\text{then } P = e^y = 1 + y + \frac{y^2}{2!} + \frac{y^3}{3!} + \ldots$$

and how can the dimensional quantity on the left (watts) be equal to a dimensionless set of pure numbers on the right?

Therefore the ratio of two quantities is alright – the units "cancel". For example

$$N = 10\log_{10}\frac{P_2\,(\text{watts})}{P_1\,(\text{watts})}\ \text{is fine.}$$

But even this is splittable by the rules of logs into

$$N = 10\log_{10}P_2(\text{watts}) - 10\log_{10}P_1(\text{watts}).$$

The answer is that the Ps must be thought of as the *measure* of the powers, in other words, as "how many times up on the basic unit is P_1".

"How can an amplifier have no gain and 43dB gain at the same time?"

Thus if P_1 = 3 watts and P_2 = 42 watts then the gain

$$G = 10\log_{10}\frac{42\ \text{watts}}{3\ \text{watts}} = 11.5dB,$$

which can also be written

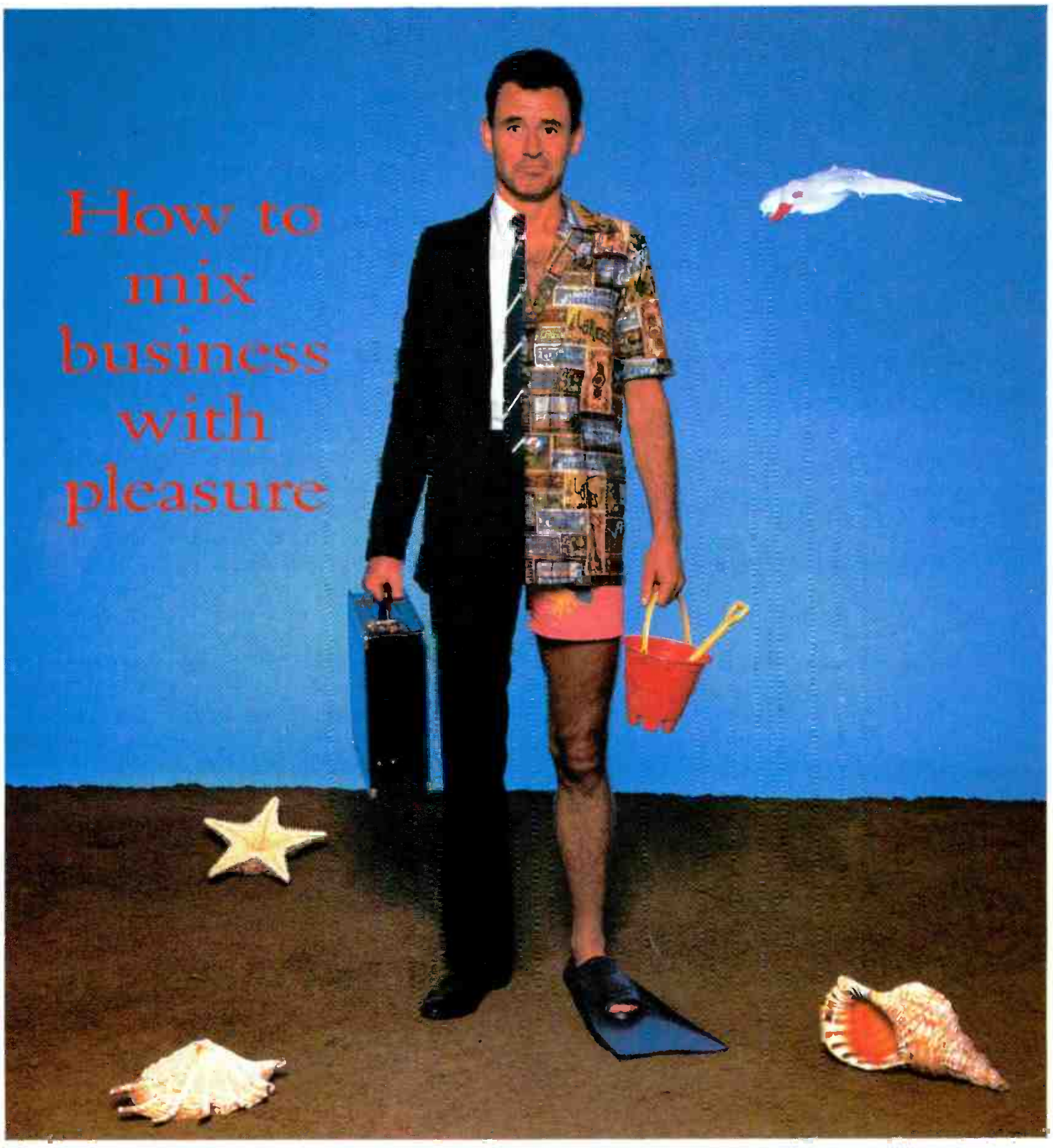
$$G = 10\log_{10}\frac{42\ \text{watts}}{1\ \text{watt}} - 10\log_{10}\frac{3\ \text{watts}}{1\ \text{watt}}$$

$$\therefore G = 16.2 - 4.7dB = 11.5dB.$$

Weber and Fechner

Rather fortuitously, but with some interest, Ernest Weber (1795-1878) found that the smallest detectable physiological response ΔR is proportional to the *fractional* change in the stimulus, given by $\Delta L/L$. G.T. Fechner[6], integrated Weber's result and experimenters found that, for instance, the human senses follow the resultant logarithmic law quite well over quite wide ranges. Thus the Weber Fechner Law is well known in the life sciences: $R = k\log_{10}L$. This means that a decibel scale of, say, sound power appears as a linear scale to the ear. It happens to be one dB change in sound level is just discernible to the ear. The use of a decibel scale is very convenient when the range of hearing from the smallest sound to the threshold of pain amounts to 10^{10}. This range of 120 dB is referenced to the lower threshold – taken as a sound flux of $10^{-12}W\,m^{-2}$ at 1000 Hz.

But the ancient Greeks had pipped us at the post. They knew (by direct observation, presumably) that the light stimulus to our eyes has a logarithmic response relationship. Hipparchus divided the visible starts into six magnitude groups. These had equal subjective divisions from the first magnitude to the dimmest, or sixth magnitude. Later it was found that the ratio of the luminosity of the brightest to the dimmest (a difference of five magnitudes) was about 100 : 1. Therefore the ratio of luminosities from one magnitude to the next is $100^{1/5}$ = 2.512. We can write the ratio as $10\log_{10}100^{1/5}$ = 4dB. Therefore stars one magnitude dimmer than a stated one are 4dB down for the astronomers. ■



There can't be too many serious electronics events that enable you to save valuable time, do a very productive day's work and have the opportunity to enjoy yourself afterwards.

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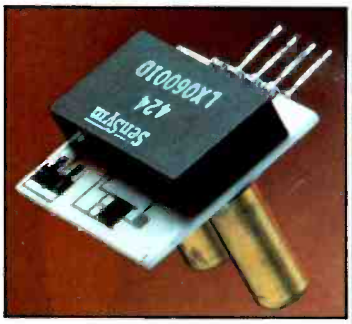
Integrated pressure sensors in acoustics



This early monolithic piezoresistive transducer is available in three forms – gauge, differential and absolute – and includes thick-film thermistor temperature compensation external to the sensor element.

Gary Morton of Hi-Tek examines the selection of integrated circuit pressure transducers as acoustic sensors in microphones and other pick-ups and explains their use in acoustics.

Integrated-circuit pressure transducers are ideal as an acoustic sensor in microphones, hydrophones, sound level meters, musical instrument pickups, audiometers, and other sound detection applications. The i.c. transducer, of which a typical example is shown in Fig. 1, has a wide amplitude response (from zero frequency to 50kHz) and a built-in operational amplifier that provides a high-level signal output for audio range (up to 30kHz) pressure variations. Because the transducer diaphragm's natural resonance is outside the audio range (~50kHz), it does not generate audio-range harmonics from input sound waves, which totally eliminates tricky microphone squealing even in heavy feedback situations. The i.c. pressure transducer's high accuracy, which can be further improved by auto-referencing, qualifies it for use in precision audio instruments.

With the pressure port tube in place, the i.c. transducer has a directional acoustic pickup pattern that can be broadened by reducing the length of the tube. If the tube is removed, the pickup pattern is similar to a high quality cardioid microphone. The transducer can be used for musical instrument pickups (Fig. 2) or for close-up directional microphones, but may require tube modification for other types of microphones. It is important to note that the port must be protected by an acoustically compliant material to prevent breath moisture from reaching the transducer circuit in any microphone, wind instrument, or other application where someone could blow into the port.

For stand-off microphones, the additional gain can be obtained by use of reflective sound collectors. A paraboloid reflector for directional pickup can be used, as shown in Fig. 3, or a hyperboloid for wide angle pickup, as shown in Fig. 4. In either case, the pressure port needs to be shortened to accept the wide angles within the acoustic system.

Transducer can be used as it is for musical instruments or close microphones, Fig. 2, but for stand-off mics the port should be shortened to accept the wider angles, Figs 3, 4. Transducer requires only excitation voltage and coupling capacitor to function as a microphone, Fig. 5.

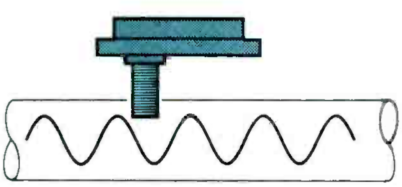


Fig. 2

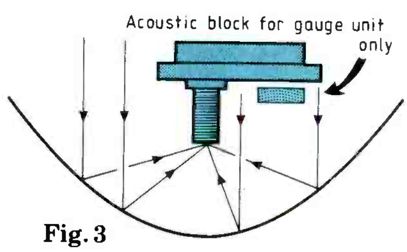


Fig. 3

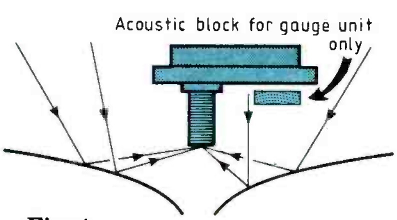


Fig. 4

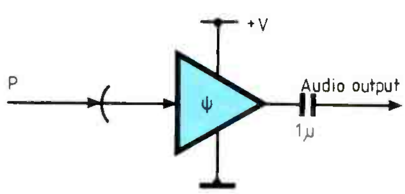


Fig. 5

Acoustic transducer selection

For acoustic measurements, the most sensitive gauge pressure transducer is normally selected. The sound pressure waves are usually small, requiring high sensitivity, and the gauge inlet balances out atmospheric pressure. Since sound pressure waves go both positive and negative around the mean atmospheric pressure, a pressure transducer with a ±5 psig is ideal for the following applications. Devices which have a response centred at 15 p.s.i. (atmospheric pressure) can also be used and often have the advantage of not requiring an acoustic block for the gauge inlet.

For microphones and other audio pickups, the transducer only requires excitation voltage V_E and a 1μF series capacitor to function effectively as a sound sensor, Fig. 5. The sound can be coupled in by any appropriate means as discussed above and by following the general principles used for all acoustic pickups.

Conventional sound pressure level meters normally use a microphone pickup. The resulting signal is amplified, retified and used to drive a meter readout. Since the i.c. transducer's signal is already amplified, it eliminates much of the s.p.l. meter circuitry, Fig. 6. But to be accurate, the s.p.l. meter must be precisely coupled with the sound pressure level input. If an accuracy better than 3% of amplitude is required, either restricted temperature range or normal mode auto-referencing should be used.

In underwater sound pickup applications, an absolute pressure transducer is used. In this case, a very simple, hermetic enclosure needs to be used to protect the sensor. Fig. 7 shows an example.

The audiometer and tympanometer combines the capabilities of the i.c. pressure transducer for precise sensing of both audio pressure variations and static pressure. As shown in Fig. 8, this instrument uses an audio generator to teat the response of the human ear. The audiometer function relies on patient response and hence is only required to measure the a.c. amplitude (and frequency, if desired) of the audio signal entering the ear via the ear plug. The tympanometer measures the compliance of the ear drum without patient cooperation by comparing a.c. amplitude with d.c. level shift resulting from back pressure between the ear plug and the ear drum. Both normal mode and common-mode auto-referencing can be used to increase measurement accuracy.

Like the audiometer and tympanometer, the sphygmomanometer makes use of both a.c. and d.c. pressure detection level measurements. It measures the absolute blood pressure levels for the systolic and diastolic points while monitoring the phase of the heartbeat cycle for more accurate location of the "true" systolic point, the point where the apparent heartbeat at the point of measurement undergoes a change in phase.

In brass instruments, the musician's mouth and throat are part of the instrument's air column. As such, the input air pressure is an important determinant of pitch, volume and the tonal quality of the sound. But in the woodwinds, the musician's mouth and throat are not part of the air column; they are part of the reed. And as such the input air pressure is associated with pitch only, and not basically with the final quality of the sound. Thus the need of woodwind players for an external method to manipulate the tonal quality of their instruments.

Fig.9 shows a fundamentally sound system for woodwind instruments – the musician's concept of the perfect microphone. It consists of an i.c. pressure transducer coupled tightly to the instrument's mouthpiece, serving both as a microphone and as a sound pressure meter. If the a.c. signal is modulated by the d.c. signal, the output of the sound system is quite similar to that of an instrument with square-law attack. The woodwind has now already acquired the attack quality of a brass; it's still up to the musician as to how the attack is to be used.

Such a system using microprocessor-controlled modulation gives an instrument of selectable bell size, a tonal quality that varies from "fat" (full and rich) to "crisp" (sharp and clear-edged), and something that no echo chamber could even achieve – selectable delay. A clarinet, for example, can be given the attack of a trombone with the bell of a sousaphone, and yet retain the clarinet's characteristic playing facility ■.

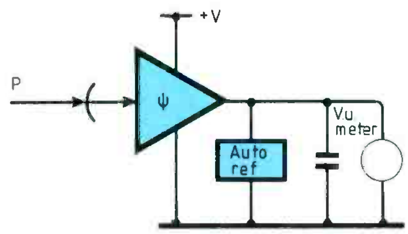


Fig. 6. Signal-conditioned type LX1801 eliminates much s.p.l. meter circuitry, though auto-referencing circuitry is required for errors of less than 3%.

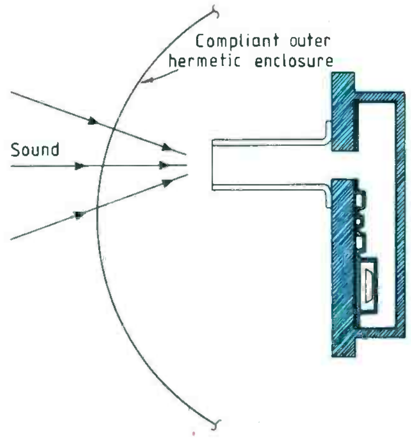


Fig. 7. Absolute pressure types are required for underwater use, for exmaple SCX01DN.

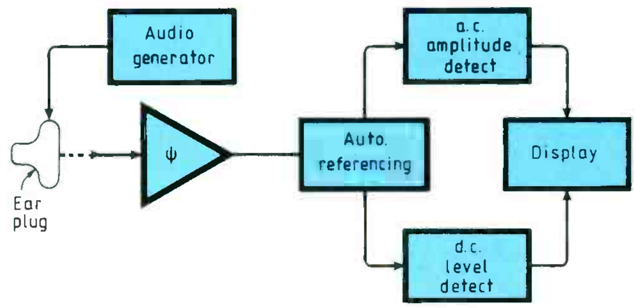


Fig. 8. Instrument determines reponse of human ear for both dynamic and static pressure using transducer type SCX01DN.

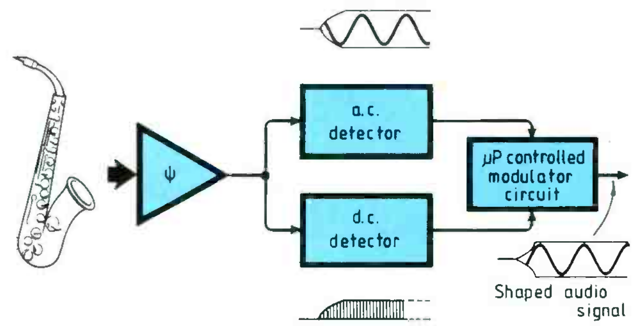
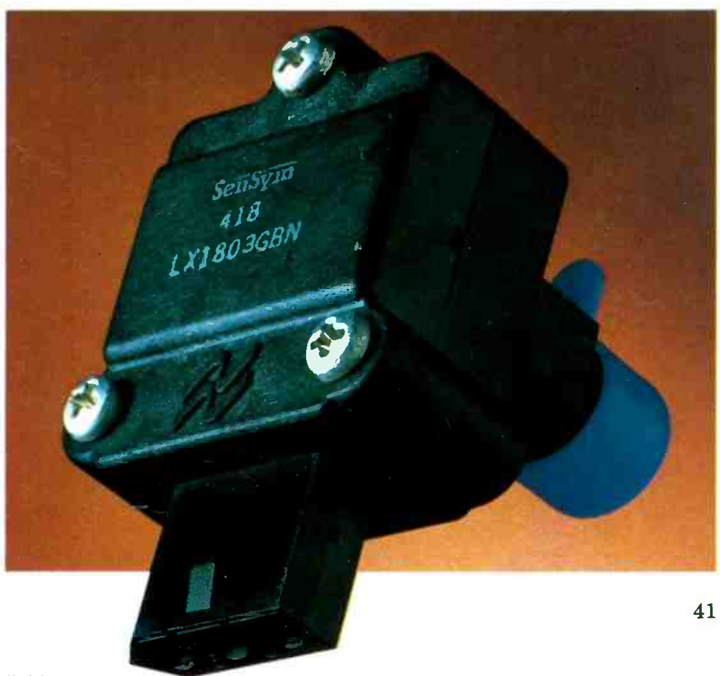
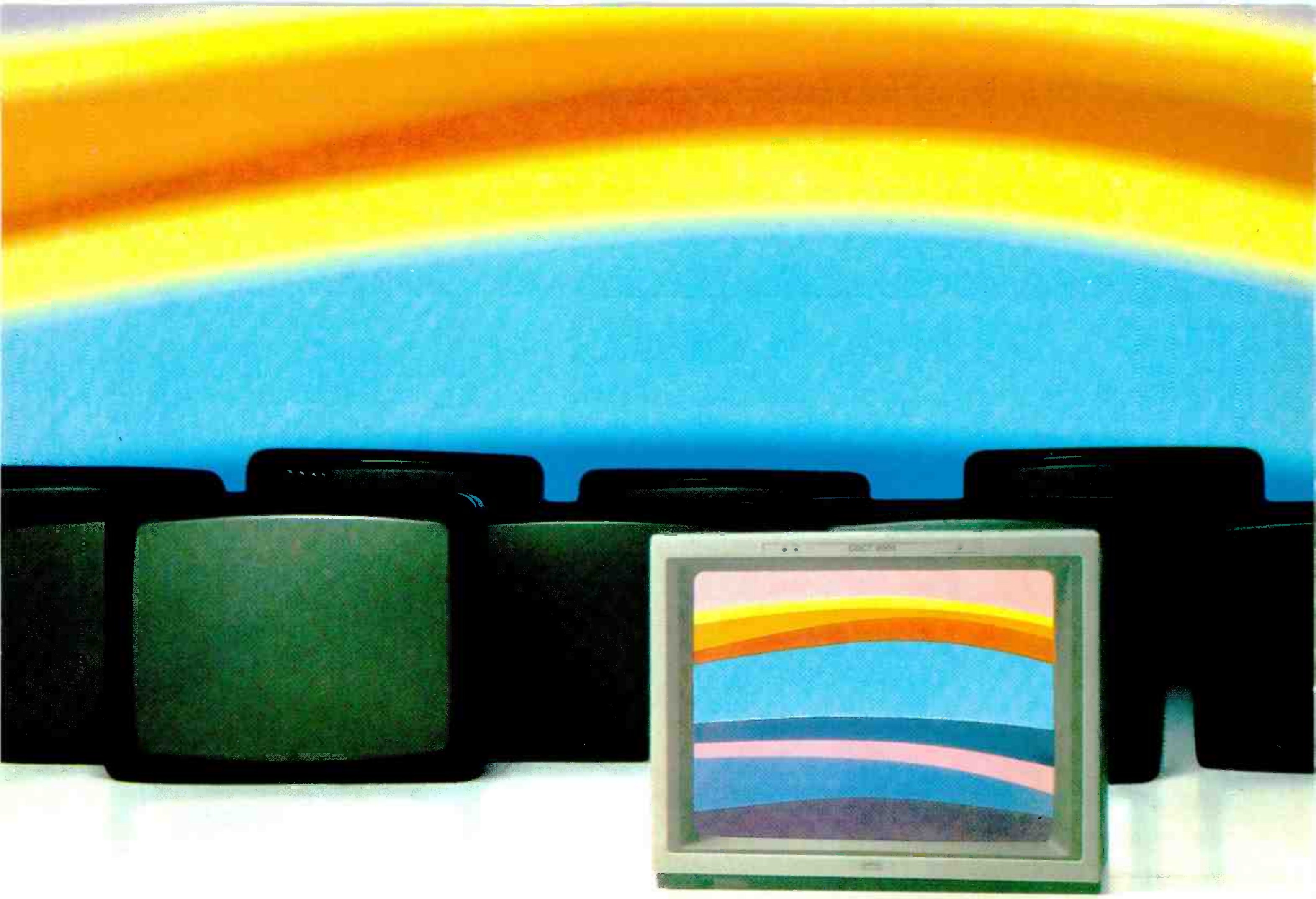


Fig. 9. Microprocessor-controlled modulation can give an selectable delay and tonal quality to an instrument.





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CIRCLE 22 FOR FURTHER DETAILS

Designing with dynamic memory

by Alan Clements, Ph.D
Teesside Polytechnic

Large memory arrays can be produced economically with dynamic ram provided care is taken over timing requirements, refreshing and the supply rail. Part 3 concludes the series.

The three parts of this article are based on part of a book 'The 68000: software, hardware and interfacing' to be published next spring by PWS Boston, who are represented in the UK by Wadsworth International.

The simplified circuit diagram of the dynamic refresh generator on the 68000 board is given in Fig. 20, and its timing diagram in Fig. 21. A refresh clock operating at 7.54kHz signals the need for a burst of refresh cycles every 1/(7.54 × 103) = 0.133 ms. This design does not carry out all refreshes in one burst – it performs eight cycles every 0.133ms, completing all 128 row refreshes in 0.133 × 16 = 2.128ms. By distributing the refresh operation over 16 bursts of eight cycles, the processor is not held up for any appreciable length of time.

The refresh control circuitry on the board uses the 68000 bus arbitration signals, $\overline{BR}$ (bus request, $\overline{BG}$ (bus grant) and $\overline{BGACK}$ (bus grant acknowledge). When $\overline{BR}$ is asserted by a device wishing to control the system bus, the 68000 responds by asserting its $\overline{BG}$ output. The requesting device recognizes $\overline{BG}$ and then waits until the end of the current bus cycle before asserting $\overline{BGACK}$ to claim ownership of the bus. Once $\overline{BGACK}$ has been asserted, the requester may release $\overline{BR}$ and the old master releases $\overline{BG}$. The new master owns the bus until it releases $\overline{BGACK}$.

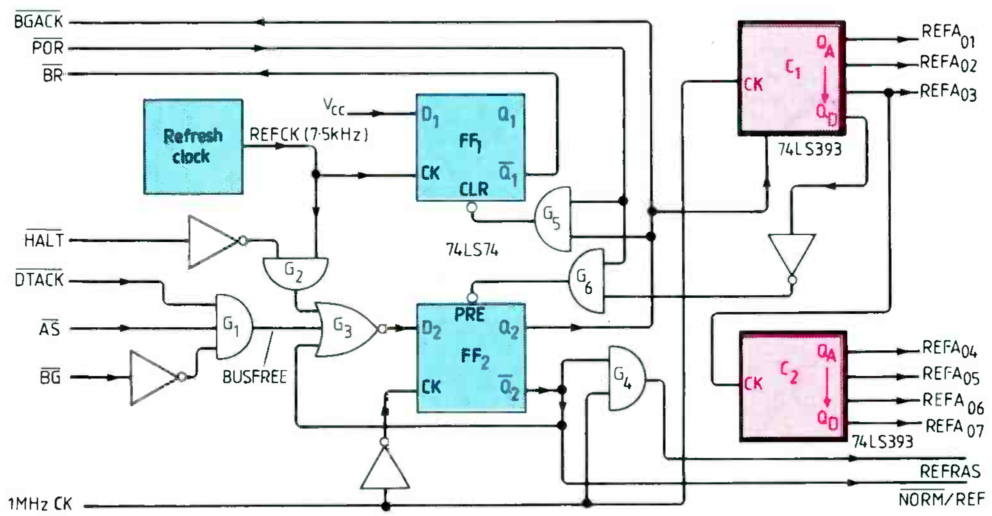
A power-up, $\overline{POR}$ (power-on-reset from the processor control circuitry) goes low, clearing FF_1 setting FF_2. Any well-designed circuit should be similarly initialized and placed in a "safe state". In this state, $\overline{Q}_1$ (i.e. $\overline{BR}$) is negated and $\overline{Q}_2$ (i.e. $\overline{NORM/RE}$) is low, signifying normal operation. When the refresh clock, a simple RC oscillator, generates a rising edge, FF_1 is set and $\overline{BR}$ asserted. The 68000 detects the bus request and asserts bus grant $\overline{BG}$ and-gate G_1 detects the condition $\overline{BG}$ = 0, $\overline{AS}$ = 1 $\overline{DTACK}$ = 1, which occurs when the 68000 has relinquished the bus and forces input D_2 of FF_2 low. Note that the other two inputs to nor-gate G_3 (at this time) are both low – one because we will assume $\overline{HALT}$ is negated and the other because $\overline{Q}_2$ ($\overline{NORM/REF}$) is low after FF_2 has been preset.

When D_2 is low, FF_2 is cleared on the falling edge of the 1MHz clock. Output Q_2 is connected to the 68000 bus $\overline{BGACK}$ input and, while low, stops the processor from regaining control of the bus. At the same time, it forces the output of and-gate, G_5 low, clearing FF_1 and negating $\overline{BR}$. Thus FF_1 has done its job in this burst of refresh cycles and is once more in its initial state. When FF_2 is cleared, its $\overline{Q}_2$ output goes high; it is also the $\overline{NORM/REF}$ line controlling the address multiplexer to the ram array. When high, $\overline{NORM/REF}$ selects the address from the refresh column-counter (i.cs C1 and C2).

The output $\overline{Q}_2$ is also fed back to the D_2 input of FF_2 via or-gate G_3, so that once $\overline{Q}_2$ is high the flip-flop is held in this state and no longer depends on the state of $\overline{BG}$ from the processor, as $\overline{BG}$ is automatically cleared following the negation of $\overline{BR}$. Flop-flop 2 is now "locked up", $\overline{Q}_2$ high, and can only be released by the assertion of its $\overline{PRE}$ (preset) input.

The final role played by $\overline{Q}_2$ is to gate the 1MHz clock in and-gate G_4, the output of which is the pulsed $\overline{RAS}$ needed in the refresh cycle. Because $\overline{Q}_2$,

MEX68KECB, referred to in September's article, is Motorola's 68000 educational computer board, requiring power supply and v.d.u. terminal. The ECB has powerful monitor called Tutor which enables 68000 programs to be entered, debugged and executed. Although now somewhat dated its monitor is the basis of most educational and training systems on the market.



C_1 & C_2 are counters which provide the dram array with a 7-bit refresh address $REFA_{01}$ – $REFA_{07}$

Fig.20. Dynamic refresh generator on the 68000 educational board distributes refresh operation over 16 bursts of eight cycles so that the processor is not held up appreciably. Timing diagram is at Fig.2, over.

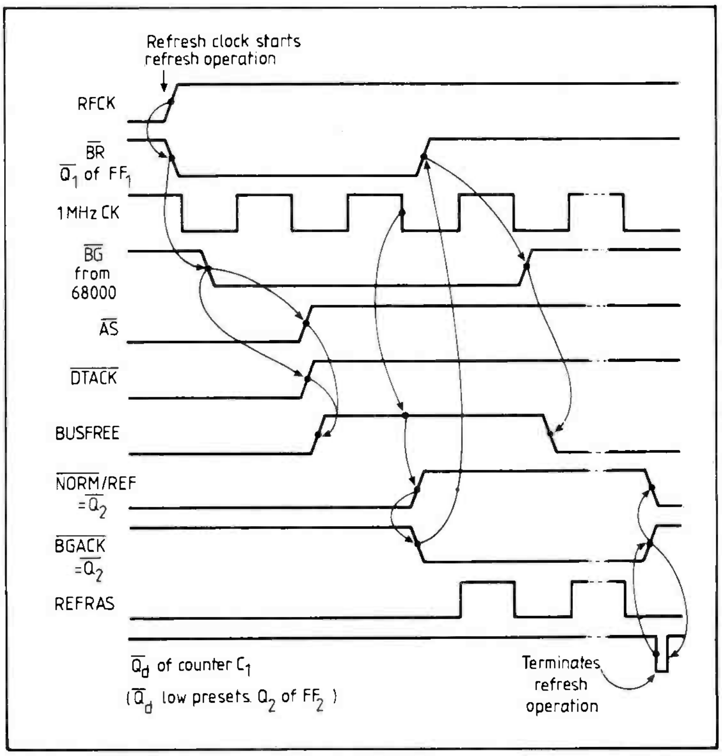


Fig.21. Timing diagram for Fig.20.

when low, allows counter C1 to operate, three bits of the refresh address appear on $REFA_{01}$ to $REFA_{02}$ which form part of the dynamic ram's row refresh address. This counter is clocked at the refresh rate – 1MHz. A second-state counter, C2, is clocked by C1 after eight cycles and provides the remaining four row refresh addresses – $REFA_{03}$ to $REFA_{07}$.

After the three-bit counter C1 has produced eight pulses, its Q_d output rises and disables and-gate G_5. This presets FF2, causing Q_2 (i.e. $\overline{BGACK}$) to be negated, freeing the processor by releasing $\overline{BGACK}$ and $\overline{Q_2}$ (i.e. NORM/REF) to go low, disabling and-gate G_4 and removing the refresh clock ($\overline{REFRAS}$). The system is now in its normal state, with $\overline{BR}$, $\overline{BG}$ and $\overline{BGACK}$ all negated. The only change since the start of the cycle is that counter C2 has been advanced by one, so that the next time the refresh clock generates a pulse, the following eight row addresses will be refreshed.

TMS4500A dynamic ram controller

I have always been surprised that the semiconductor manufacturers have done so little to make it easy to interface drams to microprocessors. Some d-ram controller chips have appeared, but most of them perform little more than address multiplexing and the generation of a refresh address. The designer still has to generate the $\overline{RAS}$, $\overline{CAS}$ and multiplexer timing signals. To be fair, it is not easy to design a d-ram controller because the timing requirements of d-ram chips are very stringent if they are to be operated at their limits.

Several controllers have been designed which include all timing and control functions on one chip and which can make a d-ram array look almost like a static ram array. One such device is the Texas Instruments TMS4500A. I am going to briefly overview the chip, but I do not intend to wade through the data sheet and applications manual in any detail here. Figure 22 illustrates its structure. A 16-bit address from the microprocessor is applied to RA_0 – RA_7 and CA_0 – CA_7 and is latched into the controller by the address latch enable input, ALE. If the $\overline{CS}$ input is active-low when it is latched by ALE, a memory access begins.

The 4500 places the row address on its MA_0 – MA_7 outputs and awaits a negative-going edge at its $\overline{ACR}$ or its $\overline{ACW}$ input. These inputs (one for a read cycle and one for a write cycle) are used to multiplexer the column address onto MA_0 – MA_7 and to assert the $\overline{CAS}$ output. All timing is performed by a clock input to the 4500. Three of the inputs, TWST, FS_0 and FS_1 are used to program the clock frequency, the number of wait states per access (zero or one) and the length of the refresh cycle.

Although a refresh can be forced at any time by strobing the $\overline{REFREQ}$ pin, it is convenient to operate the 4500 in a hidden refresh mode. the 4500 performs a single refresh automatically at a rate determined by the clock input and its programming pins. If the controller is accessed by the processor when a refresh is due, either the processor or the controller must wait. An internal arbitration mechanism determines which goes first.

The recommended interface between a 4500 and a 68000 microprocessor is show in Fig. 23. The address on A_{01} – A_{16} from the 68000 is latched into the 4500 by $\overline{AS}$. The $\overline{ACR}$ input is clocked by a delayed version of the $\overline{AS}$ pulse, providing a suitable $\overline{RAS}$ to CAS delay.

Note that $\overline{ACW}$ is permanently connected to V_{cc}. Two banks of d-ram are provided; one strobed by $\overline{LDS}$ and one by $\overline{UDS}$. A clever feature of this circuit is that the $\overline{DTACK}$ acknowledge to the 68000 is derived from $\overline{CAS}$ from the 4500

continued on page 46

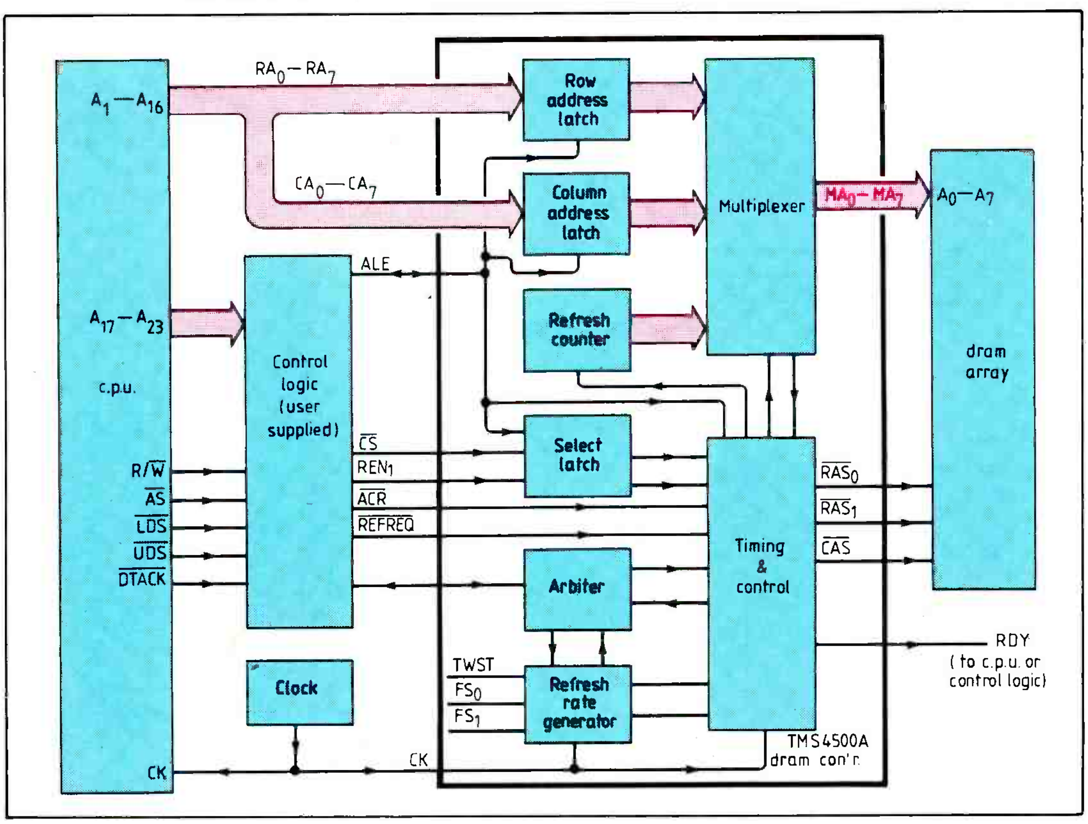


Fig.22. Structure of TMS4500A dynamic ram controller which produces additional MUX, CAS and RAS signals, and generates refresh control and arbiration signals required by the d-ram.

IBM's PC filing system

by Frances Stubbs, Ph.D.

This description of PC DOS – a version of MS DOS – complements last years series on floppy disc filing systems for microcomputers.

Disc operating systems insulate the user from that way the data is stored on the disc, and allow the manipulation of sets of data (files) simply by referring to their names and common English words such as LIST, COPY and ERASE.

Floppy discs are divided into concentric tracks, each divided into radial slices (sectors). A sector is of a fixed size for a particular system, for example, a PC DOS sector contains 512 bytes of useful data. The sector also contains the track number and sector number for identification, the sector size, and cyclic redundancy checking information, used to check whether data has been read or written correctly. A file may occupy one or a number of sectors, which may be contiguous or scattered over the disc. The user does not have to worry about this, as the DOS keeps a directory of all the files on the disc, and which sectors each occupies.

IBM's PC DOS associates corresponding tracks on opposite sides of the disc to form a cylinder, which allows two tracks to be read from the disc without any movement of the read/write head, with a consequent increase in speed over systems which use the two sides of the disc separately, for example CP/M. A PC DOS disc contains 40 cylinders, consisting of one track on each side of the disc, or one track only if the disc is a single-sided one. Each track is divided into 9, 512 byte sectors. (Earlier versions had only eight sectors per track).

The directory

A disc operating system keeps a directory on the disc of all the files together with information about which sectors each occupies. This is analogous to the index of a book which contains the chapter titles and the page number where the start of each chapter is to be found. Usually a chapter in a book occupies a number of consecutive pages, but this is not always the case on a computer disc; sectors occupied by a file may be scattered randomly over the disc. How PC DOS uses the file allocation table (FAT) to overcome this difficulty is shown later.

In PC DOS the directory information (and some other system information) is always found in a fixed place on the first cylinder, and the rest of the disc is available for file data. This file space is divided into clusters, analogous to pages in the book. A cluster consists of two consecutive sectors. (On a single-sided disc a cluster contains only one sector.) The clusters are numbered, starting at cluster number 2, which starts immediately after the directory.

Directory format

The directory occupies seven sectors, starting with sector 6 of the first cylinder (sector 4 on eight sector/track discs). Each entry occupies 32 bytes as follows:

Byte no.	Content
00-07	File name
08-10	Extension
11	Attribute byte: 1 = hidden file 2 = system file
12-21	Not used = 00
22-23	Time = h × 2048 + min × 32 + sec/2
24-25	Date = (yr − 1980) × 512 + month × 32 + day
26-27	Number of first cluster occupied
28-31	File size (bytes)

Each of the seven directory sectors can contain up to 16 file names, thus a disc may contain up to 112 files.

File name and extension

The file name is supplied by the user when the file is written on the disc, for example by using the SAVE command, and consists of up to eight characters padded by spaces, followed optionally by an extension of up to three characters, also padded by spaces. The extension is sometimes used to denote special types of files such as BAS for Basic files, ASM for assembly language source files, and EXE for executable machine code files. A character is represented by a byte of data, according to ascii.

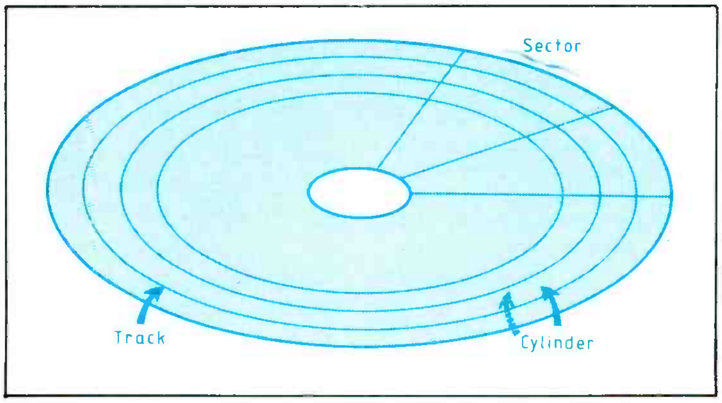
Attribute byte: Enables the DOS to identify files which must be protected in some way from user interference. Not all of the attribute byte is used. If the first (least significant) bit is set (=1) the file is a hidden file and will not appear if DOS is asked to list the directory. Bit 2 set denotes a system file as distinct from a user file. A system file may also be hidden.

Time and date: These entries contain the date and time at which the file was created in coded form, for reference.

File allocation table

Entry (cluster)	Value	Meaning
0	FFF	Double-sided, 8 sectors
	FFE	Single-sided, 8 sectors
	FFD	Double-sided, 9 sectors
	FFC	Single-sided, 9 sectors
1	FFF	Filler
2	003	Pointer to the next cluster
3	004	Pointer to the next cluster
4	005	Pointer to the next cluster
5	FFF	Last cluster in this file
6	000	Unoccupied cluster
7	000	Unoccupied cluster
8	FF7	"Bad track" cluster

Frances Stubbs is a freelance programmer/analyst and microcomputer enthusiast, having pre7iously worked in Geneva at CERN. His degrees are in physics from Durham University.



File size: Contains the size of the file in bytes and used to find the actual size of the file if the last cluster is not full.

First cluster number: Number of the first cluster occupied by the file. Then DOS goes to file allocation table (FAT) to find where on the disc the rest of the file is.

File allocation table: The disc contains two copies of the FAT, starting at sector two of the first cylinder, each copy occupying two sectors (only 1 sector is needed for eight sector/track discs).

The file allocation table is a map of the total disc space available for files, and contains an entry of three hexadecimal digits for each cluster on the disc. The directory contains the number of the first cluster occupied by a file; the FAT entry for that cluster contains a pointer to the next cluster in the file, and so on.

If the cluster is the last one in the file, the entry is FFF. In this way the DOS can trace the sequence of clusters which make up a file, no matter where they are on the disc. The entry for unoccupied clusters is 000. If a cluster has been damaged in some way so that the DOS cannot successfully read or write to it, the entry is FF7, and PC DOS does not use clusters marked in this way.

If the FAT is displayed on a v.d.u. it is not immediately obvious what it means, because a byte is displayed with the most significant digit in the left-hand position. For example, 12 means 2 in the 'ones' column and 1 in the '16's' column. This is the 'obvious' way for human beings, as it is the way we write decimal numbers. But on a floppy disc or in a computer memory the least significant digit is written first. Taking the example of file allocation table entries shown, the entries for the first file would be written as

300 400 500 FFF

or rather 300400500FFF

as the spaces are not there. Now as data is usually written to a v.d.u. as bytes (two hex. digits), with the most significant digit appearing first for convenience, this would then appear as

03 40 00 05 F0 FF.

Erasing files

When a file is erased from the disc the first letter of the filename in the directory is changed to E5, and the FAT entries for all the clusters which it occupied are changed to zero. The directory space and the file space which the file occupied are now available for further use. (Because the FAT entries are changed to zero the information about where the file was is lost, thus unlike CP/M where this information is retained when a file is erased, PC DOS files cannot easily be 'unerased'.)

Tree directory

More recent versions of PC DOS also support a tree directory structure. In this system the directory is called the root directory, and may contain files which are themselves directories (subdirectories). An entry in the directory is flagged as a subdirectory name by having bit 4 of the attribute byte set. The subdirectory is now a file in normal file space. It has the same structure as the root directory, but can be any length. And it may itself contain further subdirectory names.

Each subdirectory contains two entries created by the DOS to allow it to determine the position of the subdirectory in the 'tree'. The first of these is an entry whose name is ".", and which points to the first cluster of the subdirectory itself, and the second is an entry whose name is "..", and which points to the first cluster of the parent directory. These two entries also have bit 4 of the attribute byte set.

The tree directory structure allows any number of files to be stored on a disc and is particularly useful where hard discs with their much larger storage capacity are used. ■

Designing with dynamic memory

continued from page 44

controller. If ever the 4500 is carrying out a refresh cycle when the 68000 requests a memory access, $\overline{CAS}$ remains high until the refresh has been completed and the 68000 is held up until the access can take place.

There are two approaches to the design of memory systems using controllers such as the TMS4500A. One is to assume that the circuit of Fig. 23 will work because it is from the manufacturer's application notes. The other is to take the data sheets of the 68000, the 4500 and the d-ram chip and to put them all together to determine whether any parameters are violated.

Problems in dynamic memory design

Although this article has concentrated on timing diagrams, that is not the whole of the store. Dynamic ram is associated with at least two other nasty problems! the current taken is very "bursty" and the current taken by the V_{cc} pin can rise at a rate of 50mA/ns when the $\overline{RAS}$ input is asserted. This corresponds to a rate of change of 50 million amps per second. Such a rate of change can cause the V_{cc} voltage at the terminal of the chip to fall to a point at which erratic operation may occur. The power supply problem is solved by a combination of attention to the circuit layout and to decoupling. The power lines to each ram chip are made as wide as possible to reduce their impedance and a 0.1μF capacitor is connected between ground and V_{cc} at each chip – or at least at every other chip. This capacitor provides the current surge required by the chip whenever $\overline{RAS}$ goes low.

Another peculiarity of the dynamic ram follows from the way in which it generates an internal back-bias supply. The back-bias does not stabilize for at least 200μs after the initial application of V_{cc}. Therefore, d-ram should not be accessed until at least 200μs after the system has been powered up. ■

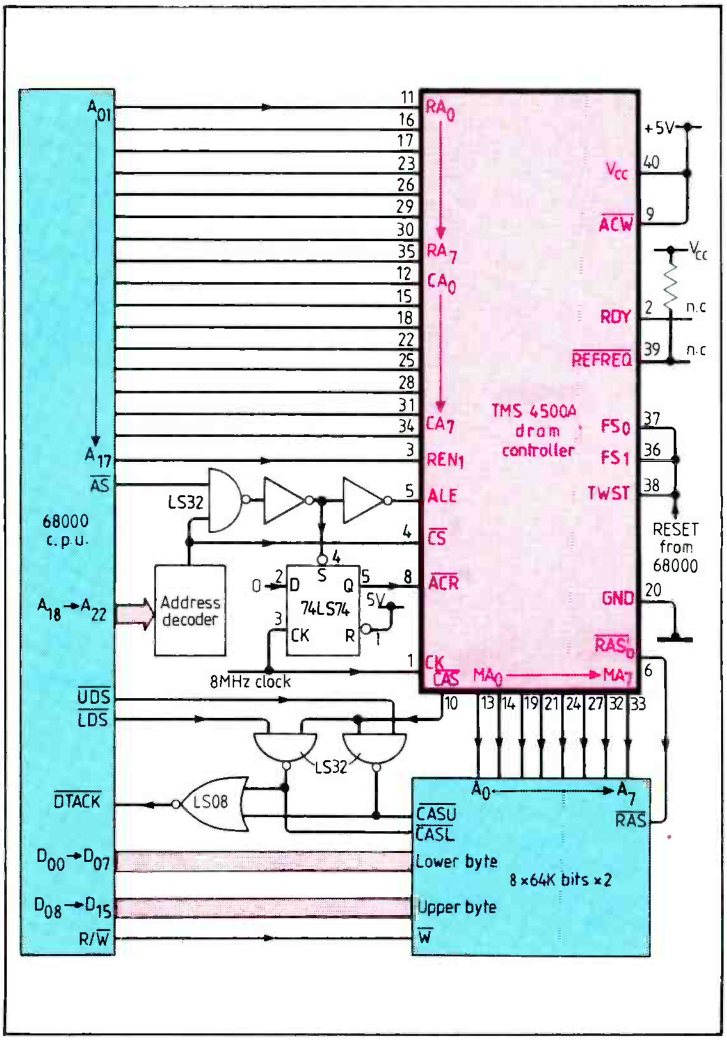


Fig.23. The TMS4500A dynamic ram controller allows the 68000 processor to be connected to d-ram in almost the same way as static ram.

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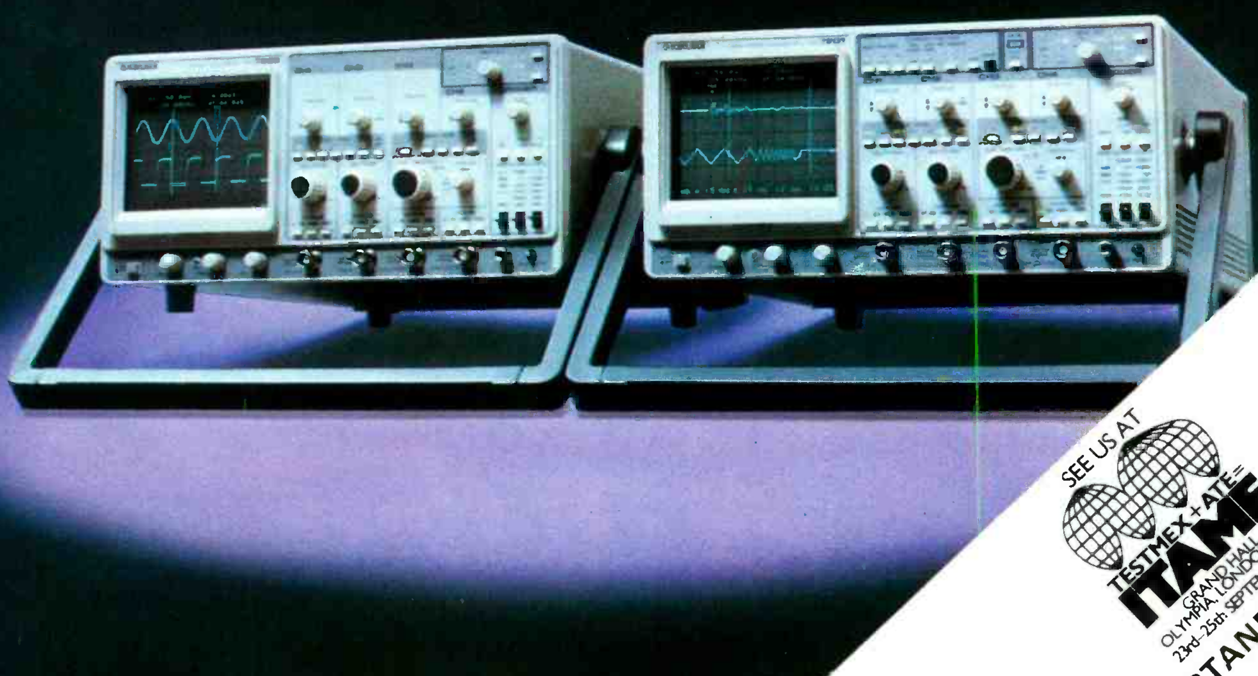

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Oscilloscope update

Speed and accuracy improve slightly but oscilloscopes are much better at displaying difficult waveforms.

Over the past few years, oscilloscopes have become a little faster but their ability to display difficult waveforms has improved significantly. Accuracy has not improved greatly either, mainly because of limitations of the c.r.t.

Instead, there is now a greater emphasis on built-in measurement aids like voltage and frequency meters whose results are displayed on the c.r.t. Custom i.cs and digital logic are not only used in digital storage oscilloscopes.

Some new oscilloscopes even have auto-ranging for both amplitude and timebase. This need not cost the earth either. For example the Grundig MO22 has automatic timebase selection and costs £425, which is not much more than a standard 20MHz instrument.

There are few single-channel oscilloscopes now and features like channel add and invert are standard. And, as expected, digital storage is becoming cheaper – Hameg and Farnell for example have d.s.os for under £1000.

Digital storage oscilloscopes cannot yet replace conventional real-time instruments, but the time will no doubt come. Hewlett Packard has stopped producing real-time oscilloscopes because d.s.os are better value for money. If component costs keep falling, this will soon apply to oscilloscopes in lower price ranges.

As you can see from our table, Scopex has produced no new instruments, but we believe that the company is working on digital storage. If you are thinking of buying a low-cost digital storage oscilloscope it may be worth waiting to see what the company's next new product is.

Display

Despite the fact that custom l.s.i. circuits are being used in oscilloscopes, the c.r.t. still remains the best display device. The main change in the display over the past few years is the addition of colour.

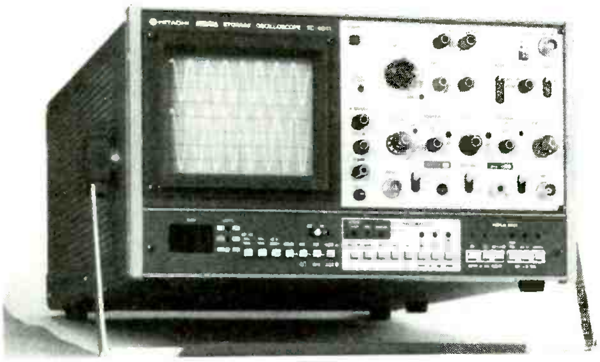
One method of adding colour is to place a fast l.c.d. filter in front of the c.r.t., as used by Tektronix. A method more suited to digital-storage oscilloscopes is to use a colour raster-scan c.r.t., as Hewlett Packard do in some of their new models. Once the waveform is digitized, it is just as easy to make raster-scan video signals from it as it is to turn it back to analogue form, given today's digital control i.cs. And, theoretically at least, raster-scanning allows an unlimited colour range.

Another advantage of the raster-scan method is that it ►

Storage oscilloscopes

Model	Chan.	Samp. rate max. MHz	Res. bits	Mem. K-byte	Ana. b.w. MHz	Single shot b.w. MHz	Pre-trig.	Trace exp'n hor./vert.	Stored wave-forms	Inter-pol'n	Curs.	Aver-aging	Time/volts disp.	GPIB	Pen rec. o/p	RS 232	Price £	Notes
ADVANCE																		
DS1525A	2	2	8	4	20		■	16/-		■							995	Analogue output
DS1526	2	2	8	4	20		■	16/-		■							995	HPGL serial
DS1527	2	2	8	4	20		■	16/-		■							995	GPIB interface
GOULD																		
4050	2	100	8	1	35		■	10/-	2	■	■	■	■	■	■		6320	Waveform proc. option
HAMEG																		
HM205	2	0.1	8	2	20				2						Opt		448	2mV/division vertical
HM208	2	20	8	4	20	5	■	10/-	4	■				Opt	■		1300	Battery-backed memory
HEWLETT PACKARD																		
HP5180T	2	20	10	~16	10	10	■	■	4	■	■	■	■	■			24384	High accuracy waveform analyser
HP5180U	4	20	10	~16	10	10	■	■	4	■	■	■	■	■			39971	High accuracy waveform analyser
HP5183T	2	4	12	<512	1	1	■	■	4	■	■	■	■	■			16675	High accuracy waveform analyser
HP5183U	4	4	12	<512	1	1	■	■	4	■	■	■	■	■			25054	High accuracy waveform analyser
HP54100D	2	40	7	~1	1G	10	■	■	2	■	■	■	■	■			16685	For repet. waveform; high speed
HP54110D	as HP54100D but colour																18249	
HP54200A	2	200	6	~1	50	50	■	■	2	■	■	■	■	■			4650	
HP54201A	as HP54200A but 300MHz analogue bandwidth																6778	
HITACHI																		
VC6020	2	1	8	2	20	150k	■	10/-	2					■	■		1395	Analyser & roll modes
IWATSU																		
DS8123	2	25G	8	0.5	100	100			2				■	■			12435	
DS6121	2	40	8	2.5	100	10	■	10/-	4	■	■	■	■	■	■	■	4335	100MHz equiv. sampling
KIKUSUI																		
DSS6520	2	2	8	1	20	100k	■		2		■		■	Opt	■		2650	Ext. clock, roll mode
DSS6521	2	2	8	1	20	100k	■		2					Opt	■		1895	Ext. clock, roll mode
DSS5020A	2	1	8	2	20	50/400k	■	100/-	2	■					■		1145	Two a-ds, ref. store
DSS5040	2	25	8	2	40	1.25/10	■	100/-	2	■					■		1595	Two a-ds, ref. store
COM7061	4	20	8	4	60	1/8/60	■	100/-	4	■	■		■	■	■		3460	Counter/d.v.m. display

HITACHI OSCILLOSCOPES



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CIRCLE 62 FOR FURTHER DETAILS

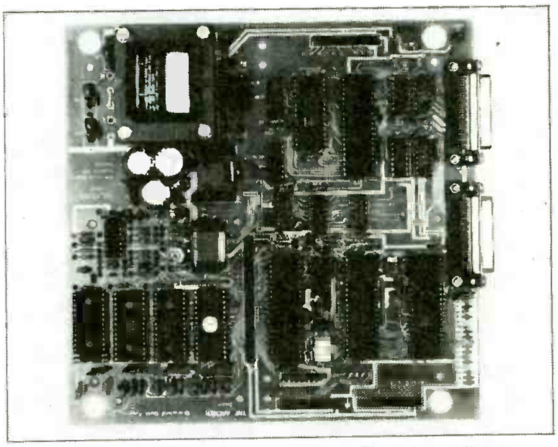
The Archer Z80 SBC

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.



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 25 FOR FURTHER DETAILS

Sherwood Data Systems Ltd

Sherwood House, The Avenue, Farnham Common, Slough SL2 3JX. Tel. 02814-5067

Storage oscilloscopes

Model	Chan.	Samp. rate max. MHz	Res. bits	Mem. K-byte	Ana. b.w. MHz	Single shot b.w. MHz	Pre-trig.	Trace exp'n hor./vert.	Stored wave-forms	Inter-pol'n	Curs.	Aver-aging	Time/volts disp.	GPIB	Pen rec. o/p	RS 232	Price £	Notes
COM7101	4	50	8	4	100	2.5/100	■	100/-	4	■	■		■	■	■		4950	Counter/d.v.m. display
COM7201	4	50	8	4	200	2.5/100	■	100/-	4	■	■		■	■	■		5950	Counter/d.v.m. display
LEADER																		
LBO582S	2	5	8	2	35		■	■	2					■	■		2300	
LeCROY																		
9400	2	100	8	64	125		■	100/-	250	■	■	Opt.	■	■		2	8275	Software opts, 2% err.
																	10615	As above but 1% error
MEGURO																		
MSO1270A	2	2	8	2	20	0.3	■	160/-	4	■	■				■		1399	Roll mode
NICOLET																		
110	2	1	8	1	20	0.2	■	100/-	2	■			■		■		1395	Gen. purpose portable
320	2	10	8	16	25	2	■	400/8	4		■		■	■	■	■	6950	Waveform processing; bubble memory option
370	2	1	10	16	0.3	0.2	■	400/8	4		■	■	■	■	■	■	9950	Signal averaging; bubble memory option
2090	2	50	8	4	25	10	■	64/64	8		■		■	Opt	■	Opt	8900	Disc drive option
PANASONIC																		
VP5740P	2	100	8	30	100	35	■	100/10	10	■	■	■	■	■	■		9785	Waveform transforms
VP5730P	2	100	8	2	100	5		10/10		■	■	■	■	Opt	■		3940	Go/no-go testing
PHILIPS																		
PM3305P	4	2	8	4	35	0.25	■	-/40	4					■	Opt		2450	
PM3310	2	50	8	1	60		90%	2.5/5	4	■			■	Opt	■		4250	
PM3311	2	125	8	1	60	30	90%	2.5/5	4	■			■	Opt	■		4500	
TEKTRONIX																		
2220	3	20	8	4	60	2	■	10/-	1	■		■		Opt	■	Opt	2650	Digital, non-storage
2230	3	20	8	4	100	2	■	■	4	■	■	■	■	Opt	■	Opt	3950	Cursors, c.r.t. readout
2430	4	100	8	1	150	10	■	■	6	■	■	■	■	■	■		7750	Dual acquisition
TRIO																		
MS1660	2	1	8	2	20		■	■/-			■			■	■		2750	Dual timebase
MS1665	2	1	8	2			■	■/-			■			■	■		2350	Module, dual timebase
AWR TECHNOLOGY																		
Microview	2	0.1	8														150	Adapter for BBC Micro

gives manufacturers a wide choice of component sources, which is not the case with l.c.d. filters.

One potential disadvantage is loss of resolution. Using an l.c.d. filter, resolution is that of the monochrome tube whereas with a colour c.r.t., resolution is governed by the number of dots on the tube. In practice though this is not a problem because the digital oscilloscopes using raster-scan c.r.ts allow zooming.

New facilities

For c.c.tv and computer servicing, Crotech has produced a 30MHz dual-trace oscilloscope that is, surprisingly, claimed to be the first that can display composite 625-line video signals as pictures. This simple addition removes the need for a video monitor.

Multi channel monitoring is the speciality of the Data Check 1880 which displays up to fourteen channels in bar-graph form or displays the waveform of one of 28 channels. Using scanning for waveform monitoring removes the need for reconnecting probes. For many applications though, the 1880's price of £5000 makes it less attractive than a few conventional real-time oscilloscopes with input multiplexers.

Both 488 and BBC computer interfaces are fitted to the Farnell 12MHz DTS12T, which is probably the cheapest digital-storage oscilloscope with computer interfacing. Software for bidirectional data transfer is supplied on floppy disc and an f.f.t./waveform analysis rom/disc package is £70. At £1195, the 12T brings computer waveform analysis within the reach of many educational users.

One example of oscilloscopes with built-in measurement devices mentioned earlier is the V1100A. This 100MHz real time instrument gives on-screen display of direct/ ▶

Non-storage oscilloscopes

Model	Y b.w. MHz	Y sens. mV/div	Chan.	Sweep max. ns/div	Sweep dual/delay	Y delay	TV sync.	Screen size cm	Acc. pot'l kV	Price £	Notes
BECKMAN INDUSTRIAL											
9020	20	0.5	2	10	■			10x8	2	319	Variable hold-off
9060	60	5–0.1	3	20(x10)	■	■	■	15.2	12	1095	Linear focus control
9100	100	5–0.1	3	50(x10)	■	■	■	15.2	18	1495	Linear focus control
CROTECH											
3337	30	5	2	40	■	■		10x8	10	425	Single-shot, XYZ mod. comp. trigger
3339	30	5	2	40	■	■	■	10x8	10	570	VDU mode, component tester
3031	20	2	1	40				10x8	1.5	195	Component tester, auto-trigger
3036	20	2	1	40				10x8	1.8	216	Component tester, auto-trigger
DATA CHECK											
1880	3	10	1/28	1000				10x8		$7712	Multi-channel monitor; scan mode

Model	Y b.w. MHz	Y sens. mV/div	Chan.	Sweep max. ns/div	Sweep dual/ delay	Y delay	TV sync.	Screen size cm	Acc. pot'l kV	Price £	Notes
FEEDBACK											
DOS650	15	5	2	500			■	10x8	1.8	275	Component tester built in
GRUNDIG											
M020	20	2	2	50 (x10)			■	10x8	2	299	Add, invert, X-Y, auto peak trigger
M022	20	2	2	50 (x10)	■		■	10x8	2	425	Auto timebase, Z mod., hold-off
M053	50	2	2	10 (x10)	■	■	■	10x8	11	995	Auto timebase with digital display
HITACHI											
V223	20	5 (x5)	2	200 (x10)			■	10x8	2	450	Trigger delay
V225	20	5 (x5)	2	200 (x10)			■	10x8	2	550	Settings display, cursors
V423	40	5 (x5)	2	200 (x10)		■	■	10x8	12	650	Trigger delay
V425	40	5 (x5)	2	200 (x10)		■	■	10x8	12	695	Settings display, cursors
V680	60	5 (x5)	3	50 (x10)	■	■	■	10x8	12	1295	Freq./V/function screen display
V1100A	100	5 (x/5)	4	20 (x10)	■	■	■	10x8	18	2390	Freq./V/function screen display
V1150	as 1100A but 150MHz bandwidth									2950	
HAMEG											
HM203-6											
IWATSU											
SS5705	40	1 (x5)	2	10 (x10)	■		■	10x8	12	620	General purpose
SS5706	30	1 (x5)	2	20 (x10)			■	10x8	12	495	
SS5712	200	1 (x5)	4	10 (x10)	■		■	10x8	20	2500	Trigger delay
KIKUSUI											
COS6100	100	5 (x5)	5	20 (x10)	■	■	■	10x8	20	2250	Military version of 6100A
COS5042	40	5 (x5)	3	50 (x10)	■	■	■	10x8	12	685	Eight traces, X-Y trigger hold off
COS5100	100	5 (x5)	3	20 (x10)	■	■	■	10x8	18	1095	Eight traces, X-Y trigger hold off
COM7060	60	1	4	5	■	■	■	10x8	12	1835	Freq./V/funct. display, GPIB option
COM7100	60	1	4	2	■	■	■	10x8	20	2775	Freq./V/funct. display, GPIB option
COM7200	200	1	4	1	■	■	■	10x8	20	3675	Freq./V/funct. display, GPIB option
LEADER											
LBO310A	4	20	1					6x4.8	1.2	189*	
LBO323	20	1	2	40			■	9.5	1.7	875*	X-Y, add, alternate, chop
LBO324	40	1	2	20	■		■	9.5	12	1050*	X-Y, add, alternate, chop
LBO325	60	1	2	20	■		■	9.5	12	1675*	X-Y, add, alternate, chop, 4kg
LBO510A	4	20	1					10x8	1.5	230*	
LBO512B	10	10	1	10000				10x8	1.3	290*	
LBO514A	15	1	2	100			■	10x8	1.8	360*	X-Y, chop, alternate
LBO516	100	0.5	3	2	■	■	■	10x8	20	1490*	X-Y, eight traces
LBO518	100	0.5	4	2	■	■	■	10x8	20	1575*	X-Y, eight traces
LBO522	20	0.5	2	40			■	10x8	2	395*	Chop, alternate, add, invert
LBO524	40		2	20	■	■	■	10x8	7	655*	Chop, alternate, add, invert
LBO526	60	0.5	2	20	■	■	■	10x8	12	950*	
MEGURO											
MO1251A	20	1(x10)	2	20(x10)		■	■	10x8	2.1	275	XY. Hold-off. Auto trigger level
MO1253	40	1(x10)	2	20(x10)		■	■	10x8	12	455	XY. Hold-off. Auto trig. level. Sweep delay
MO1255	100	1(x5)	3	2(x10)	■	■	■	10x8	19	965	XY. Hold-off. Auto trig. level. Dual sweep
MO1252	35	1(x5)	2	20(x5)		■	■	10x8	6	360	XY. Hold-off. Sweep delay
PANASONIC											
VP5610P	100	5	3	50	■		■	7x5.8	16	2147	Auto-ranging, GPIB option, portable
VP5512P	100	2	4	20	■		■	15x15	18	1433	Eight traces
PHILIPS											
PM3050	50	2	2	5 (x10)		■	■	10x8	16	795	Auto timebase and level
PM3055	50	2	2	5 (x10)	■	■	■	10x8	16	845	GPIB option, auto timebase and level
PM3206	15	5	2	500			■	10x8	2	295	
PM3217	50	2	2	100 (x10)	■	■	■	10x8	10	1075	
PM3256	75	2	2	50 (x10)	■		■	10x8	10	1550	
PM3264	100	2	4	50 (x10)	■		■	10x8	17	3995	
PM3267	100	2	3	50 (x10)	■	■	■	10x8	10	1395	
SOLARTRON											
5070	12	5	2	1000 (x5)			■	10x8	2	1308	Bistable storage tube; compact
5220	100	5	2	50 (x10)	■	■		10x8	12	1911	Digital time, voltage measurement
5224	100	5	4	50 (x10)	■	■		10x8	12	2200	Digital time, voltage measurement
5227	100	5	3	50 (x10)	■	■	■	10x8	12	2700	Video measurements, multimeter
5228	250	2	3	10 (x10)	■	■		10x8	8	3884	Built-in multimeter
5229	500	10	2	10 (x10)	■	■		10x8	18	6020	Digital attenuator/timebase readout
5277	100	5	3	50 (x10)	■	■		10x8	10	5466	Storage tube; time/voltage readout
TEKTRONIX											
2245	100	2	4	2	■	■	■	10x8	16.5	1820	C.r.t. readout, general purpose
2246	100	2	4	2	■	■	■	10x8	16.5	2426	As above, but with "smart cursors"
THANDAR											
SC110A	10	10	1	100			■	3.2x2.6	0.5		Mains/battery portable
TO315	15	5	2	100			■	9.5	1.5		Mains/battery portable
TRIO											
CS2150	150	5 (x5)	4	20 (x10)	■	■	■	10x8	20	2165	Eight trace
CS1100	100	5 (x5)	2	20 (x10)	■	■	■	10x8	16	1320	

Model	Y b.w. MHz	Y sens. mV/div	Chan.	Sweep max. ns/div	Sweep dual/ delay	Y delay	TV sync.	Screen size cm	Acc. pot'l kV	Price £	Notes
CS2075	70	5 (x5)	4	50 (x10)	■	■	■	10x8	12	1220	
CS1065	60	1	3	50 (x10)	■	■	■	10x8	12	899	
CS1045	40	1	3	100 (x10)	■	■	■	10x8	12	729	
CS1044	40	1	2	200 (x10)		■	■	10x8	6	569	
CS1025	20	1	2	200 (x10)		■	■	10x8	6	450	
CS1021	20	1	2	500 (x10)		■	■	10x8	2	299	
CS1352	15	2	2	500 (x10)			■	7.5	1.5	499	Portable
UNAOHM											
G50	10	10	1	100				10x8	2	215	Component tester
G491	0.04	1	2	1000				18x12		872	Plug-in timebase
G508	20	5	2	500			■	10x8		439	Component tester
G4004	30	5	2	100	■		■	10x8	2	640	
G4005	50	5	2	100	■	■	■	10x8	10	780	

*Price includes probes

alternating voltage, decibel ratios, frequency, period, time delay and phase shift. All setting conditions and ground-reference information are also displayed on screen. An important advantage of having all this information displayed is that it is automatically included on any screen photographs taken.

Most computer-controlled instruments have a facility to store and recall front panel settings, which allows frequently made measurements to be carried out quickly. Auto-ranging goes a step further.

The facility is not new but nor is it common. There were problems associated with setting for low duty cycle pulses but these are now being ironed out so the numbers of auto-ranging oscilloscopes should increase.

With oscilloscopes such as the new Tektronix 2445/2465 family, pressing one button sets signal level, period, duty cycle and trigger requirements. Bandwidth of these instruments ranges from 150-350MHz and besides auto-ranging, they also allow up to 20 stored front-panel settings.

Add-ons

On the premises that dedicated f.f.t. analysers are expensive and can be difficult to use and that microcomputer add-ons are slow and given spurious results, Data Acquisition has designed an f.f.t. add-on suitable for any two-channel oscilloscope with trigger input.

This two-channel analyser, which also acts as a 50kHz-sampling digital-storage unit, can send information through a serial link to a microcomputer for further analysis or to a printer.

As a fully anti-aliased analyser, the adaptor's span is selectable from 0-20Hz or 0-20kHz with 100 or 200-line resolution and up to 256 averages can be taken. Scaling is either linear or logarithmic, with 40dB log span, and Hanning or rectangular weighting is switchable.

Cross-transfer function ability is possible using the oscilloscopes's signal add and invert facilities. The f.f.t./digital-storage adaptor will cost around £800.

For readers with a real-time oscilloscope wanting faster digital storage there's a two-channel module made by Polar with 10MHz sampling per channel and a 2K-byte memory. An RS232 interface is now available for this unit which allows waveforms to be transferred directly to a computer so a real-time oscilloscope is not essential. The polar DS102 is £575, the RS232 interface is £50 and software for the IBM PC is £25. Resolution of the 102 is eight bits.

Bandwidth of Thurlby's eight-channel input multiplexer has been increased to 35MHz. Costing £179, the OM358 displays both digital and analogue signals and has a calibrated attenuator. Any channel can be used as the trigger source. ■

Advanced Bryans Instruments (Trio, Advance), 14 Wates Way, Mitcham, Surrey CR4 4HR, 01-640 5624

Advid Electronics (Unaohm), 17A Mill Lane, Welwyn, Hertfordshire AL6 9EU, 0438 714159

Antron Electronics Ltd (Polar), Hamilton House, 39 Kings Road, Haslemere, Surrey GU27 2QA, 0428 54541

AWR Technology, 67 Thornbridge Road, Deal, Kent, 0304 367711.

Beckman Industrial Ltd, Queensway Industrial Estate, Queensway, Glenrothes, Fife KY7 5PU, 0592 753811

Crotech Instruments Ltd, 2 Stephenson Road, St Ives, Huntingdon, Cambridge PE17 4WJ, 0480 301 818

Data Laboratories (Philips), 28 Wates Way, Mitcham, Surrey CR4 4HR, 01-640 5321.

Electronic Brokers Ltd (Grundig, Philips, Hameg) 140-146 Camden Street, London NW1 9PB, 01-267 7070

Electronic and Computer Workshop (Crotech) 171 Broomfield Road, Chelmsford, Essex CM1 1RY, 0245 262149

Eletroplan Ltd, P O Box 19 (Gould, Tektronix, Leader, Thandar), Orchard Road, Royston, Herts. SG8 5HH, 0763 45145

Farnell Instruments Ltd, Sandbeck Way, Wetherby, West Yorkshire LS22 4DH, 0937 61961

Fieldtech Heathrow Ltd (Meguro), Huntavia House, 420 Bath Road, Longford, Middx UB7 0LL, 01-897 6446

Flight Electronics (Trio), Flight House, Ascupart Street, Southampton SO1 1LU, 0703 227721

George Cook (Hamag Thurlby), 21 Manor Road, Kneresborough, North Yorkshire HG5 0BN, 0423 862641.

Hameg Oscilloscopes Ltd, 74-78 Collingdon Street, Luton, Bedfordshire LU1 1RX, 0582 413 174

Henry's Audio Electronics (Hitachi, Hameg, Crotech), 301 Edgeware Road, London W2, 01-724 3564

Hewlett Packard, Literature section, Eskdale Road, Winnersh Triangle, Wokingham, Berkshire RG11 5DX, 0734 696622

Hitachi Denshi (UK) Ltd, 13-14 Garrick Industrial Centre, Garrick Road, London NW9 9AP, 01-202 4311

Lawtronics Ltd, 139 High Street, Edenbridge, Kent TN8 5AX, 0732 865191

Le Croy, Elms Court, Botley, Oxford, OX2 9LP, 0865 727275

Levell Electronics Ltd (Hameg), Moxon Street, Barnet, Hertfordshire EN5 5SD, 01-449 5028

Nicolet Instruments Ltd, Budbrooke Road, Warwick, CV34 5XH, 0926 494111

Pye Unicam Ltd, (Philips), York Street, Cambridge CB1 2PX, 0223 358866

Radio Supplies, PO Box 27, 39 Whitby Street, Hartlepool, Cleveland TS24 7BR, 0429 275750

RMR Measurements, 138 Lime Crescent, Cumbernauld G67 3PQ, 02367 28170

Scopex, 117 Knowle Road, Mirfield, W. Yorks WF14 9RJ, 0924 490703

Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middx TW16 7HS, 09327 85691

Solartron Schlumberger, Victoria Road, Farnborough, Hants GU14 7PW, 0252 544433

STC Instrument Services (Iwatsu), Dewar House, Central Road, Harlow, Essex CM20 2TA, 0279 29522

Tektronix UK Ltd, Forth Avenue, Globe Park, Marlow, Buckinghamshire SL7 1YD, 06284 6000

Telonic Instruments Ltd (Kikusui), 2 Castle Hill Terrace, Maidenhead, Berks SL6 4JP, 0628 73933

Thandar Electronics Ltd (Leader, Thandar), London Road, St Ives, Huntingdon, Cambs. PE17 4HJ, 0480 64646

Thurlby Electronics Ltd (Hitachi, Thurlby), New Road, St Ives, Huntingdon, Cambs. PE17 4BG, 0480 63570

Timebase (Hitachi), Unit 6, 28 Bottley Road, Hedge End, Southampton SO3 3HE, 04892 81487

Watetek (Panasonic), Tag Lane, Hare Hatch, Reading, Berks. 075322 4121.

Component integration in oscilloscopes

by Johan Helfferich and Eppi Kruisdijk

Custom i.cs reduce oscilloscope manufacturing time and costs but also improve reliability.

One of the principal design objectives in Philips' medium-frequency oscilloscopes was a significantly reduced component count. Primarily to reduce manufacturing time and cost – thereby permitting a low selling price – this would also ensure high reliability and simplify service and trouble-shooting.

To achieve this aim, a number of custom i.cs were specially developed with the expectation that large production volumes for these new instruments would allow the relatively high costs of developing custom i.cs to be recovered.

A number of the i.cs used are of particular interest and they are the preamplifier, channel switch, display logic/control circuit, peak-to-peak detector and auto level circuit and the integrated time-base logic circuit. These are all custom i.cs.

The preamplifier consists of a unity-gain amplifier, a ×10 gain amplifier, a two-quadrant multiplier, a multiplier control circuit and power supply and switching circuits.

Only one of the two amplifiers is active at any time. This separation of the ×1 and ×10 amplifier sections provides a pulse response which is independent of the setting.

Signal delay is also almost constant for the different settings. Input sensitivities are 20mV/div. for the ×1 amplifier, and 2mV/div. for the ×10 amplifier and output is a symmetrical current of 100μA/div.

To provide variable amplification, a two-quadrant multiplier is built in. The multiplier is a new development with eight transistors featuring stable multiplication and a pulse response independent of the multiplication factor over the entire range.

To translate control voltage from the variable potentiometer into a stable multiplication, the preamplifier has a special multiplier control circuit which limits the variable range from 1:1 to 1:2.5. A switching circuit with t.t.l.-compatible input activates the ×1 or ×10 amplifier.

Switching of the vertical channels and trigger selection in the PM3055 is done by the integrated channel switch, Fig. 1.

This i.c. consists of two current switches to switch channels on and off, two inverters for inversion of channel B if required and two circuits for positioning or levelling the signals (dual timebase). The inverters are used as slope switches in the trigger path.

The display logic and control circuit was developed to control all the vertical channel switches, trigger selectors and timebase selector, Fig. 2.

Settings of the vertical display, trigger source and timebase mode are transmitted to the display/control circuit via the I^{2}C bus from the microprocessor in the front panel. After setting, the control circuit autonomously sends the correct signals to the channel switches, trigger switches and time base selector in a number of modes including alternate, chop, composite triggering, alternate time base etc.

In the 3055, the display/control i.c. makes it possible to display from one to eight traces. The i.c. controls A, B, add and trigger-view traces which can be displayed in main, main-intensified, delayed or alternate-time-base modes. This circuit operates in

The authors are with Philips' Enschede facility in The Netherlands.

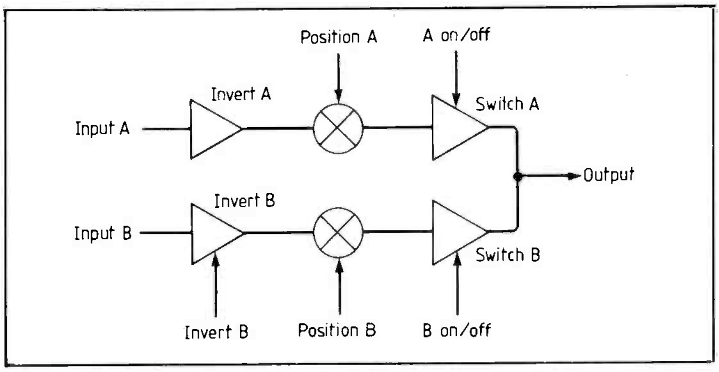


Fig. 1. Vertical channel and trigger selection i.c.

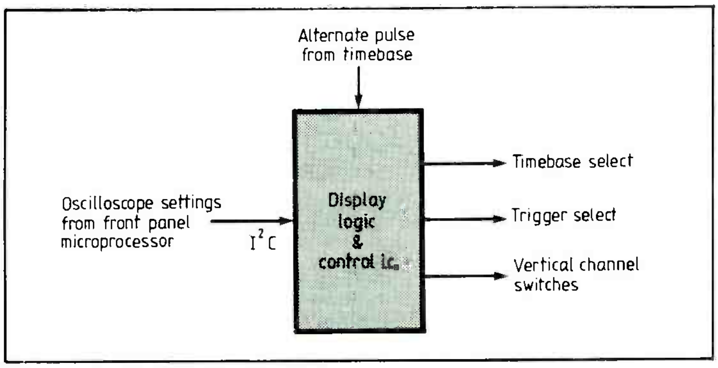


Fig. 2. Settings for vertical display, trigger source and timebase mode are sent to this display logic and control circuit through the I^{2}C bus from a microprocessor on the front panel.

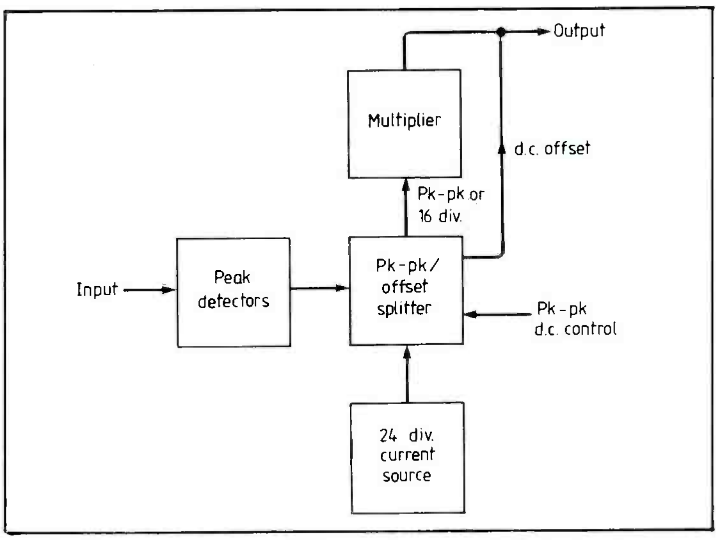


Fig. 3. Output current of this peak-to-peak detector/auto-level i.c. feeds the trigger amplifier.

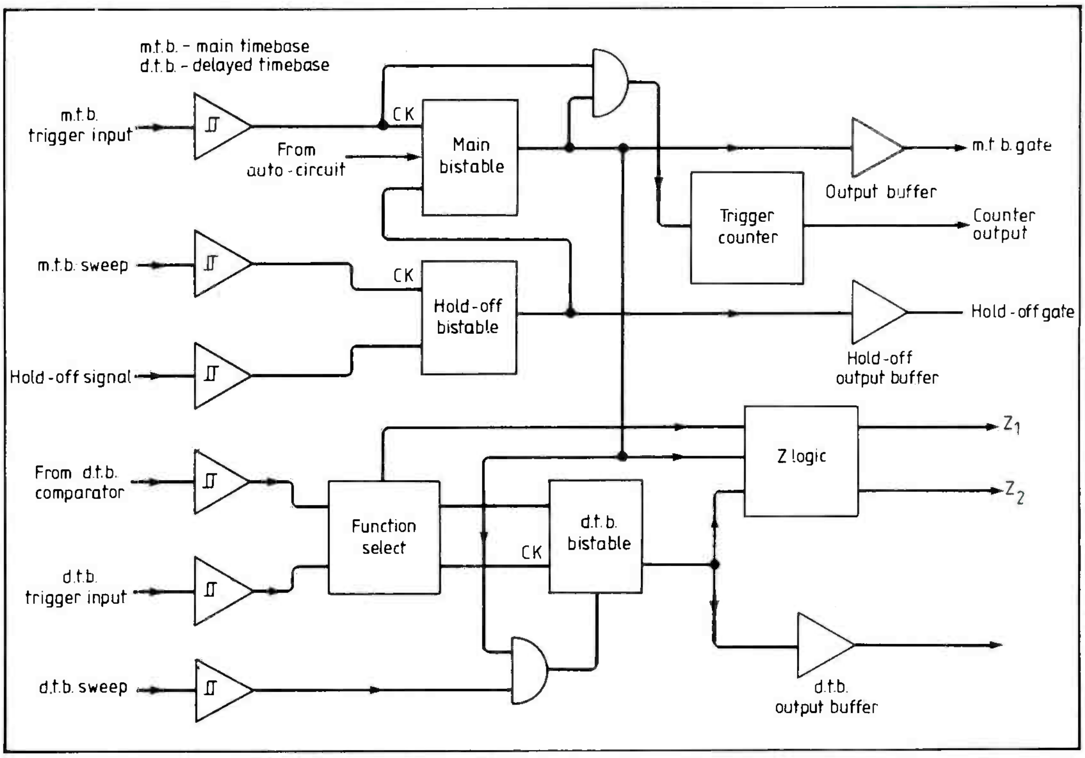


Fig. 4. Implementation of the auto-set function shows both sections of the integrated timebase logic i.c.

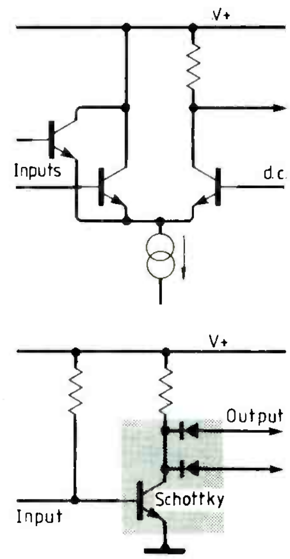


Fig. 5. Both current-mode logic, top, and integrated Schottky logic, bottom, are used for the timebase logic i.c. of Fig. 5.

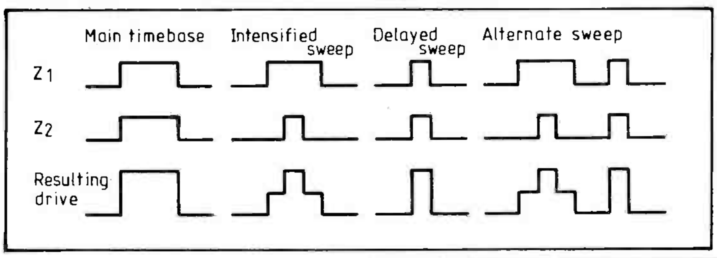


Fig. 6. Tube drive waveforms with intensified and delayed sweeps.

two modes – peak-to-peak levelling and d.c. levelling.

In d.c. model the 16-div. current is separated from 24-div. current. The 16-div. part feeds the multiplier. Controlling the muliplier with the level potentiometer gives a level variable through 16 signal divisions. Residual current is fed directly as a common-mode signal to the output pins.

In the peak-to-peak mode, a part of the signal proportional to the signal's pk-to-pk value is fed to the multipler, controlled by the level potentiometer.

Residual current is modulated with the mean d.c. value of the signal's two peak values and fed to the output pins. Output current peak-to-peak detector/auto-level i.c., Fig. 3, is fed to the trigger amplifier.

Using this principle in peak-to-peak mode gives d.c. rejection on both trigger and trigger-view signals independently of the waveform and signal duty cycle. In this mode, only the level potentiometer influences the position of the trigger view over signal amplitude.

Figure 4 shows the integrated timebase logic i.c. All main and delayed time-base logic for the new medium-frequency oscilloscope family is incorporated in one full-custom chip.

This chip starts and stops the main and delayed time-bases and opens and closes the seven output gates. It also co-operates with the vertical display-selection i.c. in alternating time-base mode.

Communication with the setting processor takes place through a serial bus and reaches the chip through a series-to-parallel converter. Also implemented in this time-base logic is the circuit that counts triggers on the trigger input during the main time-base sweep. This circuit makes the auto-set function possible (Fig. 4) which always endeavours to include at least three periods of the input signal on screen.

The chip has two sections containing the fast circuit and the other handling slower function-selection operations.

The first section is implemented in current-mode logic and the second in integrated Schottky logic, well known from its use in gate arrays, Fig. 5. Design of the fast section posed the greatest problems as it proved to be difficult to simulate analogue circuits running at twice the bandwidth of the oscilloscope.

To ensure that none of the transistors saturates, the input Schmitt trigger and the bistable circuit that starts and stops the sweep are analogue.

Delay between the trigger inputs and the start sweep output is kept as small as possible, which makes the necessary delay line as short as possible. Function selection inputs are t.t.l.-compatible.

Intensity signals Z_1 and Z_2 make it possible to drive the c.r.t. with intensified and delayed sweeps, Fig. 6. The delayed time-base comparator is not incorporated on the chip.

Figure 7 shows triggering of main and delayed time-bases■

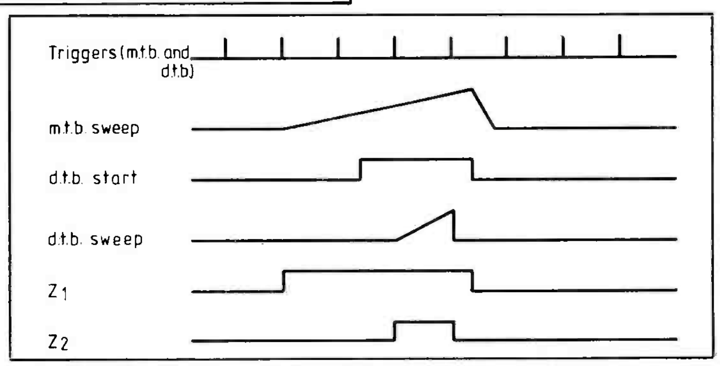


Fig. 7. Main and delayed timebase triggering.

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U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.25
UBC81	1.50
UBF89	1.00
UBL21	1.75
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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
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2B7	1.50
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2C42	29.50
2C43	60.00
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2E26	7.95
2J42	93.00
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3A/107B	12.00
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3A/2	3.95
3A3A	3.95
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3L5	0.95
3AT2	3.35
3B2	3.00
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6EA8	2.50
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6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
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6P26	4.00
6P28	2.00
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6Q7GT	1.20

6R7G	3.15
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6SG7	2.50
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6SJ7GT	1.20
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6SN7GT	1.35
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6SS7	1.95
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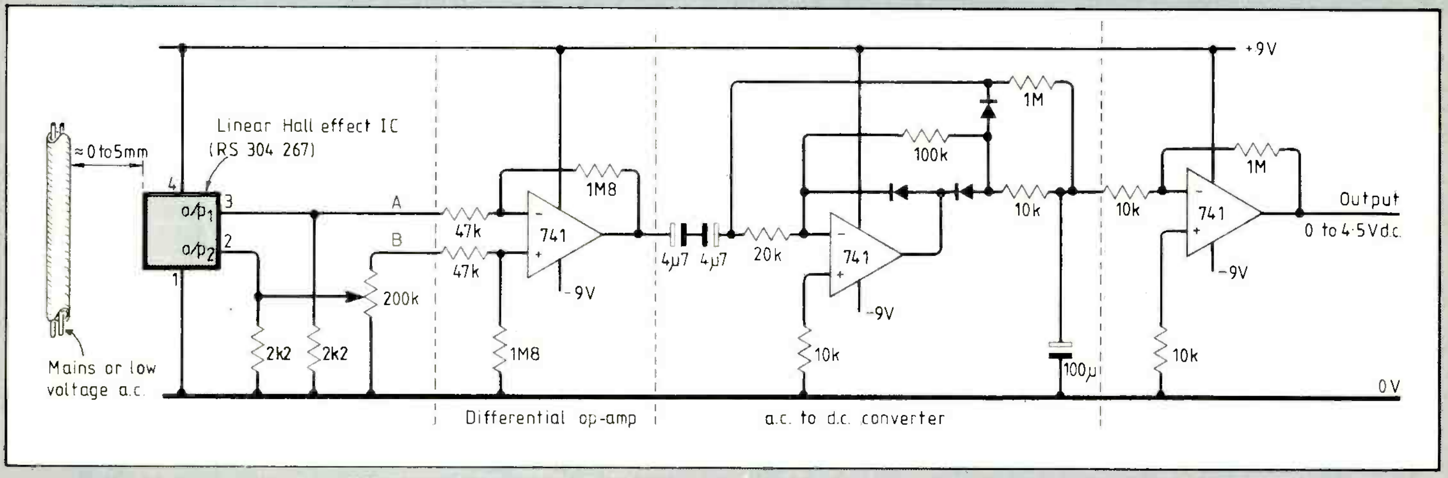
CIRCLE 31 FOR FURTHER DETAILS

CIRCUIT IDEAS

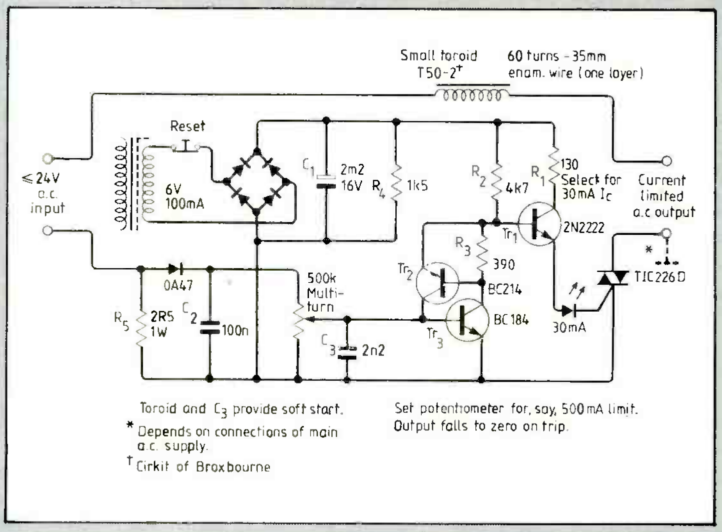


Hall-effect current detector

Alternating current flow in cables can be monitored using a linear Hall-effect device. This circuit detects current down to about 150mA.

The potentiometer is adjusted for equal voltages at points A and B with no current being monitored. Direct-current output can easily be fed into a computer for data-logging applications.

A. Smith
Llanelli
Dyfed



AC power supply with limiting

A simple current-limited a.c. power supply is handy for checking transformers and coils before applying full power. This supply can be used on its own or added to a d.c. power-supply unit with multi-tap mains transformer.

Alternating supply voltages from tappings on the main transformer are selected using a two-pole break-before-make switch. A useful selection of voltages is 3,4,5,6,20,22 and 24V.

A separate small mains transformer of say 6V at 100mA powers the circuit. Rectified current of 30mA feeds the TIC226 gate to ensure positive switching.

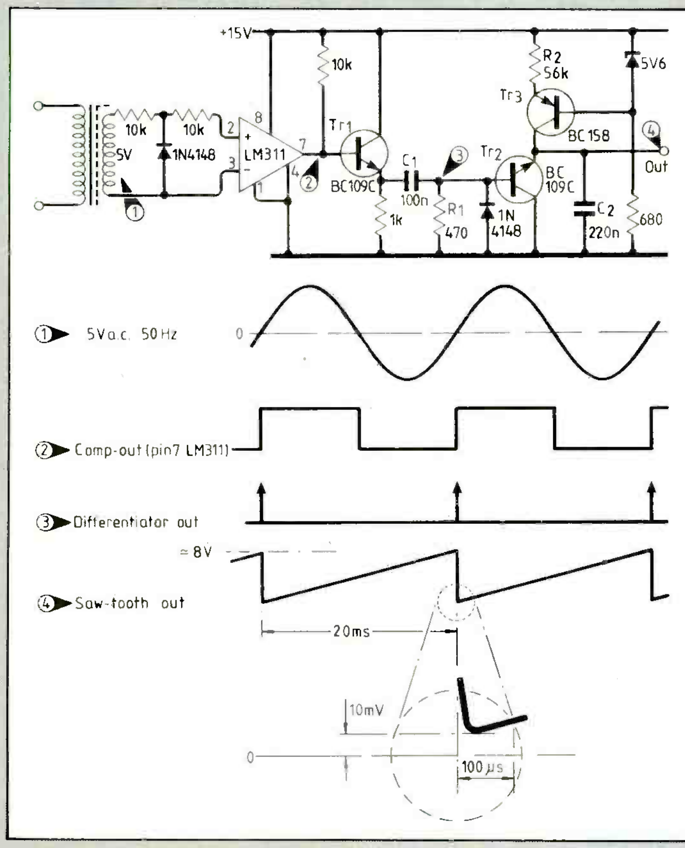
Voltage proportional to the alternating test current appears across R_5 and is available, rectified, across the potentiometer. This potentiometer is set so that Tr_3 triggers at the desired r.m.s. current limit of for example 500mA.

As Tr_3 conducts, Tr_2 latches both transistors on, turning off the led and denying base drive to Tr_1; the circuit under test is protected.

Pressing the reset button allows C_1 to discharge, bringing the led on momentarily

At this point the button is released. If the excess load is still present, the led flickers and then remains off.

P.E. Thompson
Antibes
France



Line-synchronized sawtooth generator

Sawtooth waveforms required for phase-control thyristor circuits must have a linear ramp, fast discharge to zero and a minimum dead time. This circuit provides such a sawtooth and operates on a single supply.

Using a reverse-connected transistor gives a very-low V_{ECsat} of 1 to 10mV, although it requires more base drive as β in this configuration drops to 0.1. Dead time, determined by R_1/C_1, is less than 100μs. A sawtooth repeating at every zero crossing can be obtained by inverting the comparator output, differentiating it then OR-gating the two pulse trains to discharge Tr_2.

V.B. Kuber
Nashik
India

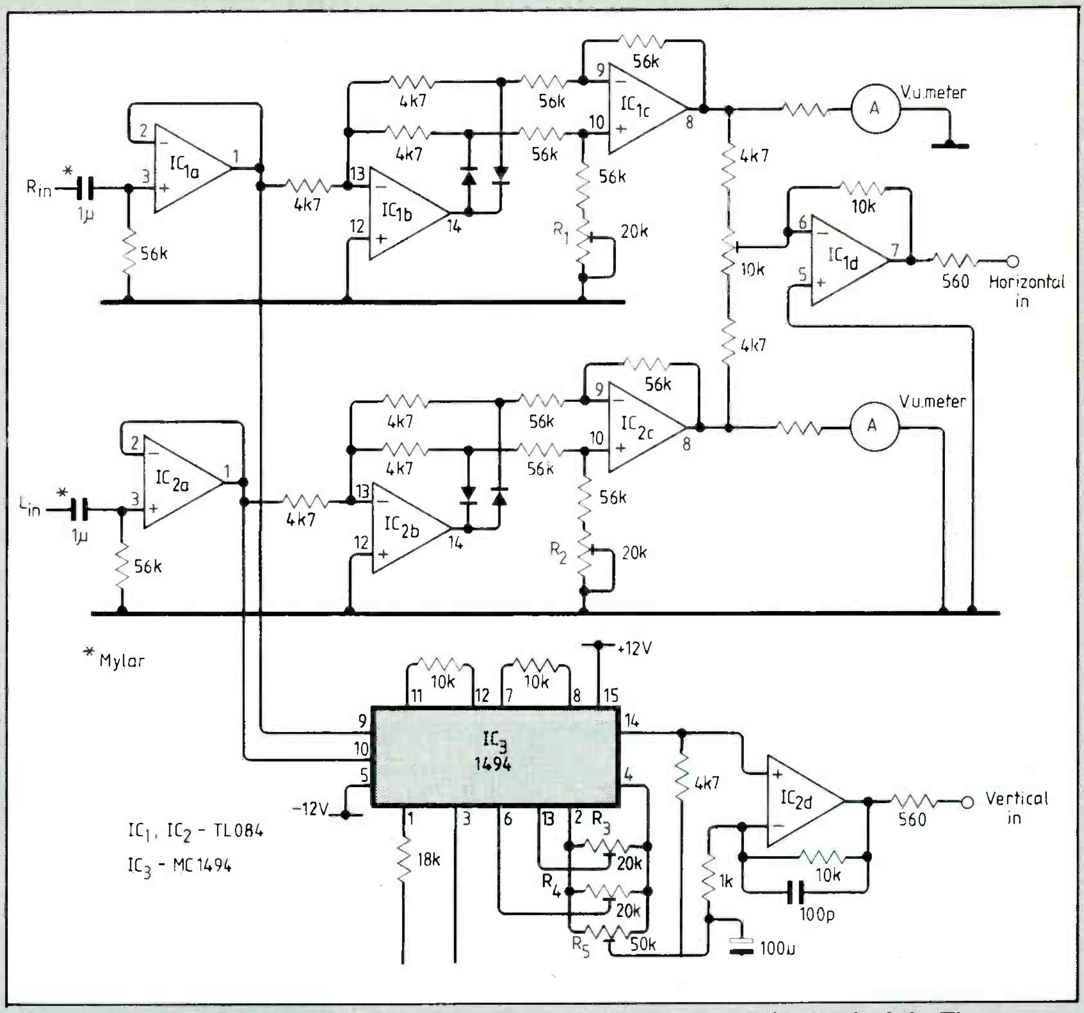
Stereo phase and level display

Live recordings have to be right first time, but when mixing multiple microphones by ear it is easy to make a listening error and have one of the microphones out of phase. Only after the recording is made can a fault like this be detected and by then it is too late.

By out of phase I mean that one microphone's position with respect to another is such that an acoustical phase shift occurs, causing colouration at certain frequencies. If a disc is made from the recording, too many out-of-phase signals cause undesirable needle movements, resulting in wooliness.

With this circuit, any general-purpose d.c.-coupled oscilloscope can be used to display a left-minus-right signal on the horizontal axis and a left-multiplied-by-right signal on the vertical axis.

Buffered left and right signals feed two rectifiers providing positive and negative signals for subtraction; rectifier symmetry is balanced using $R_{1,2}$. If the two input signals are identical, the 10kΩ potentiometer can be adjusted for null.



Simultaneously, both channels feed an MC1494 multiplier. Resistor R_3 is adjusted for null output with a left-channel signal only and R_4 nulls output for a right-channel signal only.

Because IC_3 is a multiplier, output follows a square law. A logarithmic amplifier could be used to linearize this circuit but balancing such an amplifier is difficult so it may not be worthwhile. The v.u. meters are optional.

Don Goodman
Rubin Academy of Music
Tel-Aviv University
Israel

Sensitive dip oscillator for titrations

In fet r.f. oscillators a diode from gate to earth is often included to stabilize output voltage. Popular belief is that this produces a bias voltage by rectification, thus reducing circuit gain.

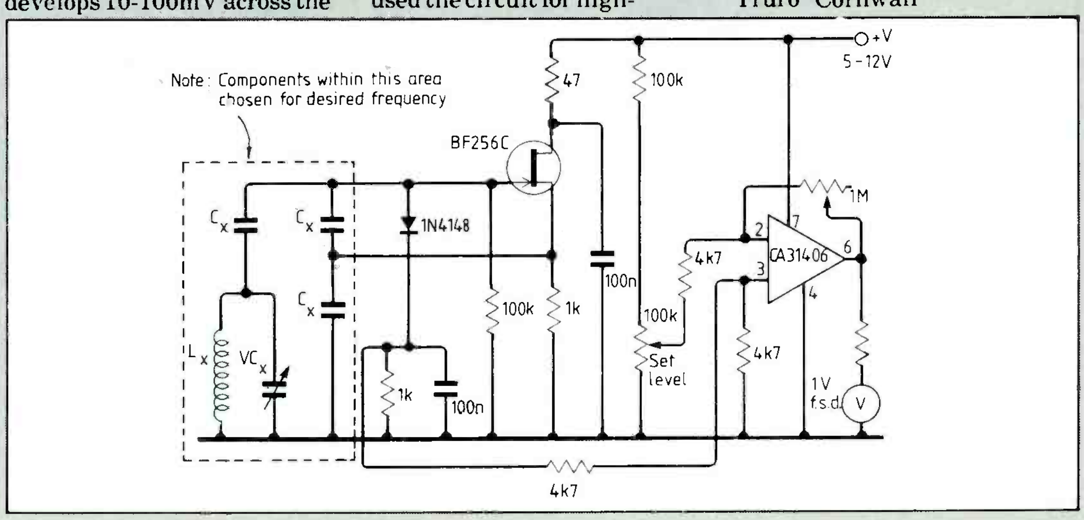
This cannot be so because the circuit still functions in the same way if the series capacitor in the tuned circuit is omitted and the gate thus connected to earth through.

The diode seems to work by clamping voltage across the tuned circuit to the diode's forward voltage level. Absorption of power from the tuned circuit, such as occurs when a tuned circuit resonant at the oscillator frequency is brought near, causes a reduction in diode current.

By placing a low value resistor in series with the diode, this clamping current may be sensed, amplified and displayed on a meter. In this conventional Clapp oscillator diode current typically develops 10-100mV across the 1kΩ resistor.

The circuit can be applied as a very sensitive dip oscillator or as a metal detector. In analytical chemistry, I have used the circuit for high-frequency titrations. The cell is the inductor, which consists of a few turns of wire round a breaker.

Lionel Sear
Truro Cornwall



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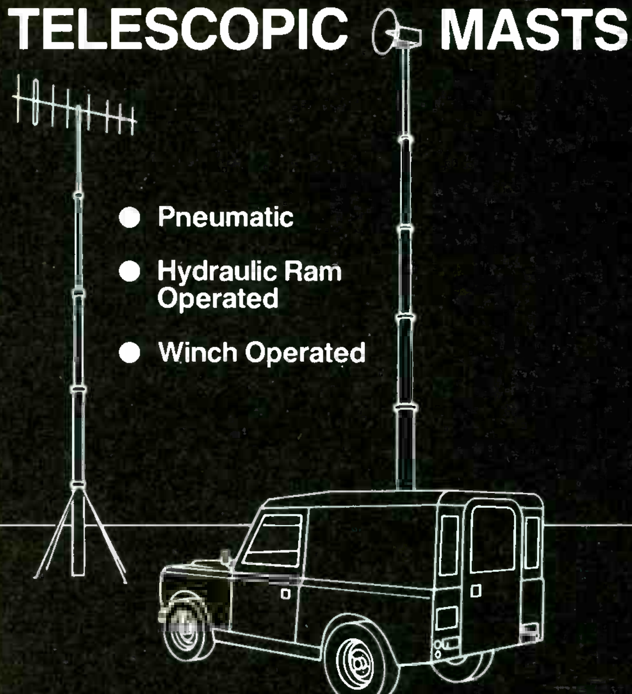

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Electronic ignition for single-cylinder engines

by John Robins

Capacitor discharge unit replaces magneto ignition to give new life to garden machinery

John Robins is a psuedonym for a well-known circuit designer now working as a consultant.

The initial requirement for a dry battery c.d. ignition system is a d.c. converter to generate a supply of some few hundreds of volts to which an energy storage capacitor could be charged, preparatory to its discharge through the primary of the ignition coil.

To a first approximation, the spark energy will depend on the energy stored in this capacitor, which is $0.5(CV^2)$. This is in joules if C is in farads, and, conventionally, energy figures in the range 30-120mJ have been suggested [1,2]. A 1μF capacitor charged to 250V with a stored energy of 62mJ would offer two advantages over a higher voltage, lower capacitance system. The first is that the use of a 400V d.c. capacitor offers a sensible safety margin and such capacitors are easier and cheaper to obtain than higher voltage units. The second benefit is that such an operating voltage would be readily obtainable from the primary winding of a small 240V mains transformer. If this could be used as the step-up unit, it would save the difficulty of winding a special unit.

Most conventional d.c. converter circuits employ self-oscillating systems, with the positive feedback required to sustain oscillation derived from additional transformer windings. In his article[1], Cooper proposes the use of a low power multivibrator to drive the inverter transistor, and this seems an eminently sensible move in that it allows a readily determined operating frequency independent of the transformer output load, and avoids difficulties in start-up if the supply or transformer load conditions are such that the oscillator fails to oscillate.

The basic circuit that I used is a symmetrical, base and emitter-coupled multivibrator of the type shown in Fig. 1. The operating frequency is effectively determined by C_1, C_2, R_1 and R_5 and this delivers an alternating square-wave drive to the bases of Tr_3 and Tr_4 via the current limiting resistors R_6 and R_7. These transistors

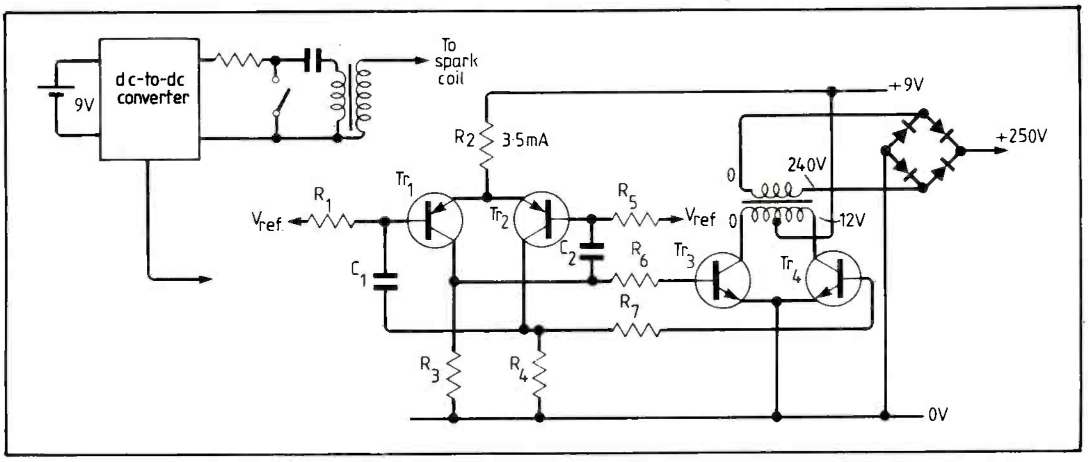

Fig.1. Simplified d.c. converter using base and emitter coupled multivibrator actually uses Darlington transistors for the output pair.

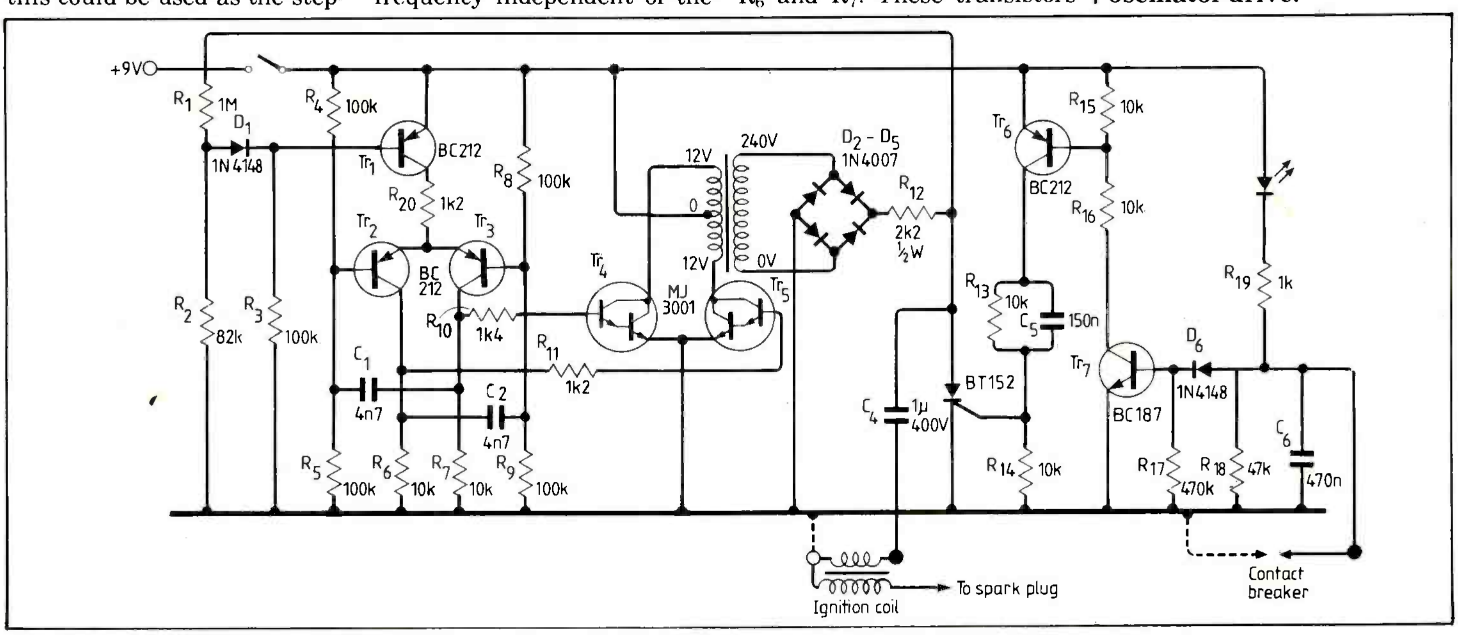

Fig.2. To prevent the voltage rating of the storage capacitor from being exceeded control transistor Tr_1 is added. If the output voltage exceeds limits set by R_1 and R_2, D_1 conducts to reduce oscillator drive.

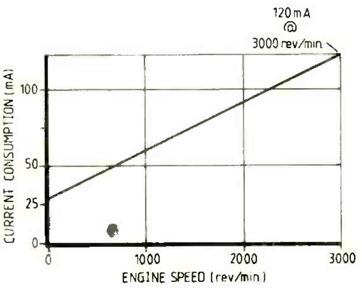

Fig.3. With the intermittent use a single-cylinder two-stroke engine might get a 9V dry battery could last up to several months – less than the cost of fuel.

The case for electronic ignition

The energy of the spark from a magneto depends on the current in the primary coil, which depends greatly on the speed with which the pole pieces pass the fixed coil unit. So if one's arm is weak or the engine doesn't turn freely, the spark can be inadequate to start the engine.

Additionally, with the passage of the years, vibration and age can weaken the strength of the magnet, or worn crankshaft bearings can increase the air gap between the magnet and the magneto coil poles, which will reduce the energy of the magneto and make the feeble slow-speed spark even weaker. Finally, and more catastrophically, the ingress of moisture into the coil windings can cause electrical leakage or chemical corrosion of the fine secondary wire.

With a new machine, replacement of the flywheel unit or magneto coil shouldn't be difficult but in the case of an elderly appliance the model may be obsolete, or the makers out of business.

A number of electronic ignition systems have been described in the technical press, but these have normally been intended for use with multiple cylinder, relatively high performance motor car engines, for which high engine speed was a greater consideration than economy of d.c. supply, so this article takes a fresh look at the circuit possibilities with the specific aims of achieving good d.c. economy and simplicity of construction.

are Darlington types, to reduce the required drive current through Tr_1 and Tr_2. I used MJ3001s because they were to hand, but less expensive devices such as the TIP121s would be entirely adequate.

In the collector circuit of the power stage I used a small mains transformer with a centre-tapped low voltage winding. The high voltage 240V a.c. winding is used with a rectifier bridge to supply the energy storage capacitor.

In general, the maximum output current which could be drawn from such a circuit will increase as the operatoring frequency increases, and some experimentation with two small p.c.b.-mounting transformers of this type, one 1.5VA and one 3VA, showed that both were quite happy up to a few kHz. The standing 'quiescent' current of the inverter stage increased with frequency, especially beyond about 3kHz, as the core losses increased.

An operating frequency of about 1kHz was therefore chosen as a reasonable compromise between these two conflicting requirements. This gave a standing quiescent current of 15-20mA in the prototype when operated from a 9V supply, but would provide an adequate high voltage supply to allow operation at 3000 rev/min, which seemed a suitable upper speed limit.

Secondary voltage control

Under light load conditions, it is probable that the rectified secondary voltage from the step-up transformer could rise to high levels due to the peak rectification of inevitable voltage spikes, and this could cause the working voltage of the energy storage capacitor (C_4 in Fig. 2) to be exceeded.

The oscillator/drive circuit has therefore been elaborated, as shown in the full circuit diagram of Fig. 2, to include a control transistor in the multivibrator emitter circuit. This is normally turned full on by base current supplied through R_3. However, if the inverter output voltage increases beyond predetermined limits, set by R_1 and R_2, the diode D_1 conducts and progressively 'throttles back' the oscillator drive.

This also helps to cut back the quiescent oscillator current once the energy storage capacitor is fully charged. Since it was intended that the unit would operate from a 9V dry battery it was not thought worthwhile to stabilize this supply, though a very low output current regulator in the emitter circuit of Tr_1 would be all that was needed.

HV capacitor discharge circuit

The output voltage from the inverter step-up transformer is rectified by a bridge-connected group of four 1N4007 diodes and feeds the energy storage capacitor through the limiting resistor, R_{12}, which serves to restrain the momentary increase in oscillator current when the capacitor is discharged.

Since Cooper[1] observes that failure of capacitor discharge units is almost always due to the failure of the thyristor, I decided to use a generously rated (13A, 600V) component for this, since the difference in cost between this and a less rugged device was very small.

The thyristor should be fired when the contact breaker points open, and it is very desirable that it should not fire again when the points reclose. This requirement is met by the circuit built around Tr_1 and Tr_2, which fires the thyristor cleanly and reliably without the need for a 'diac', for which, in any case, the available d.c. supply voltage would be too low.

Contact breaker points

It is normally assumed in the design of capacitor discharge electronic ignition systems that the lower the current which passes through the contact breaker points, the better will be their longevity. Up to a point, this is true, but the points normally operate in an atmosphere of oil vapour from the engine, and it is desirable that enough current should flow through these points to burn off any thin insulating film which may form. This is unfortunately incompatible with the design requirement that the direct current consumption for the unit should be as low as possible. I therefore opted for a 1kΩ resistor for R_{19}, with an led in series with it. If it is suspected that the points may not be closing satisfactorily, the led will verify this point. Also, the 0.47μF capacitor across the points will contribute a small amount of discharge energy (23μJ) to assist in keeping the points oil film free.

The whole unit fits comfortably within a small (114×64×55mm) diecast metal housing, with external leads to the primary of the ignition coil, battery, and contact breaker points.

The relationship between running speed for a single cylinder two-stroke engine and d.c. supply demand, at 9V input, is shown in Fig.3. For the sort of usage such machines get, one or two hours at a time, a 9V dry battery could well last many months, and cost substantially less than the petrol used to power the appliance.

For the benefit of those whose skills are mechanical rather than electrical, convert the existing magneto-operated c.d. unit as follows. Disconnect the h.t. lead from the magneto to the spark plug, and the internal connection between the magneto high current (primary) winding and the contact breaker. The contact breaker will almost invariably consist of an insulated moving contact and a fixed contact connected to the chasis of the machine. Identify the insulated point, from which the magneto primary winding is to be disconnected, and provide an adequately robust connection from this point to the c.b. input lead of the c.d. unit. Provided that the carburation is satisfactory, the machine should start easily and run freely.

References

1. Cooper. R., *Wireless World*, March 1982, pp74-76 and 87
2. Anderson. D., *Wireless World*, November 1974. p426.
3. Watkinson. J., *Wireless World*, July 1974. pp216-219. ■

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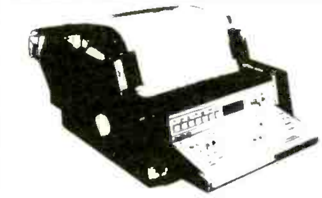
Compact ultra reliable quality built unit made by the **USA EXTEL Corporation**. Often seen in major Hotels printing up to the minute News and Financial information, the unit operates on **5 UNIT BAUDOT CODE** from a Current loop, **RS232** or **TTL** serial interface. May be connected to your micro as a low cost printer or via a simple interface and filter to any communications receiver to enable printing of worldwide **NEWS**, **TELEX** and **RTTY** services.

Supplied **TESTED** in second hand condition complete with **DATA, 50** and **75 baud xtals and large paper roll**.

TYPE AE11 50 Column	ONLY £49.95
Spare paper roll for AE11	£4.50
TYPE AF11R 72 Col. + Ribbon	£65.00
TYPE AH11R 80 Col. ASCII/BAUDOT	£185.00

Carriage and Insurance £7.50

GE TERMIPRINTER



A massive purchase of these desk top printer terminals enables us to offer you these quality **30** or **120** cps printers at a **SUPER LOW PRICE** against their original cost of over £1000. Unit comprises of full **QWERTY** electronic keyboard and printer mech with print face similar to correspondence quality typewriter. Variable forms tractor unit enables full width – up to 13.5" 120 column paper, upper – lower case, standard **RS232** serial interface, internal vertical and horizontal tab settings, standard ribbon, adjustable baud rates, quiet operation plus many other features. Supplied complete with manual. Guaranteed working **GE30 £130.00**. **GE1200 120 cps £175.00**. Untested **GE30 £65.00**. Optional floor stand **£12.50**. Carr & Ins. £10.00.

SEMICONDUCTOR 'GRAB BAGS'

Mixed Semis amazing value contents include transistors digital, linear, IC's triacs, diodes, bridge recs. etc. etc. All devices guaranteed brand new full spec with manufacturer's markings, fully guaranteed. **50+ £2.95 100+ £5.15**

TTL 74 Series. A gigantic purchase of an "across the board" range of **74 TTL** series IC's enables us to offer **100+** mixed "**mostly TTL**" grab bags at a price which two or three chips in the bag would normally cost to buy. Fully guaranteed all IC's full spec. **100+ £6.90, 200+ £12.30, 300+ £19.50**

20,000 FEET OF ELECTRONIC AND COMPUTER GOODIES

ENGLAND'S LARGEST SURPLUS STORE – SEEING IS BELIEVING!!

DEC CORNER

PDP 1140 System comprising of CPU, **124k** memory & MMU 15 line RS232 interface, RP02 40 MB hard disk drive. TU10 9 track 800 BPI Mag tape drive, dual track system. VT52 VDU, etc. etc. Tested and running.	£3,750.00
BA11-MB 3.5" Box, PSU, LTC	£395.00
DH11-AD 16" x RS232 DMA interface	£1,900.00
DLV11-J4 x EIA interface	£350.00
DLV11-E Serial, Modem support	£190.00
DUP11 Synch. Serial data i/o	£650.00
DQ200 Dilog – multi RK controller	£495.00
DZ11-B 8 line RS232 mux board	£650.00
KDF11-B M8189 PDP 1123 PLUS	£1,100.00
LA30 Printer and Keyboard	£80.00
LA36 Decwriter EIA or 20 mA loop	£270.00
MS11-JP Unibus 32kb Ram	£80.00
MS11-LB Unibus 128kb Ram	£450.00
MS11-LD Unibus 256kb Ram	£850.00
PDP11/05 Cpu Ram, i/o etc	£450.00
PDP11/40 Cpu, 124k MMU	£1,850.00
RT11 ver 3B documentation kit	£70.00
RK05-J 2.5 Mb disk drives	£650.00
KL8 JA PDP 8 async i/o	£175.00
M18E PDP 8 Bootstrap option	£75.00
VT50 VDU and Keyboard – 20 mA	£175.00
VT52 VDU and RS232 interface	£250.00

Give your VT100 a Birthday!!!
Brand New VT100 Keyboards
only £85.00

1000's OF EX STOCK spares for PDP8, PDP8A PDP11, PD P1134 etc. **SAE.** for list, or **CALL** sales office for details.

ALL TYPES OF COMPUTER EQUIPMENT AND SPARES WANTED FOR PROMPT CASH PAYMENT.

MAG TAPE DRIVES

Many **EX STOCK** computer tape drives and spares by **PERTEC, CIPHER, WANGO, DIGIDATA, KENNEDY** etc. Special offer this month on **DEI** Cartridge tape drives **ONLY £450.00 each.**

CALL FOR DETAILS

COMPUTER/SYSTEM CABINET & PSU

All in one quality computer cabinet with integral switched mode PSU, mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the psu is fully screened and will deliver a massive **+5v DC at 17** amps, **+15v DC at 1 amp** and **–15v DC at 5 amps**. The complete unit is fully enclosed with removable top lid, filtering, trip switch, **power** and **run** leds mounted on ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. Give your system that professional finish for only **£49.95** + carr. 19" wide 16" deep 10.5" high. Useable area 16" w 10.5"h 11.5"d.

Also available less psu, with fans etc. Internal dim. 19"w, 16"d, 10.5"h. **£19.95. Carriage £8.75**

66% DISCOUNT ON ELECTRONIC COMPONENTS EQUIPMENT

Due to our massive bulk purchasing programme, which enables us to bring you the best possible bargains, we have thousands of ICs, Transistors, Relays, Caps, PCBs, Sub-assemblies, Switches etc. etc. surplus to OUR requirements. Because we don't have sufficient stocks of any one item to include in our ads we are packing all these items into the **BARGAIN OF A LIFETIME**. Thousands of components at giveaway prices. Guaranteed to be worth at least 3 times what you pay. Unbeatable value and perhaps one of the most consistently useful items you will every buy!!! Sold by weight.

2.5kls £5.25 + pp £1.25 — 5 kls £6.90 + £1.80
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CURE those unnerving hang ups and data glitches caused by mains interference with professional quality filters. **SD5A** matchbox size up to **1000 watt 240 V** Load **ONLY £5.95. L12127** compact completely cased unit with **3** pin fitted socket up to **750 watts ONLY £9.99.**

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The amazing **SOFTY 2** The "Complete Toolkit" for copying, writing, modifying and listing **EPROMS** of the **2516, 2716, 2532, 2732** range. Many other functions include integral keyboard, cassette interface, serial and parallel i/o UHF modulator ZIF socket etc.

ONLY £195.00 + pp £2.50

"**GANG OF EIGHT**" intelligent Z80 controlled 8 gang programmer for ALL single 5v rail EPROMS up to 27128. Will copy 8 27128 in ONLY 3 MINUTES. Internal **LCD** display and checking routines for **IDIOT PROOF** operation. Only **£395.00** + pp £3.00

"**GANG OF EIGHT PLUS**" Same spec. as above but with additional **RS232** serial interface for down line loading data from computer etc. **ONLY £445.00** + pp **£3.00**

Data sheets on request

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Keep your hot parts **COOL** and **RELIABLE** with our range of **COLING FANS ETRI 126LF21** 240v 5 blade equipment fan Dim. 80 × 80 × 38mm £9.95 **ETRI 99XUOI** 240v Slimline Dim. 92 × 92 × 25mm. equipment gfan. **NEW £9.95 GOULD JB-3AR** Dim. 3" × 3" × 2.5 compact very quiet running 240v operation **NEW £6.95. MUFFIN-CENTAUR BOXER** standard 120 × 120 × 38mm fans Order 110v OR 240v 3 or 5 blade. **NEW** at **£10.50** or tested **EX EQUIPMENT** £5.50. Low Voltage DC Fans **BUHLER 69.11.22.** 8-16v DC micro minaiature reversible. Uses brushless servo motor, almost silent running, guaranteed 10,000 hr life. Measures only 62 × 62 × 22mm. Current cost **£35.00 OUR PRICE ONLY £13.95** complete with data 120 × 120 × 38mm (4" DC fans). **PANSONIC FB-12C12H** 12v DC 5 blade **£18.00 PAPST 4124X 24** — 28v DC 5 blade **£18.00.**

100's of other fans Ex Stock.

Call for Details. Post & Packing on all fans £2.00

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Don't forget, ALL TYPES and QUANTITIES of electronic surplus purchased for CASH

CIRCLE 68 FOR FURTHER DETAILS

NEW PRODUCTS

Low voltage references

Teledyne Semiconductors say their new bandgap references offer a much wider reverse current range than alternatives currently available. The 1.25V type's range is from 15μA to 20mA (TSC04), while the range of the 2.5V device is 20μA to 20mA. They are available in two temperature coefficients, 0.01% per deg C and half that value (50 ppm/deg C). These low voltage references, accurate to 2%, are used for data acquisition converters, multimeters, and battery powered telecommunication circuits.

Enter 200 on reply card.

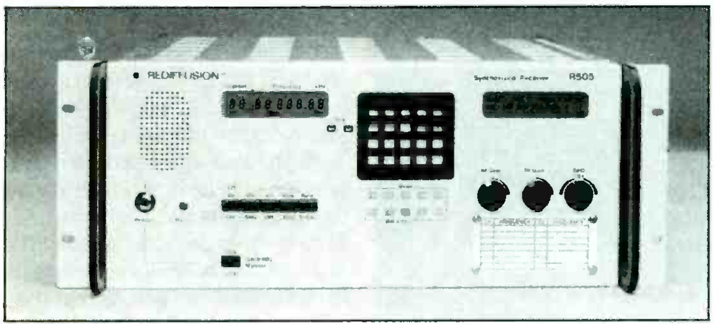
Industrial Pascal for 68000

OmegaSoft Pascal takes the Pascal framework and expands the basic data types, operators, functions and memory allocation to fit the needs of real-time systems. "With the rising cost of writing real-time control software" says Bill Stanley of RCS Microsystems, "the advantage of using a high level language are widely recognised". The compiler generates assembly language for assembly and link to run on the target system. As a true relocation assembler and linking loader is used, only those runtime modules required are linked in, providing a smaller object module than other compilers. Large Pascal programs can be split into conveniently sized modules to speed the development process. Procedures, functions and variables can be referenced between Pascal modules and assembly language modules using Pascal directives.

The compiler package includes an interactive, symbolic debugger, which allows setting of break-points, displaying and changing variables, and tracing statements as well as a full relocatable macro assembler and linking loader, and a full screen editor which can be used with a variety of intelligent terminals.

Full source code is included for the runtime library, debugger, screen editor and other support utilities.

Versions are available to run under OS9/68000 and Versados, and a subset of this Pascal is available for 6809 program generation.
Enter 201 on reply card.



HF receiver has i.s.b. mode

Rediffusion new h.f. receiver is a high performance, synthesized, programmable receiver intended for the professional communications market. Based on the company's R500 receiver, it adds independent sideband operation to the list of mode available – c.w., m.c.w., a.m., l.s.b. and u.s.b. with optional f.s.k. data. High-speed data up to 2400 baud can be received.

Channel, frequency and mode are set through a keypad on the front panel and shown on two liquid crystal displays. Operating parameters for up to 63 channels at a time can be stored in the equipment's memory and brought into operation by selecting channel number and pressing a 'use' button. Frequency is selectable in 10Hz steps in the range 60kHz to 30MHz.

Local, extended or remote control is available, and the receiver can be integrated into a computer-controlled network.

The R505 is the latest addition to Rediffusion's Series 2000 range and shares 80% of functional modules with the DU505 transmitter drive unit.
Rediffusion Radio System Ltd.

Enter 202 on reply card.

Microprocessor crystals

Long-established in the field of manufacture and supply of professional crystals from 10kHz to 360MHz, Webster Electronics announce that they now offer one of the wider ranges of crystal for microprocessor use, from 1 to 60MHz. Specification provides a setting accuracy of ±30ppm measured at 23°C and with a temperature coefficent of ±20ppm over a working temperature range of −10 to +60°C.

All crystals are made in Europe by the manufacturing division of a West German company and claimed to be extremely high quality. They are encapsulated by the resistance weld method.

In addition the company factor a range of oscillators, including 14-pin oscillators with t.t.l. output covering the range 250kHz to 70MHz, crystal filters, and communication antennae.
F. Webster (Electronics & Engineering) Ltd.

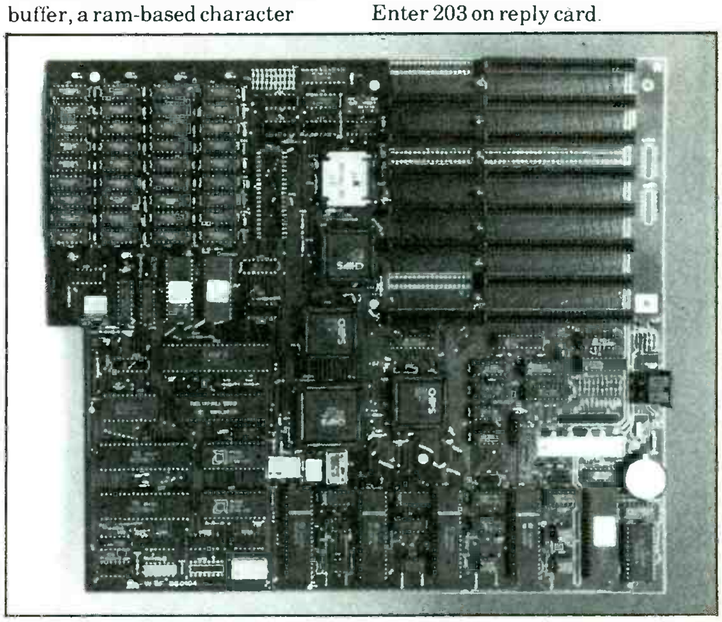
Enter 204 on reply card.

IBM/AT-compatible mother-board and graphics card

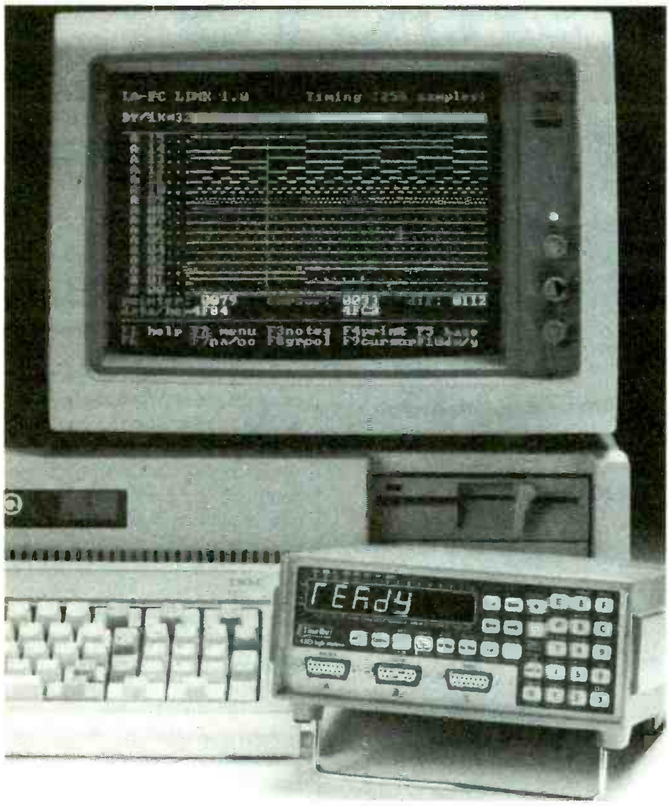
According to Microkey their 286 VLSI is capable of fulfilling many roles in the electronics market-place, its specially designed i.cs implementing the functions of an IBM/AT but in a much reduced area and parts count. In the space saved Microkey implement four serial channels and a parallel printer channel to allow for stand-alone applications. Multi-user environments can be easily implemented. 1Mb ram is standard together with a real-time clock and battery back-up. Firmware comes from Aware Software of the USA and is compatible with IBM's firmware, allowing most present software and hardware packages to run on the basic card. The processor is an 8MHz 80286 on the standard unit; 6MHz is selectable on the card and a 10MHz version will be available early 1987, and the board has a socket for the 80287 co-processor. Eight standard slots for cards are implemented: six 16-bit slots, two 8-bit.

To complement Microkey's IBM-compatible product the VLSI Microkey 1000 graphics card implements the following functions: Hercules graphics standard, IBM's EGA, CGA, MDA and is therefore compatible with software designed to run on them. The board has 256K ram screen buffer, a ram-based character generator, virtual device interface and a light pen interface. The 13.5 by 4in board fits any short slot in a Microkey 286 VLSI, IBM PC, XT or AT and most compatibles.

Enter 203 on reply card.



low-cost PC based logic analysis - from Thurlby



Now you can use your IBM-PC or compatible computer as the basis of a sophisticated logic analyser system.

LA-PC Link is an interface package which links your computer with the low-cost Thurlby LA-160 logic analyser to provide facilities normally associated with only the most expensive analysers.

- **Sophisticated data state listings**
Up to 32 words per screen in multiple data formats.
Scrolling by line, page or word, plus random page access.
Rapid screen compare facility. Full repetitive word search.
- **High resolution timing diagrams**
Sixteen channels of 64, 256 or 1024 samples per screen.
Instantaneous pan and zoom. Moveable channel positions.
Dual cursors with automatic time difference measurement.
- **16 or 32 channels, clock rates to 20MHz**
Operates with all versions of the LA-160 with or without LE-32.
- **Comprehensive data annotation**
Each data and control input can be allocated a user-defined label.
Data files are date/time stamped and can be fully annotated.
- **Full disk storage facilities**
Data files can be saved to disk and recalled for comparison.
Data includes the analyser's set-up conditions and all annotation.
- **Versatile printing facilities**
State listings and timing diagrams with annotation can be printed.
- **Colour or mono display; keyboard or mouse control**
Colour, monochrome or text-only modes suit any display adaptor.
Parts of the programme can be controlled by a mouse if required.
- **Terminal mode for uP disassemblers**
Acts as a terminal for use with Thurlby uP disassembler ROMs.

Thurlby
designed and built in Britain

Thurlby Electronics Ltd
New Road, St. Ives, Cambs.
PE17 4BG **Tel: (0480) 63570**

If you already have an LA-160 logic analyser the LA-PC Link interface package costs just £125. If you don't, an LA-160 with LA-PC Link costs from £520.

CIRCLE 56 FOR FURTHER DETAILS

The world's most advanced low-cost bench multimeter!

Thurlby 1905a £349 + VAT

A complete high performance bench DMM
- 5½ digits; 0.015% acc; 1µV, 1mΩ, 1nA.
- Full ac and current functions as standard

A sophisticated computing and logging DMM
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- dBV, dBm general logarithmic calculations
- Limits comparison; min and max storage
- 100 reading timed data logging
- RS232 and IEEE-488 interface options

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Now Thurlby makes logic analysis affordable ! from the new Thurlby LA-160 £395 + vat

- 16 channels, expands to 32
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- State and timing displays
- Selectable display formats
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- Non-volatile reference memory
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- Hard-copy data print-out

An oscilloscope and logic probe are not enough to unravel the complexities of today's electronic equipment. A logic analyser is as essential for observing digital signals as an oscilloscope is for observing analogue signals, and now Thurlby puts one within every engineer's reach.
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Cambs. PE17 4BG, England. **Tel: (0480) 63570**

CIRCLE 58 FOR FURTHER DETAILS

Development boards

Offered as a low-cost rapid development tool for prototype construction is the 85000 series of computer boards centered on an 8085 single-board computer. The potential on-board memory capacity of 98Kbyte can be extended by use of an inhibit line.

Peripheral boards include a communications board, based on Intel's 8256 muart, and a display board for driving Epson character or graphics l.c.ds. Each of the peripheral boards includes a development section designed for use with the BICC-Vero Speedwire system. Three voltages and a ground plane are available as well as data, address and control buses which are distributed through the development area so that devices can be added and wired easily. Timing has been optimized to accept a wide variety of ram and rom chips. Control signals can be altered by shorting jacks and memory size and addressing modes can be selected by a series of 8-way dil switches. Languages can be installed in roms, and an assembly-language programming service to complete the operation. Automation and Control Technology, Cofton Road, Barton, Exeter EX2 8QW.
205 on reply card

Satellite dish

The 'square' offset receiving and transmitting dish from Sat-Tel is claimed to overcome many of the problems associated with elliptical or circular antennae. It offers equal performance from both polarizations and a very low sidelobe response, and a 1.4m dish gives a similar performance to 1.8m circular.

The same company offers SBR80, a satellite beacon monitoring receiver which can locate a non-transmitting satellite. Beacon signals are typically 40dBW lower than transmission signals. The SBR80 used in conjunction with Sat-Tel's multi-standard broadcast quality receiver, could prove useful in circumstances such as electronic news gathering, where a satellite needs to be accurately located prior to a transmission. Space Communications (Sat-Tel) Ltd, 9 Edgemead Close, Round Spinney, Northampton NN3 4RG.
218 on reply card

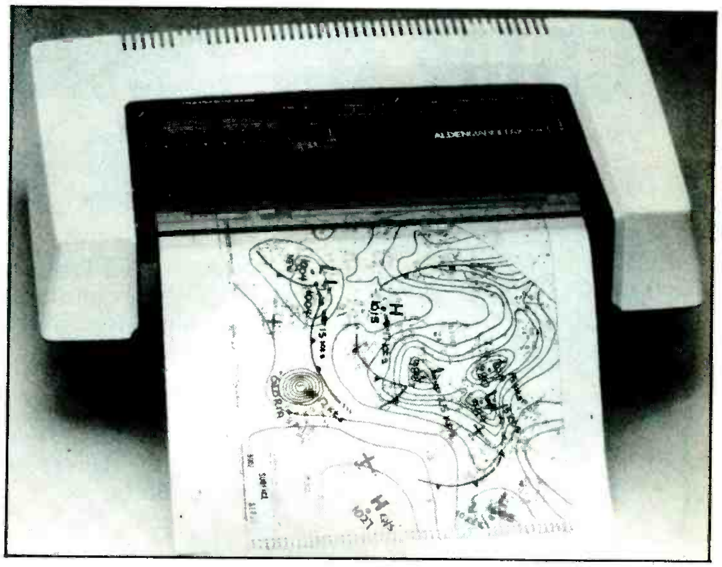
Portable h.f. receiver

The use of microprocessor and l.s.i. devices in the Yaesu field portable transceivers enables them to offer full professional' facilities but remain physically small and weigh only 5.8kg including NiCd battery pack. The frequency-synthesized circuits produced a 10W (5W on a.m.) transmitter ranging from 2 to 30MHz with reception down to 500kHz. Upper or lower sideboard, carrier wave and a.m. transmission and reception are all included. Other facilites include high/low power selection; receiver squelch and noise blanking; a meter for signal strength, transmitter power or battery condition; the receiver has an offset (clarifier) control. A transmitter tune switch can simplify zero beat frequency interference by other transmitters.

A wide range of optional extras include a high capacity rechargeable NiCd battery pack, a quick charger, various antennae and antenna tuners, as well as a telephone-style handset and a backpack carrying case. Amcomm-ARE, 373 Uxbridge Road, London W3 9RN.
219 on reply card

Audio components

Precision components for builders of audio equipment and service engineering are offered by Audiokits. These include IAR Wonder capacitors (imported from the USA), Filmcap reservoir capacitors and Holco precision metal film resistors. Audio Precision Components, 6 Mill Close, Borrowash, Derby DE7 3GU.
220 on reply card



Weather map receiver

Combining the functions of receiver and printer, the Marinefax TR1 has a microprocessor-based programmable memory. It incorporates all the worldwide radiofax frequencies and can be set to select the time and frequency of the desired from any chosen transmitter. The instrument will turn itself on, select the desired transmitter and frequency, receive the chart and turn itself off. This cycle can be programmed to occur for up to 250 on/off sequences. Ten frequently used services can be accessed by a single push button, all other stations are chosen from prompts given by the display and any other frequency can be keyed into the receiver. The receiver can be tuned in 0.1kHz steps to capture transmitters using odd frequencies.

The instrument incorporates a thermal printer to give dry paper recordings of the received chart. CNJ Services, Churchfield House, Upcott, Latton, Swindon, Wilts SN6 6DS.
210 on reply card

Linescan processor

Microprocessor Analyser (MIA) from IPL is a stand-alone vision system module designed to operate with IPL's 5000 series high speed linescan camera. The camera is connected directly to the MIA which is based on the 68000-based microcomputer, which processor handles the camera data and can be programmed according to the specific needs of the customer.

The unit allows connection of up to four cameras for complex problems, whilst the VME bus structure allows for further expansion.

MIA offers a choice of inputs via keypad, opto-isolated, differential and t.t.l.-compatible lines. Outputs include relays, analogue, large character display, parallel printer port.

Typical applications are in the automotive and steel industries for non-contact dimension gauging and process control. Integrated Photomatrix Ltd, Grove Trading Estate, Dorchester DT1 1SY.
227 on reply card

Appointments

Advertisements accepted up to 12 noon October 1 for November issue

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Senior Design Engineer

For exciting development of computer graphics products for television use.
Experience in Digital and Analogue design, and an understanding of video technology would be essential. You would be required to manage a small development team, and be able to take products from conception through to production. If you have an active enthusiasm for Computer graphics together with a liking for a small but expanding company you would be ideally suited to this job.
Salary dependent on age and experience up to £15,000.

Design Engineer

For assisting in the design of Computer Graphics products.
Experience in at least one of the following fields would be required. Digital Design, Analogue Design, Video Engineering.
You would have the opportunity to participate in many aspects of design, from CAD or schematics and PCB layouts to prototyping.
Salary depending on age and experience from £8,000 to £12,000.

Applications in writing please, together with full C.V. to **The Technical Director, Spaceward Microsystems Ltd., The Old School, Stretham, Cambridge CB6 3LD.**

306

NORWICH **VIDEO** PRODUCTION COMPANY

Seeks enthusiastic and experienced person to repair and maintain video equipment, assist on shoots and provide editing, duplication and administrative support. Essential requirements are past job experience in maintaining video/TV systems, genuine video production experience and organisational flair.

Exceptionally nice working environment in a city that offers a very desirable lifestyle. Salary negotiable. Good prospects for advancement.

Full details and CV to: I. McLaren, 5 Curtis Road, Norwich, Norfolk NR6 6RB.

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The work will involve investigations into methods for accomplishing microwave signal delay with applications for radar test systems.

Salary: £7,170-£7,953 (Inclusive of London Allowance)

Application form and further details are available from The Personnel Office, The Polytechnic of North London, Holloway Road, London N7, quoting ref. R10AD.
Telephone: 609 9913 (24 hour answerphone service).

Closing date for the receipt of applications is 14 days from the appearance of this advertisement.

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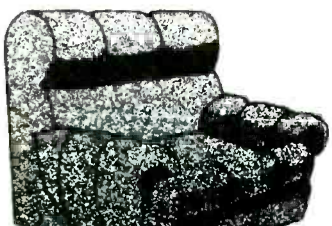

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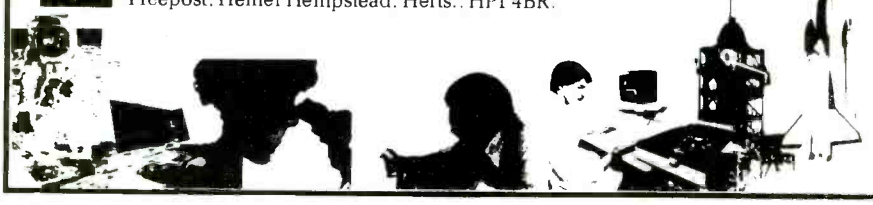

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ADDRESS ....
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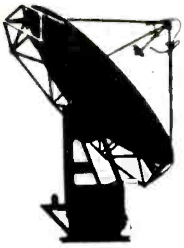
POST CODE ....
TEL NO ....
QUALIFICATIONS .... AGE ....
☐ NONE ☐ CG/HNC ☐ DEGREE ☐ OTHER
SALARY ....
JOB .... WW



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If you are leaving College and planning a career in modern communications or if your present job lacks interest and challenge . . . why not join us in GCHQ?

We are recruiting

RADIO OFFICERS

who after initial training will become members of an organisation that is in the forefront of communications technology. Government Communications Headquarters can offer you a satisfying and rewarding career in the wide field of communications. Training involves a 32 week course (38 weeks if you come straight from Nautical College) which will fit you for appointment to RADIO OFFICER.

Not only will you find the work as an RO extremely interesting but there are also good prospects for promotion opportunities for overseas travel and a good salary. Add to this the security of working for an important Government Department and you could really have the start of something new.

The basic requirement for the job is 2 years radio operating experience or hold a PMG, MPT or MRGC or be about to obtain a MRGC. Registered disabled people are welcome to apply.

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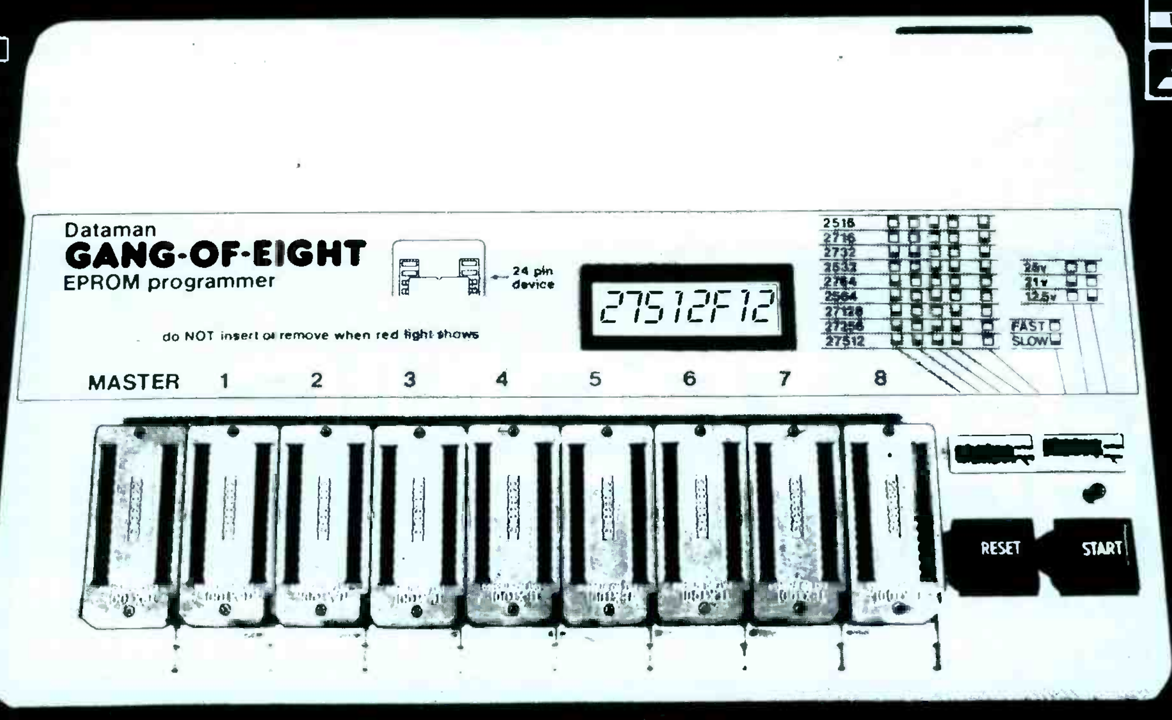

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